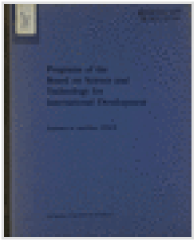

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Programs of the Board on Science and Technology for International Development

Summary of Activities, 1970-78

Commission on International Relations
National Research Council
National Academy of Sciences

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1978

TABLE OF CONTENTS

INTRODUCTION

The experience of the less developed countries (LDCs) in recent years has provided considerable evidence that science and technology play an important role in the complex processes of economic and social development. It is not at all clear, however, how science and technology can both complement and stimulate social and economic development without introducing distortions in these processes. What kinds of science and technology are appropriate for specific countries? What kinds of policies are needed to make science and technology a significant element in social and economic development? What kinds of organizations and institutions are needed? What types of people need to be trained and how? How can U.S. scientific and technological resources contribute to development abroad? These questions illustrate the range of issues that BOSTID continues to address.

Over the past 12 years, the National Academy of Sciences (NAS) Board on Science and Technology for International Development has been involved in the examination of development issues with LDC counterparts by means of joint workshops and studies convened in 24 countries in Africa, Asia, and Latin America. The attractiveness of these meetings to both American and host country participants lies in their truly cooperative character with shared funding, planning, and organizational responsibilities. Most recently, in recognition of the growing desire of LDC officials to diversify their sources of scientific and technological knowledge and experience, a number of BOSTID programs have included participants from LDCs with similar problems and opportunities, as well as representatives of both national and international development institutions.

More than 1,200 persons (see Section V) from American universities, research institutes, government agencies, and private industry have participated in BOSTID workshops and studies, contributing their time and effort as a public service. Participants are reimbursed for travel expenses, but receive no fees or honoraria.

Through the current reporting period, workshops have been held in the following countries: Arab Republic of Egypt, Argentina, Brazil, Chile, Columbia, Ghana, Guatemala (regional), Guyana, India, Indonesia, Korea, Nigeria, Pakistan, Peru, Philippines, Republic of China (Taiwan), Singapore (regional), Sri Lanka, Sudan, Tanzania, Thailand, Tunisia, Venezuela, and Zaire.

HIGHLIGHTS

BOSTID programs have been characterized by the common theme of collaboration with counterpart organizations in developing countries in the search for ways to use science and technology in the process of social and economic development. Because of the wide range of problems involved, the differences in individual countries, and the desire to strengthen BOSTID's effectiveness, these programs also have involved considerable experimentation and diversity of approach. This section draws attention to a number of the interesting and significant aspects of BOSTID programs during the past eight years.

Overseas programs (see Section II) have focused on most of the major development sectors, including problems associated with agriculture, industrialization, and the use of natural resources. Workshops have covered topics as broad as national science policy and planning and as specific as natural products development.

The BOSTID study program (see Section II) has addressed large issues in such studies as Arid Lands of Sub-Saharan Africa and U.S. International Firms and R, D and E in Developing Countries, and specific problems or opportunities in such studies as those on systems analysis and operations research in relation to development planning and on remote sensing and development. The study program has been enhanced with regard to innovative uses of science and technology in development by the activities of the Advisory Committee on Technology Innovation (ACTI) (see Section II). ACTI's program has two specific objectives: (1) generating ideas for innovative applications of current technology to immediate problems of developing countries and (2) identifying research that could shorten the time characteristic of the usual progression from scientific discovery to application. Studies have been completed on such topics as Underexploited Tropical Plants with Promising Economic Value, Firewood Crops: Bush and Tree Species for Energy Production, and Energy for Rural Development.

Increased awareness has developed of the need to strengthen the direct linkages between studies and bilateral activities and to encourage greater utilization of both. For example, the study on the productive utilization of freshwater aquatic weeds was followed by a workshop on aquatic weed management and utilization in the Nile Basin. Several workshops have been followed by return visits of NAS workshop participants to encourage and help with the implementation of recommendations. The creation of joint committees for scientific cooperation which meet at regular intervals has been an important approach to providing continuity and follow-up to BOSTID programs. Such groups have been formed in Korea, Taiwan, and Brazil; a group is being planned for Egypt.

Several interesting developments have occurred in BOSTID program methodology. Increasing emphasis has been given to participation by representatives of developing countries on BOSTID panels and committees. Several workshops gave experimented with multilateral rather than bilateral participation. New modes of cooperation also have been tried with U.S. institutions. In May 1975, for example, the NAS and NSF jointly planned and took part in a workshop in Egypt on research management. In Korea, several activities have involved small advisory teams of two or three persons sponsored by BOSTID, rather than the typical larger workshop approach.

In order to involve as many institutions and persons as possible in its development activities, BOSTID has continued to seek diversified sources of funding for its activities. Although the largest source of funding has been AID, private funds have been contributed for activities in Brazil, Guatemala, Singapore, Taiwan, Venezuela, and Zaire. A recent important and encouraging financial development has been the willingness of some countries to use resources they control to support BOSTID activities. In Korea, Ghana, and Brazil, for example, science bloc grants from AID or local funds have been used for BOSTID activities.

Approximately 25 percent of the countries with which BOSTID has had collaborative programs are classified as least-developed or so-called "fourth world" countries, including India, Indonesia, Sri Lanka, Sudan, Tanzania, and Zaire. For all the countries with which it works, BOSTID acts as a mechanism for apolitical communication among individual scientists and engineers. This stance has enabled contacts to be maintained with countries such as Chile, despite severe political crises.

As BOSTID has gained experience with the kinds of programs described in this report, it has been possible to reduce the number of professional staff members without decreasing the level of program activity. The present number of staff members is 25 percent less than the peak level during the reporting period.

Special efforts have been made to increase the participation of women and members of minority groups on BOSTID panels and committees. Special rosters and lists of possible candidates have been prepared and are used in the process of selecting participants.

This section has emphasized the experimental character of the BOSTID program. Although the studies and overseas programs have been useful mechanisms for achieving the overall objectives of BOSTID, the Board will continue to explore new mechanisms and directions for utilizing science and technology in significant efforts aimed at economic and social development. A significant change in BOSTID's normal operating procedures is contemplated in the planned program in Egypt. The NAS plans to assign two NAS professional staff to work together with our Egyptian colleagues in strengthening their research infrastructure.

BASIC ORDERING AGREEMENT AND TASK ORDERS

The Basic Ordering Agreement between AID and NAS was initiated in 1969 as a result of discussions between AID Administrator John Hannah and NAS President Philip Handler. Because of AID's previous experience with NAS programs related to development problems, Dr. Hannah suggested the establishment of an NAS program that would provide both a continuing source of advice to AID and specific program activities with developing countries. The Basic Ordering Agreement, signed in 1970, has been carried out through task orders for specific activities, outlined in the pages that follow:

Task Order No. 1 provides for: (a) bilateral workshops and meetings with developing countries to help strengthen their scientific base and their capabilities for using science and technology more effectively in support of development; and (b) advisory panels and special studies dealing with science, technology, and specific problems of development (Effective dates: April 1, 1970 - March 1, 1978. Amount: $5,500,000). No-cost time extension to December 31, 1978, requested February 6, 1978.

Task Order No. 2 provided for an ad hoc panel to study "East Pakistan Land and Water Development as Related to Agriculture" (Effective dates: August 7, 1970 - January 31, 1971. Amount: $22,491).

Task Order No. 3 provided for the continuation of the Cooperative Science Program with the Argentine Council for Scientific and Technical Research (Effective dates: August 15, 1970 - December 31, 1972. Amount: $55,000).

Task Order No. 4 provided for Academy assistance in a Seminar on Protein Food Promotion in Bangkok, Thailand in November 1970 (Effective dates: October 15, 1970 - February 1, 1971. Amount: $24,500).

Task Order No. 5 provided for the continuation of the NAS-COLCIENCIAS Cooperative Science Program with Colombia, involving study group assessments of the potential for graduate education and research in Colombian universities (Effective dates: November 15, 1970 - December 31, 1972. Amount: $40,600).

Task Order No. 6 provided for a workshop with the Indonesian Institute of Science on industrial research and Indonesian economic development in January 1971 (Effective dates: November 23, 1970 - May 31, 1971. Amount: $40,500).

Task Order No. 7 provided for the continuation of a study on the assessment of African agricultural research capabilities (Effective dates: February 10, 1971 - December 31, 1976. Amount: $203,430).

Task Order No. 8 provided for a three-man study panel to visit Korea in January 1972 to advise the Korean Ministry of Science and Technology on its long-range plan for policy and program development (Effective dates: January 2 - March 2, 1972. Amount: $13,450).

Task Order No. 9 provided for a joint study group on Demographic Training and Research in Zaire (Effective dates: January 15 - December 31, 1972. Amount: $13,350).

Task Order No. 10 provided for an NAS panel to examine the feasibility of a proposed AID/Brazil loan program for the development and utilization of science and technology for specific social and development goals in the State of Sao Paulo (Effective dates: April 1 - December 31, 1972. Amount: $27,506).

Task Order No. 11 provided for NAS participation in a workshop on natural resources planning and management, in cooperation with the Indonesian Institute of Sciences (Effective dates: September 1, 1972 - February 1, 1973. Amount: $39,500).

Task Order No. 12 provided for giving advice with respect to the critical medium-and long-term problems of the drought-stricken regions of west Africa (Effective dates: June 28, 1973 - June 30, 1975. Amount: $100,000).

Task Order No. 13 provided for the continuation of the NAS-Brazilian Natural Research Council (CNPq) Cooperative Science Program involving study groups and program-development activities (Effective dates: June 1, 1973 - December 31, 1976. Amount: $86,000).

Task Order No. 14 -- not issued.

Task Order No. 15 provided program funds for an ACTI study on "The Winged Bean as a Potential New Crop Plant for the Humid Tropics" (Effective dates: October 1, 1974 - June 30, 1975. Amount: $17,745).

Task Order No. 16 provides funds for continued NAS collaboration with CNPq involving continuing committee and study group activities. (Effective dates: June 30, 1975 - March 31, 1978. Amount: $85,165).

Task Order No. 17 provides funds for a study of underexploited tropical legumes and a separate study on the legume Leucaena latisiliqua. (Effective dates: June 2, 1976 - August 31, 1978. Amount: $57,000). Time extension to February 28, 1979, and $17,985 and additional funds requested June 22, 1978.

Task Order No. 18 provided funds for staff to support the continuation of the effort of four (4) study teams for the National Research Council's (NRC) World Food and Nutrition Study. (Effective dates: May 20, 1976 - July 20, 1977. Amount: $32,300).

Task Order No. 19 supported an ad hoc working group to provide technical review of the AID organizational activity in considering the establishment of an International Industrialization Institute. (Effective dates: April 16, 1976 - September 30, 1977. Amount: $75,000).

Task Order No. 20 provided funds for the NRC Commission on Sociotechnical Systems to establish a Committee on International Disaster Assistance (CIDA) which provides assistance and guidance to the AID Office of the Foreign Disaster Relief Coordinator. (Effective dates: May 17, 1976 - May 31, 1977. Amount: $218,500). Continuing support of the CIDA has been negotiated under Contract Aid/otr-C-1582. (Effective dates: October 1, 1977 - September 30, 1978. Amount: $199,655).

Task Order No. 21 -- not issued.

Task Order No. 22 provided funds for translation into French and printing of two NAS (BOSTID) reports, More Water for Arid Lands and Energy for Rural Development. (Effective dates: August 24, 1976 - August 31, 1977. Amount: $37,370).

Task Order No. 23 provided funds for a BOSTID study to establish the nature and dimensions of the postharvest food loss problem, to summarize and evaluate available postharvest loss data and make recommendations for studies to determine the extent of losses, and for immediate use to reduce the losses. (Effective dates: January 10, 1977 - June 30, 1978. No-cost time extension to December 31, 1978 requested April 26, 1978. Amount: $150,000).

Other Grants and Contracts between AID/State and NAS-NRC (BOSTID)

AID/ta-G-1329 provides funds for NAS to provide, support, develop, and expand the Brazilian Research Program on nitrogen fixation and to assist in the establishment of a training program in modern research techniques in nitrogen fixation for Brazilian students. (Effective dates: June 24, 1976 - April 14, 1979. Amount: $87,600).

AID/afr-G-1307 provides funds for NAS to assist the Ghanaian Council for Scientific and Industrial Research in order to strengthen Ghana's central institutional mechanism for planning, coordinating, and applying cooperative multidisciplinary programs of science and technology to national economic development priorities. (Effective dates: May 1, 1977 - April 30, 1980. Amount: $25,000).

AID/afr-C-1354 provides for assistance to AID in designing long-term development interventions in the Sahel Region generally and specifically in cooperation with the Ecology and Forestry and Adaptation of Technology working groups of the Club du Sahel. (Effective dates: August 31, 1977 - August 31, 1979. Amount: $520,000).

AID/ta-C-1433 provides funds for (1) strengthening the capability of LDC institutions to apply science and technology resources to economic development problems, and (2) assisting LDCs in using improved techniques to adapt scientific and technological advancements in the U.S. and other industrialized countries to the solution of specific development problems. (Succeeds Contract AID/csd-2584, Task Order No. 1.) (Effective dates: September 30, 1977 - September 30, 1980. Amount: $2,125,000 for September 30, 1977 - August 31, 1979, with additional funding of $1,250,000 for September 1, 1979- September 30, 1980, anticipated).

AID/ta-C-1437 provides for secondment of BOSTID staff member Julien Engel to the Organization of Economic Cooperation and Development (OECD) for preparations for the U.N. Conference on Science and Technology for Development. (Effective dates: September 16, 1977 - June 16, 1978. Amount: $49,000). Time extension to December 31, 1978 and $57,280 additional funds requested May 30, 1978.

AID/NE-C-1474 provides funds for services to assist the Egyptian scientific and technological research community in improving its institutional capability to develop and manage research programs applied to national development needs. (Effective dates: December 16, 1977 - March 15, 1980. Amount: $1,221,250; international travel and subsistence within Egypt, plus other expenses in Egypt, will be provided in Egyptian pounds by AID/Cairo).

Contract 1019-866001 (Department of State) provides funds for assistance to the Department of State in the preparation of the U.S. national paper for the 1979 U.N. Conference on Science and Technology for Development. (Effective dates: October 19, 1977 - August 31, 1978. Amount: $385,000). Time extension to August 31, 1979 and $133,724 additional funds requested June 6, 1978.

Table 1. Overseas programs and staff visits, NAS counterpart organizations, and sources of funding

Country	Counterpart organization	Source(s) of funding
AFRICA		
Cameroon*	Office Nationale de Recherches Scientifiques et Techniques	OST/AID*
Chad*	Lake Chad Basin Commission	Africa Bureau, AID
Ethiopia*	National Council for Scientific and Technical Research	OST/AID*
Ghana	Council for Scientific and Industrial Research; Universities of Ghana	OST/AID
Ivory Coast*	Ministry of Scientific Research	Africa Bureau, AID*
Kenya*	Kenya National Parks Board of Trustees	OST/AID*
Liberia*	Agricultural Research Council	OST/AID*
Morocoo*		OST/AID*
Nigeria	Council on Science & Technology	Africa Bureau; OST/AID*
Senegal*	Delegation General a la Recherche Scientifique et Technique	Africa Bureau*
Sudan	National Council for Research; University of Khartoum	Africa Bureau*; OST/AID
Tanzania	Tanzanian National Scientific Research Council	Private funds*; OST/AID
Zaire	Office Nationale de la Recherche et du Developpement	Private funds; mission and OST/AID
ASIA		
Afghanistan*	Ministry of Agriculture: Kabul University	OST/AID*

* Staff visits only

Table 1 continued.

Country	Counterpart organization	Source(s) of funding
Bangladesh*	Bengal Academy of Sciences	OST/AID*
Burma*		OST/AID*
China, Republic of (Taiwan)	Academia Sinica; National Science Council	Private funds
India	Indian National Science Academy; Indian Pugwash Committee	Mission funds; private funds; OST/AID*
Indonesia	Indonesian Institute of Sciences (LIPI)	Mission funds; OST/AID*
Korea	Ministry of Science and Technology	TAB/AID; mission funds; OST/AID; Government of Korea
Nepal*	National Research Council	OST/AID*
Pakistan*	National Science Council	OST/AID*
Philippines	National Science Development Board	Mission funds; OST/AID
Singapore	Science Council of Singapore	OST/AID; private funds
Sri Lanka	National Science Council	OST/AID
Thailand	Institute of Food Research and Product Development, Kasetsart University; National Research Council; National Economic and Social Development Board	Mission funds; OST/AID; RED
LATIN AMERICA		
Argentina	National Council for Scientific and Technical Research	Mission funds
Bolivia*	Academy of Sciences	OST/AID*
Brazil	National Research Council; Brazilian Planning Ministry; Brazilian Academy of Sciences	Mission funds; NSF; private funds; Government of Brazil: STS/TAB/AID

* Staff visits only

Table 1 continued.

Country	Counterpart Organization	Source(s) of funding
Central America	Central American Research Institute for Industry (ICAITI)	OST/AID; UNEP
Chile	National Commission for Scientific and Technical Research; University of Chile	OST/AID
Colombia	Colombian Fund for Scientific Research (COLCIENCIAS); Colombian universities	Mission funds
Costa Rica*	National Council for Scientific and Technical Research (CONICIT)	OST/AID*
Dominican Republic*	Dominican Institute of Technological Research	OST/AID*
Guatemala	Guatemala Academy	Private
Guyana	National Science Research Council; University of Guyana	OST/AID, NSF
Haiti*	National Research Council	OST/AID*
Mexico*	National Council for Science and Technology	Private
Peru	National Research Council; Peruvian Association for the Advancement of Science: Institute for Technological Research and Standards	Latin American bureau; OST/AID
Venezuela*	National Council of Scientific and Technological Research; Venezuelan Academy of Sciences; Institute of Scientific Research	OST/AID*; Private
MIDDLE EAST AND NORTH AFRICA		
Egypt	Academy of Scientific Research and Technology; Egyptian Academy of Sciences: Universities of Egypt	NSF; OST/AID

* Staff visits only

Table 1 continued.

Country	Counterpart organization	Source(s) of funding
Iran*	Ministry of Science and Higher Education; Arya Mehr University	OST/AID*
Jordan*	Royal Scientific Society	OST/AID*
Tunisia	Office of the Prime Minister	OST/AID
Turkey*	Scientific and Technical Research Council of Turkey; Middle East Technical University	OST/AID*
Yemen*		OST/AID*

* Staff visits only.

OVERSEAS PROGRAMS

Africa

CAMEROON

Three visits by BOSTID staff to Cameroon in 1976 for discussions with AID officials and representatives of the National Office for Scientific and Technical Research (ONAREST) resulted in agreement to pursue cooperative activities on the organization of applied research for social and economic development. The initial focus was to be a workshop on agricultural research management. A number of factors prevented the workshop from taking place in 1977; thus a BOSTID staff member visited Cameroon in February 1978 to update workshop planning. A BOSTID panel is scheduled to go to Cameroon for two weeks, beginning the latter part of June 1978.

ONAREST's director general, Dr. F. A. Gandji, is enthusiastic about collaborative activities with BOSTID, and the relationship has the strong support of the AID Regional Development Office. Dr. J. Nya Ngatchou, director of ONAREST's Institute for Agricultural and Forestry Research (IRAF), headquartered at Buea, is coordinating the upcoming activity. The five-person BOSTID panel will undertake a week's field visit to research centers prior to the actual workshop at Buea. Some 15 to 20 Cameroonians, from government ministries and university faculties as well as research institutions, will participate. At the conclusion of the workshop, a colloquium will be held in Yaounde, both to convey the results of the workshop and to explore more broadly the relationships of science and technology to development.

ETHIOPIA

Following several staff visits, the Ethiopian National Council for Science and Technology asked BOSTID to collaborate in organizing a workshop program on science and technology in relation to Ethiopia's development. The objective of the workshop was to consider guidelines for formulation of national priorities in science and technology and to consider relationships among and responsibilities of new Ethiopian science organizations--the National Council for Science and Technology, the Ethiopian Science Foundation, and the Haile Selassie I University Institute for Scientific and Technical Research and Development.

The workshop was originally scheduled to be held April 8 - 14, 1974 in Addis Ababa, Ethiopia. In February, Dr. Akilu Lemma, chairman of the National Council for Science and Technology, requested that the proposed workshop be postponed because of Ethiopia's political situation. In view of its continuing political developments, it is uncertain whether the workshop will be rescheduled. With the cooperation of the AID mission, BOSTID has been keeping in contact with Ethiopian officials of the "development through cooperation" program and providing information on rural small-scale technologies that might be of help to them.

GHANA

A joint workshop, "Research Priorities and Problems in the Execution of Research in Ghana," was held in Accra in January 1971. Convened under the auspices of the NAS, the then newly created (1968) Ghanaian Council for Scientific and Industrial Research (CSIR), and the University of Ghana, the workshop brought together 12 U.S. scientists and over 60 Ghanaian scientists, cabinet ministers, and university and research institute administrators. At this meeting, two areas of critical importance were identified for further study by a joint group: (1) agricultural research and extension, and (2) research priorities in relation to Ghanaian development.

Ghanaian scientists and government officials agreed that the workshop was of decisive importance in that it brought together for the first time many disparate elements of the scientific community. Later developments included an All-Ghanaian Conference on the Role of Agricultural Research and its Relationship to the Development of Agriculture convened in July 1971 and the dissemination of a crops research handbook to personnel in the agricultural ministry, in agricultural extension work, and in other fields.

Study Group on Agricultural Research and Extension

An analysis of the Ghanaian agricultural research situation pointed to the need for greater attention to the relationship between agricultural research and extension and, in particular, to the development of a more coordinated system of agricultural extension training and implementation. The study was formally begun with a planning visit in June 1971 by the NAS co-chairman, Donald Barton, and an NAS staff member. This visit had three main objectives: (1) arrive at mutually acceptable terms of reference for the study; (2) identify and meet the people who have the power to implement agricultural programs; and (3) determine the best timing for the study in terms of political, economic, and social conditions in Ghana.

The planning meeting came at a fortuitous time, because the Government of Ghana had recently formed a committee to draft the Medium-Term (three- to five-year) Plan for the economic development of Ghana. This committee established subcommittees on those sectors of the economy that would contribute to the final plan. The agricultural research and extension study was scheduled so that the NAS visitors and members of the key subgroups of the Ghanaian Medium-Term Plan Committee could exchange ideas. As a result, some of the U.S. visitors' ideas were incorporated into the Medium-Term Plan, and, in turn, ideas contributed by the Ghanaian Medium-Term Plan Committee were incorporated into the planning for the joint study.

The primary recommendations emerging from the study were: (1) the establishment of a "National Agricultural Service" administration within the Agricultural Ministry, which would comprise basic extension services and related activities; (2) the separation of the ministry's Information and Publications Unit into two distinct entities, one to be retained by the minister as a public information dissemination unit and the other--an agricultural information extension unit--to be located within the CSIR; and (3) the establishment of a mechanism for evaluating, through internal and external systems, the effectiveness of agricultural extension in Ghana.

Study Group on Science Policy and Research Priorities

The decree establishing the CSIR in 1968 states that one function of the council shall be "to advise the Government on scientific and technological advances likely to be of importance to national development and in particular to advise the Government or other agencies of Government on scientific and technological matters affecting the utilization and conservation of the natural resources of Ghana and on how best scientific research may be coordinated and employed in the interests of such utilization and conservation." The workshop recommended a joint study to draw up the operational guidelines for this function.

At the request of the CSIR chairman, the study originally scheduled for March 7 - 23, 1972 in Accra was postponed because of the political situation. A joint NAS-CSIR workshop was finally convened in Accra, March 20 - 30, 1973 to consider how the CSIR could fulfill its mandate to advise the Ghanaian government on science policy and research priorities. CSIR and NAS participants conferred with Ghanaian scientists, government officials, university administrators, and representatives from the private sector.

After examining alternative methods for developing advice on science policy and research priorities, the workshop produced the following recommendations and observations:

1. A new Science and Technology Planning and Analysis Group should be established within the CSIR to help perform the broad science advisory functions specified in Article I, Part 4 of the 1968 decree. The functions, administrative relationships, and operating guidelines for the Planning and Analysis Group (PAG) were defined.

2. The workshop group identified some principles that should influence development of science and technology in Ghana. Those principles recognized a key economic priority: assuring an adequate scientific and tech-

nological infrastructure to support the aspects of industry and agriculture in Ghana that can compete in the world market, thereby generating foreign exchange and supporting the areas essential to Ghana's general agricultural, industrial, health, and social development.

3. The CSIR should consider a number of key areas related to development objectives and needs when setting priorities for special studies; these areas included agriculture, industry, education, computer utilization, and the environment.

Following these activities, an ad hoc committee of the CSIR-NAS program met in Washington, D.C. July 1 - 3, 1974. The group reviewed the progress on previous activities and agreed on the need to create an ad hoc joint study group to meet in Ghana around October 1973 to assess the present and potential impact of drought on agricultural and rural development in northern Ghana. Following the July meeting, the CSIR and the AID mission to Ghana agreed to undertake an assessment which was conducted by AID with the assistance of the University of Arizona.

In October 1975, a past member of the NAS committee and an NAS staff officer visited Ghana to discuss the next steps to be taken in the cooperative program between NAS and CSIR under the Development Applications of Science and Technology Project. The chairman of the CSIR suggested a number of specific joint CSIR-NAS studies for consideration in the context of the future collaborative program.

It was agreed that the first priority would be "Alternative Approaches to Funding and Managing Cooperative Research in Ghana." A proposal was submitted to AID/Africa Bureau for program costs to carry out that study as well as several other priority areas in Ghanaian development under the science project. It was anticipated that the first study would be held in July 1976 in Ghana.

At the same time, the CSIR was in touch with BOSTID regarding a study on scientific and technical information needs in Ghana. BOSTID and CSIR's Committee on International Scientific and Technical Information have met informally to plan this activity but funding is still uncertain. During the most recent BOSTID staff visit to Ghana (March 1976), the AID mission indicated that this was not among their top priority interests; however, AID/Washington, NSF, and other national and international agencies have indicated an interest in this project.

Both the mission and the CSIR expressed the hope that the NAS could arrange for an appropriate individual to visit Ghana at an early date for further consultations on the operations of the PAG and the study of alternative approaches to funding and managing cooperative research in Ghana. Recruitment of staff for the PAG has been slower than hoped but a nucleus now exists. The functioning of this unit is the most important current activity. The funding and management study will be rescheduled appropriately depending on the progress of these consultative discussions.

In June 1977, a BOSTID staff member visited Accra to firm up plans for the CSIR-NAS study on the funding and management of science. The study was scheduled to be held in June 1978, in Accra. The objectives of the study were:

-- to explore the present ways of means of funding and managing science in Ghana;

-- to consider and compare means of funding and managing science in three other countries representative of low, middle, and high-income countries;

-- to consider and devis]alternative systems of funding and managing science in Ghana; and

-- to make recommendations for a feasible system in Ghana.

At the request of the CSIR, the program has been temporarily postponed.

IVORY COAST

The National Academy of Sciences has had cordial relations with Ivorian officials since 1968 when the NAS and the Ivory Coast Ministry of Agriculture sponsored a conference in Abidjan on Agricultural Research Priorities for Economic Development in Africa. However, since the Ivory Coast is a former French colony, it has been looking mainly to France for technical assistance, and until recently, the scientific and technological agencies in the country, which are predominantly branches of French overseas research institutes for the various export crops, were staffed at the senior level by expatriates.

Recently, the Ivorian Government created a Ministry of Scientific Research, and contact has been made with the Directeur du Cabinet, M. Gabriel Lahoury, who has expressed interest in collaboration with the NAS. As of yet no specific activity is planned.

KENYA

During a study tour of the American national parks in early 1975, a team of trustees of the Kenya National Parks (KNP) initiated discussion with a number of U.S. colleagues and scientists about research needs for the scientific management of national parks in Kenya. As a result of these discussions and in view of the keen interest of U.S. scientists in cooperating with their Kenyan colleagues in executing this scientific approach to conservation in Africa, the chairman of the Kenya National Parks Board of Trustees formally requested BOSTID's help in convening an International Study Workshop (ISW) to produce major policy guidelines for proper scientific management of the national parks of Kenya. Subsequent to this request, a BOSTID staff member visited Nairobi in October 1975 and met with the KNP Trustees and AID and U.N. Environment Programme (UNEP) officials. These discussions resulted in a recommendation to expand the proposed cooperation to include a follow-up phase to the ISW.

The ISW, which was planned for Nairobi in 1976, had the following objectives:

1. to formulate ways and means of establishing a functional research device for National Parks and Reserves of Kenya as a model for their park systems of developing countries;

2. to discuss and formulate guidelines for identifying suitable research topics that should be given priority attention in National Parks and Reserves; and

3. to discuss ways of establishing mechanisms for determing external and internal excesses and strains experienced by National Parks and Reserves of Kenya and to formulate ways and means to absorb or dissipate both.

A proposal to UNEP for funding for these activities was submitted, but action on it was deferred due to a shortfall of funds. It was hoped funding would be available to hold the ISW before the end of 1976.

In the summer of 1977, Dr. Odhiambo, president of the newly reorganized Wildlife Fund Trustees, informed NAS that they would again like to pursue the possibility of a workshop on research needs for the parks system, with a possible rescheduling in November 1977. Details of the workshop were refined during BOSTID staff visits in August 1977; however, it became apparent that UNEP might have difficulty in making a grant to the NAS.

BOSTID was subsequently informed that UNEP was unable to support the Academy's participation; however, the workshop was held as scheduled without NAS participation.

LIBERIA

Encouraged by the U.S. Embassy in Liberia and AID's Africa Bureau, BOSTID staff members visited Monrovia in late 1975 and early 1976 for discussions with officials of the Liberian government and AID regarding possibilities for a BOSTID program there. Liberian officials expressed great interest in BOSTID's overseas programs and asked BOSTID to consider the possibility of convening a workshop in Monrovia in 1976. Liberia is producing its first four-year national development plan. Liberian officials recognized that several areas of the plan require scientific and technical inputs that are not yet clearly defined. They hope that the workshop program might provide advice on these inputs, particularly in agricultural research since agricultural development is the highest national priority. A formal request for a workshop on the organization and management of agricultural research, to be convened jointly with the Liberian Agricultural Research Council, was expected.

BOSTID finally received copies of Liberia's four-year national development plan. Following a staff visit to Monrovia in June 1977, NAS Foreign Secretary, Dr. George Hammond, received an official request for a joint workshop. The objectives of the workshop are:

-- to explore the potential benefits of science and technology in increasing the standard of living in the rural and urban areas;

-- to discuss new and old methodologies for delivering science and technology to rural people;

-- to identify short- and long-term science and technology research priorities;

-- to discuss the feasibility of introducing an SA/OR capability for development planning; and

-- to discuss the needs and objectives of manpower training in science and technology in Liberia and consider methods for attracting trained Liberians back to Liberia.

The workshop was tentatively scheduled to be held in Monrovia in the summer of 1978.

MOROCCO

In the spring of 1972, a BOSTID staff member visited Rabat with the director of the Office of Science and Technology (OST) of AID to explore the potential of a cooperative program with the scientific group within Morocco. Discussions were held with AID staff and Moroccan officials, and several visits were made to Moroccan institutions. The possibility of an NAS science policy workshop was discussed at length. It was agreed that the AID mission and the Moroccans would be in touch with OST and/or BOSTID regarding their desires; however, no further word has been received.

NIGERIA

In February 1965, members of the Africa Science Board visited several

African countries to establish closer ties with African colleagues. Discussions in Nigeria concerned science organization and policy matters in relation to pending legislation before the Nigerian Parliament that called for the creation of a National Research Council and an Academy of Sciences. Nigerian scientists were especially interested in the NAS experience with government, industry, and academic institutions. Further meetings on these questions were proposed.

Following the visit to Nigeria, the Africa Science Board and staff encouraged Nigerian participation in such programs as the Upper Mantle Project and the International Biological Program, sponsored a panel discussion, "Science Research Opportunities in Nigeria," at the meeting of the African Studies Association, and attempted to recruit a science policy advisor for Nigeria under UNESCO auspices. The Board also arranged for preliminary studies of ecological changes and resettlement resulting from construction of the Kainji Dam.

The first U.S.-Nigerian science workshop was held in August 1965 at the conference center of the Rockefeller Foundation in Bellagio, Italy. The Africa Science Board and an ad hoc group of Nigerian scientists, university heads, and economic planners met to consider which elements of a science policy for Nigeria would bear on the country's economic development and on the organization of scientific and technological research by the proposed Research Council and Academy of Sciences. Discussions centered around: (1) training of scientific personnel, (2) division of labor between universities and applied research institutes, (3) public health aspects of economic development, (4) natural resources, (5) economic planning and the use of data from agricultural research, (6) priorities and international cooperation, and (7) contributions of academies and research councils to economic development.

Subsequently, two military coups and a prolonged civil war made it difficult to proceed with a program. However, BOSTID maintained contact through correspondence and periodic visits with members of the Nigerian scientific community and the AID mission in Lagos. It appeared to the BOSTID staff that the national science policy, coordination, and funding structure by then put in place had not yet come to maturity. Consequently, there is a reluctance to engage in formal bilateral activity involving national science policy issues with U.S. institutions. This situation was further complicated by the policy decision of the U.S. Congress to reduce technical assistance to members of the Organization of Petroleum Exporting Countries (OPEC). As a result, the AID program in Nigeria is being phased out. However, informal contact has been maintained with Nigerian scientists, including a staff visit in October 1975. BOSTID has been approached informally by the University of Ibadan regarding the possibility of arranging a collaborative program to strengthen postgraduate research and teaching in areas of chemistry related to national development priorities--petrochemicals and natural products chemistry. Discussions are continuing about a possible cooperative program, although no particular project can be identified until questions of Nigerian sponsorship can be worked out. The Science Association of Nigeria, a private organization, is being reorganized into a National Academy of Sciences, with which a cooperative program could possibly be undertaken.

SENEGAL

In early 1975, BOSTID staff participated in two regional meetings (the "Nianing Dialogue" on the Sahel and the Second General Conference of the Association for the Advancement of Agricultural Sciences in Africa) held in Senegal. This participation provided an opportunity for informal contact and discussions with Senegalese officials regarding possible collaboration with BOSTID. A Delegation General for Scientific and Technical Research was recently established, and problems of water resource management and long-term improvement of the fertility of irrigated soils have been discussed as potential subjects for joint discussions with the NAS. No specific activity is planned as yet, however.

SUDAN

Visits by officials of the Sudanese National Council for Research to Washington and subsequent visits by NAS staff to Khartoum in 1972 and 1973 fostered the interest of the Sudanese Council, the NAS, and the AID representative in Khartoum in a collaborative relationship between Sudanese and U.S. science institutions. As a result of the serious drought problems affecting the Sudan during the past few years, the first activity discussed was a workshop that would provide AID and Sudanese authorities with recommendations regarding natural resource development and environmental stabilization.

The workshop, initially scheduled to be held in Khartoum the end of 1973, was later scheduled for 1974; however, as a result of political considerations, the meeting had to be delayed both times.

In addition, in early 1974 the U.S. ambassador to Khartoum, William O. Brewer, visited the NAS and expressed interest in the possibility of convening a workshop in Sudan on aquatic weeds, a major problem there. Due to conflict of political priorities, Ambassador Brewer was subsequently recalled to the United States and this topic too was shelved. However, in November 1974, the NAS received a copy of an official request sent to Ambassador Brewer, who by then had returned to Khartoum, requesting a workshop on aquatic weeds. Shortly thereafter, a formal request for a joint activity was sent directly to the Academy.

A later staff visit resulted in agreement to organize the workshop as a regional working group meeting with major participation of Sudanese, Egyptian, Federal German, and U.S. scientists, and representatives from countries adjacent to the Sudan.

The Regional Workshop on Aquatic Weed Management and Utilization in the Nile Basin was held in Khartoum November 24-29, 1975. In addition to Sudanese and U.S. representation, participants also came from Egypt, Ethiopia, Mozambique, and Indonesia, as well as the Federal German Republic which already cooperates with the Sudan in the Sudanese-German Water Hyacinth Control Project. The objective of the workshop was to undertake a review of the aquatic weed situation in the Sudan. Although particular emphasis was placed on the water hyacinth, the workshop considered other weeds as well. Recommendations regarding existing control measures and additional alternative techniques that might be effectively applied to weed control, management, and utilization in the short and long term were formulated.

Specific recommendations of the workshop included:

1. Introduction, under controlled quarantine conditions for screening, of the water hyacinth weevil (a specific biological control agent from Latin America now being released in Florida).

2. Introduction of grass carp and spikerushes for biological control of other aquatic weeds in irrigation canals.

3. Introduction of the water buffalo (from Egypt).

4. Adaptation for Sudanese conditions of harvesting equipment (being acquired from the U.S. by the Sudanese-German Water Hyacinth Control Project) and research into use of the harvested weed for a human food supplement, animal feeding (after ensilage), and compost and biogas fermentation.

5. Promulgation of regulations controlling the introduction to or movement of aquatic plants within the Sudan.

Follow-up visits by several of the NAS panelists have taken place to assist the Sudanese with implementation of the recommendations. Reports have been received from officials at the University of Khartoum regarding the successful breeding of water hyacinth weevils under quarantine in Khartoum.

In the fall 1976, a BOSTID staff member participated in a seminar on Sudanese development arranged for AID and the Department of State by Development Alternatives, Inc., to obtain information from a number of organizations, including BOSTID, that have recently had projects in the Sudan. This meeting was organized to assist AID and the State Department prepare for a resumption of AID programs suspended since the assassination of the U.S. ambassador in 1973.

In January 1977, the AID Africa Bureau asked BOSTID to assist them with program planning and identification of priorities. AID has decided that its Sudanese program should include assistance in traditional agriculture, health care delivery, and manpower development. Because of a specific request by President Nimiery that his country be helped "to achieve the benefits of U.S. technology," AID is under considerable pressure to include a "technology" element in its overall program.

In order to define what a "technology program" could and could not reasonably include, BOSTID organized a one-day discussion-seminar at the

NAS in Washington on April 13, 1977. Participants were asked to review current information concerning plans and ongoing development programs under the Sudanese 6-year economic plan. For the purposes of the meeting, the focus was upon natural resource assessment, agricultural R&D needs, agro-industrial strategies, energy needs, and major environment-development problems in the Sudan. Among the principal points presented by participants were:

1. Manpower resources. A critical factor for the success of Sudanese development will be manpower availibility. Although it is true that the University of Khartoum has a long history of producing qualified scientists and engineers, the outflow of trained personnel from the Sudan to oil-producing Arab countries is so great that manpower for Sudanese development programs is already in short supply. In terms of stemming the "brain drain," both a program of incentives for Sudanese to remain at home and the employment of expatriates will be required.

2. Natural resources. Considerable data on water and mineral resources are available in the Sudan, but they are scattered in various ministries and departments of the government and are believed to be of uneven reliability. A major effort needs to be made to bring these data together and to plan further programs of resource assessment. If the techniques of remote sensing are properly used, they may have very great utility both for short- and long-term development planning.

3. Agricultural R&D. There are agricultural research stations in most of the ecological regions of the Sudan. There is not, however, a coherent agricultural R&D policy nor good communications among the various stations. Improvement in agricultural R&D is currently under study by the International Agricultural Development Service. The Sudanese government appears to be assigning high priority to the policy planning and program management of agricultural R&D.

4. Agro-industries strategies. Information available on agro-industries is meager. A World Bank agricultural team was scheduled to visit the Sudan in May 1977, partially to study possibilities for agricultural processing and the enhancement of products for export markets.

5. Development of the environment. In their rush to modernize their infrastructure in the agricultural and industrial sectors, the Sudanese appear to be overlooking the environmental aspects of development. They need assistance in planning and evaluation, but the initiative cannot be imposed from the outside.

A BOSTID staff member visited Khartoum April 27 - May 5, 1977 for further discussions on a future BOSTID program. Following the recommendations that arose during the discussion-seminar, and further conversations with senior AID officials in both Washington and Khartoum, discussions with Sudanese officials were focused on the conceptual framework of a proposed science and technology project concerned not only with technology transfer but with the use of technology and the planning and mangement of technology choices for achieving development objectives. Areas of technology transfer discussed included remote sensing for natural resources and other purposes, energy supply, water resource management, and scientific and technological manpower training.

Canal weed management was identified as a priority problem for which the Sudanese would appreciate U.S. assistance. In view of the well-developed linkages between the research organizations the the Ministry of Irrigation, a team of specialists was scheduled to visit Sudan in the fall without waiting for the planning and management workshop.

TANZANIA

In response to an inquiry about BOSTID from Dr. Wilbert Chagula, Tanzanian minister of economic planning, Dr. Djerassi (chairman of BOSTID) visited Dar-es-Salaam in early 1974 to discuss the possibility of a collaborative program. Dr. Chagula suggested two problems for possible oration with the NAS: documentation for applied science, particularly the biological sciences; and standards and norms.

In October 1975, a BOSTID staff member visited Tanzania and met with Dr. Chagula, the president of the Tanzania National Scientific Research Council (UTAFITI), and AID officials. Dr. Chagula expressed his continued interest in cooperation with NAS, reemphasizing his interest in a workshop concerned with technical information initially focusing on agriculture, medicine, and engineering. He also suggested that a workshop/seminar on solar energy be convened.

The workshop/seminar was held in Dar-es-Salaam on August 11-19, 1977, and was jointly sponsored by UTAFITI and NAS. Its purposes were to (1) review the state-of-the-art of small-scale solar energy devices, including both the technical and economic aspects of their use; and (2) suggest short- and long-range projects using solar devices in the villages, with particular emphasis on implementation.

Among the recommendations endorsed by the workshop was the establishment of a Solar Energy for Villages Pilot Project under UTAFITI. It was suggested that UTAFITI, in planning, implementing, and evaluating the project, work with the Ministry of Water, Energy and Minerals, the Prime Minister's Office of Regional and District Authorities, and any other relevant institutions. In addition, it was proposed that UTAFITI undertake an inventory of the institutions and individuals having particular interest in and/or related to solar energy and other alternative energy systems, and that it also establish a Solar Energy Promotion Committee, under its direction, to ensure that the workshop's recommendations were brought before the government and to prepare for the launching of the pilot project should it be endorsed by the government.

Several technologies were singled out for use in the pilot project, based principally on cost-effectiveness, availability of resources, and long-range power requirements of villagers. They were: photovoltaic electricity generation, biogas generation, small-scale hydroelectric generation, and solar refrigeration and drying for food and/or crop preservation. Other recommendations of the workshop dealt largely with the specifics of launching and operating the pilot project.

ZAIRE*

In late 1968, a scientific delegation from the Congo, visiting the NAS on a mission to study U.S. science policy organization, expressed an interest in cooperative relations with the Academy. The NAS was unable to take action until January 1970, when a staff officer visited Kinshasa. Several staff visits followed during the course of 1970, leading to an agreement in January 1971 with the Office Nationale de la Recherche et du Developpement (ONRD) for a joint workshop, which took place in Kinshasa in June 1971.

The workshop, "Science and Technology in the Economic Development of the Congo in the Seventies," examined science policy and economic development, natural resources, human resources, agriculture, and food and nutrition. Bilateral activities recommended by the workshop included joint study groups on (1) agricultural economics, (2) demography, (3) earth sciences, (4) a primate center in the Congo for the breeding and study of dwarf chimpanzees, and (5) food and nutrition.

Four months after the workshop, the ONRD established under its auspices a center for research on food and nutrition. In December, Ansley Coale, chairman of the prospective NAS panel for a joint study group on demography; John Maxwell, earth sciences chairman; and Ray Pariser, the workshop member particularly concerned with the nutrition recommendations, visited Kinshasa to make arrangements and formulate the terms of reference for future activity in these three areas. In the area of nutrition, Mr. Pariser formulated a program designed to assist the new Zaire research center partly through periodic visits of an advisory group, and partly through a telex connection with his department at the Massachusetts Institute of Technology (MIT) that would permit prompt communication for information on technical questions.

The NAS did not take further action on agricultural economics because negotiations were in progress between Michigan State University, AID, and the Government of Zaire for a project to establish an economic research unit in the Zaire Ministry of Agriculture and a training program within the national University of Zaire.

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* The name of the Democratic Republic of the Congo was officially changed to Zaire in late 1971.

Demographic Training and Research in Zaire

The major recommendation of the joint study group on Demographic Training and Research in Zaire, which met in December 1971, has been implemented. A proposal submitted by the National University of Zaire to the Population Council, Inc., of New York for assistance in strengthening the demographic research and training capabilities of the university resulted in a $75,000 grant for one year to permit the university to undertake a thorough planning effort for long-term development of a department of demography. The initial grant provided for the services of two expatriate advisors and the award of two fellowships to qualified Zairian candidates for advanced training in demography at institutions abroad. The board of the Population Council has approved, in principle, a five-year follow-up project to provide expatriate leaders with fellowships, and an expanded teaching and research program, budgeted at $300,000-$500,000.

Earth Sciences

Dr. John C. Maxwell, then chairman of the NAS Division of Earth Sciences, visited Zaire in December 1971. He discussed with ONRD counterparts the scope, timing, objective, and panel membership of the projected joint study. Following his visit, a meeting of U.S. scientists and Zairian scientists and government administrators took place in Kinshasa July 20 - August 1, 1972 to carry out the work program agreed upon by the two parties. The NAS panel of six specialists, accompanied by several Zairian counterparts, traveled in Zaire for one week to gain firsthand knowledge of the principal training and research facilities in the earth sciences and of the major mineral exploitation projects. The report of the joint study group considered the present state of the geological and mining professions in Zaire. It recommends increasing the number and quality of professionals, and suggests mechanisms for increasing the effectiveness of geological work, especially in the minerals industry. The report emphasizes that to assure itself of a continued and increased income from its mineral and energy resources, Zaire must formulate long-range plans for their systematic discovery and development. Such plans should include a coordinated program of topographic, geologic, and hydrologic mapping. In conjunction with the mapping, research studies should be designed to accumulate the basic scientific data needed by government and industry to find and exploit mineral, water, and energy resources and to collect the geologic and hydrologic data necessary for the construction and engineering groups engaged in developing the country.

To implement a comprehensive program in mineral prospection, evaluation, and exploitation, the joint study group also recommended the formation of a national company composed of the best qualified Zairian geologists, mining engineers, and metallurgists to plan and oversee a program for developing the country's mineral, water, and energy resources.

With respect to local training of specialized manpower, the joint study group noted the need for (1) better coordination of the curricula of the various institutes, (2) greater flexibility for the student in choosing his courses within his individual academic program, (3) better use of existing teaching personnel, (4) closer coordination of the present academic time schedules to permit students to avail themselves of existing programs of the institutions, and (5) opportunities for on-the-job training in government service and in private mining and petroleum industries. The report also discussed the need for better use of available teaching equipment and identified critical deficiencies in equipment, library facilities, and other material essential to an effective program for instruction and training.

Primate Center for the Breeding and Study of Dwarf Chimpanzees

The NAS panel of the Zaire primate project, under the chairmanship of Dr. Carl Djerassi, spent a week in Kinshasa and Mabala (site of the Institute for Scientific Research in Central Africa (IRSAC) satellite station on Lake Tumba, Equateur Province) April 16 - 22, 1972 to discuss with Zairois counterparts the feasibility and plans for establishing a dwarf chimpanzee (Pan paniscus) breeding colony. The discussions concluded with the formulation of an 18-month operations plan, which constitutes the first phase of what might ultimately develop into an international primate research center. The first phase effort consisted of field census and behavioral studies, capture of some 20 specimens, initial breeding efforts in captive but natural conditions, and concurrent intensive biomedical testing. The effort was expected to produce extremely valuable information on a primate species about which virtually nothing is known. If results obtained during this period proved favorable, a decision would be made whether to continue the breeding effort on a larger, more systematic basis.

As a consequence of various delays caused by personnel changes in Zaire, the dwarf chimpanzee project remained in abeyance until early 1974, when certain changes in the projected sequence of operations were agreed to by both sides. Before engaging in the costly field census and breeding activity, IRSAC and NAS (on behalf of the Yerkes Regional Primate Center, Atlanta, which was to have operational responsibility for the project) decided that preliminary studies should be undertaken on a pair of chimpanzees at Yerkes to confirm the suitability of the animal as a model for a broad variety of biomedical and behavioral research needs. The animals were captured in February 1975 and transferred the following month to Yerkes. Funds for the capture operation and related expenses, as well as for the training of two Zairois veterinary technicians at Yerkes, were obtained from the National Institutes of Health (NIH), Office of Naval Research (ONR), pharmaceutical companies, and private foundations (one technician from Zaire has successfully completed a training program at Yerkes and returned to Zaire).

The expectation is that, on the basis of the Yerkes findings, financial support from U.S. and other sources will be obtainable to allow continuation of the project along the lines initially projected, i.e., (1) establishment of a breeding colony in Zaire; and (2) if successful, creation of an international center of scientific research patterned on the model of the International Centre of Insect Physiology and Ecology (ICIPE), Nairobi.

Like ICIPE, the proposed Zaire center would provide an atmosphere of scientific excellence that would draw distinguished talent from research centers abroad and provide means for collaboration with and the training of African scientists in a broad range of biomedical disciplines. It is hoped the center will be of particular value for the study of reproductive physiology and effects of future birth control agents using primates such as the dwarf chimpanzee as experimental models.

Future Activities

In the course of a major program development visit to Africa in early 1976 BOSTID staff were welcomed most cordially by officials of the recently reorganized Institut National de Recherches, who expressed determination to resume cooperative activities with BOSTID. Discussions, which included working discussions with senior ministers, focused on a wide range of areas of potential collaboration. Agreement was reached in principle to convene a joint steering group later in 1976 which would focus on priority areas in which science and technology can contribute to increasing and improving agricultural and food crop production. These areas have been tentatively identified to include: food technology, agricultural diversification, food losses, water and energy, and scientific information and training needs.

The joint committee meeting to formulate a program of collaboration between BOSTID and the Zairian Institut de Recherche Scientifique (IRS) was held in Lwiro, November 23-27, 1976. A small BOSTID panel spent 10 days visiting Zairian institutions and discussion research needs to stimulate agricultural production and rural development. A planned three-day workshop session was curtailed because of local travel problems, but the group was able to agree on a list of subject areas of potential future collaboration between NAS/NRC and IRS study groups. These areas include:

1. creation of a rural sector data bank;

2. extension service oriented to integrated rural development;

3. comparative study of past and current Zairian rural development models;

4. comparative study of tropical agricultural research and teaching systems;

5. policy formulation for science and technology oriented to rural development;

6. research structure, organization, and management;

7. conservation and storage of selected Zairian food commodities;

8. small-scale water management;

9. renewable energy resources.

Follow-up will depend on the degree of priority and interest attached to these problem areas by Zairian and AID officials as well as the political situation. The size of the country and scale of its problems, together with the severely limited scientific and administrative manpower resources, render Zaire a major challenge and present particular difficulties for BOSTID's style of collaboration.

Asia

AFGHANISTAN

Following a staff visit to Kabul in February 1973, the NAS was asked by the AID mission and officials of the Afghan Ministry of Agriculture to convene a joint workshop on agricultural research priorities with particular reference to research on crop diversification, marketing, and food processing.

The main purpose of the workshop was to provide AID and Afghan authorities with recommendations on agricultural research related to economic development. Specifically, the workshop was to address:

1. policy decisions concerning agricultural planning, research priorities, and management;

2. improvement of linkages and communication between the senior Afghan government officials and members of Kabul University charged with improving agriculture;

3. management of agricultural research and development within the Ministry of Agriculture and Irrigation and the university;

4. ways of making agricultural research more relevant to improved production and marketing.

Before the workshop could take place, however, there was a change of government in Afghanistan. Discussions with newly appointed officials indicated continued interest in holding such a workshop; and yet no official request was received. BOSTID plans to have a staff member visit Kabul at the next appropriate occasion.

BANGLADESH

In 1974, the BOSTID staff director visited Bangladesh to determine the possibility of a collaborative program. Bengali scientists expressed interest in any type of assistance BOSTID could provide. A letter was received subsequently from a member of the Secretariat of the Bangladesh Council of Scientific and Industrial Research requesting collaboration between the two institutions.

More recently, as a result of conversations held at the January 1976 Pugwash Conference in Madras, a letter was received from the vice president of the Bangladesh Academy of Science requesting a cooperative workshop on science policy for Bangladesh. The Bangladesh Academy, through their government, plans to approach the AID mission for support and will keep BOSTID informed of the results. A BOSTID staff member visited Cadda in early 1978 for further discussions. No specific activity is planned at this time.

BURMA

During the BOSTID staff director's visit to Burma in September 1974, discussions with members of the Burmese scientific community and local U.S. Embassy officials indicated considerable interest in future contact and collaboration. However, Burmese political isolationism and the shortage of foreign exchange have so limited the activities of local scientists that it is doubtful that anything productive (other than continuing informal contact) can be done by BOSTID. This contact will be pursued as the opportunity is presented, both for the "intellectual aid" BOSTID may be able to give Burmese colleagues and in the expectation that the level of isolation will be sufficiently reduced in the future to make cooperation possible.

REPUBLIC OF CHINA (TAIWAN)

In October 1963, the president of the Academia Sinica met with the Foreign Secretary and members of the Pacific Science Board and requested NAS support in planning the development of science and technology in Taiwan. The first joint meeting sponsored by the two academies was held in Taipei in April 1964 to define areas of mutual interest. At this meeting, the two academies agreed to form a Sino-American Science Cooperation Committee to recommend programs in areas of science relevant to Taiwan's socioeconomic development. Since AID was phasing out its program in Taiwan, support for NAS participation had to be obtained elsewhere, namely from the Asia and Ford foundations, with supplementary support from the National Science Foundation, the Smithsonian Institution, and the Department of State.

The two major topics covered at the first workshop were (1) science policy, (2) scientific personnel and graduate training, (3) marine resources, and (4) medical sciences. In considering cooperative programs, the Chinese expressed a desire to include the social sciences and the humanities, as well as science and engineering. A major problem of the Chinese was the "brain drain," caused in part by the lack of adequate graduate training facilities in Taiwan. In addressing this critical problem, the workshop recommended the following priorities for immediate action: (1) making an inventory of ongoing research projects and research personnel, (2) establishing institutional cooperation between Chinese and U.S. universities and research institutes, (3) establishing well-equipped and competently staffed research centers in Taiwan, (4) developing closer collaboration between research institutes and industries in Taiwan, and (5) continuously appraising high-priority research targets important to economic development in Taiwan.

Shortly after the first workshop, the Chinese took several steps to follow through on these recommendations. In 1964, to establish institutional ties, Chinese representatives interested in atomic energy, building research, marine sciences, and manpower studies visited counterpart institutions in the United States.

Soon after the first meeting, the Academia Sinica asked the NAS to send a science policy advisor to Taipei. Joseph B. Platt, a physicist and president of Harvey Mudd College, spent several weeks in Taiwan in 1964 reviewing governmental policy structures and graduate education in the sciences. The recommendations submitted to the Premier of the Republic of China by Dr. Platt and his Chinese colleagues were instrumental in modifying science policy mechanisms within the government. For example, in 1967 the National Science Council was created to replace the National Council on Science and Development, and the Committee for Science Development was formed within the National Security Council.

Graduate Education and Research

In an effort to stem the "brain drain" and to improve facilities for graduate education and research in Taiwan, shortly after the 1964 meeting the Chinese conducted a survey on scientific personnel in some 40 institutions. The NAS, for its part, compiled through its Office of Scientific Personnel a roster of Chinese scientists and engineers in the United States. This roster ultimately helped the Chinese recruit scholars for the graduate research centers created in 1965 for agriculture, chemistry, physics, biology, mathematics, and engineering. The Chinese appropriated over US $3 million for four years for the centers, created special chairs at the universities, and increased salaries to draw scholars for short-term and long-term appointments. The effort to improve graduate education was further strengthened by the intergovernmental Sino-American agreement signed in early 1969. This agreement, administered by the National Science Council of Taiwan and the U.S. National Science Foundation, provided for the exchange of scientific and technical information and personnel and the support of cooperative research projects.

Between 1964 and 1971, six joint Sino-American workshops were held alternately in the United States and Taiwan. In addition to the tasks already meantioned, the Chinese have systematically undertaken programs in marine sciences, industrial research, scientific and technical information, and the social sciences and humanities--all of which have been the subject of discussion at the bilateral meetings.

Marine Biology and Oceanography

Participants in the first and second workshops presented proposals for cooperative research in marine biology and the creation of an institute of oceanography. A program in oceanography was later developed through the cooperative efforts of Y. S. Tsiang of the Joint Commission on Rural Reconstruction, Burr Steinbach of the Woods Hole Oceanographic Institution, and I. E. Wallen of the Smithsonian Institution. The Institue of Oceanography was created in 1968 at the National Taiwan University, and the following year a U.S. ship was procured for research and training purposed on a lend-lease basis. A subsequent Sino-American meeting in May 1971 focused on ocean resources. The major recommendation of the meeting was the creation of a National Commission on Marine Sciences to serve as a coordinating and policymaking body.

Industrial Research

Industrial research was the focus of a major workshop sponsored by the Academia Sinica and the NAS in 1968. The meeting was attended by approximately 40 Chinese scientists, industrialists, and government officials, including the vice-president of the Republic and the ministers of economic affairs and education. NAS participants were selected from leading industries, laboratories, and other institutions representing sectors and activities of interest to the Chinese. Workshop recommendations were made on R&D aspects of food technology, textiles, chemicals and plastics, electronics, metals, and energy needs. A committee was formed by the National Science Council and the Executive Yuan to oversee implementation of some of the proposed actions. A special committee for marketing research and management was established by the China Productivity and Trade Center, and two high-level groups made a four-week tour of the United States to study business and industrial management. Specific institutions were designed to implement such recommendations as the development of the Hsinchu Industrial Research Park, the transfer of technology to medium and small industries, and the translation of textbooks for graduate education.

The Chinese have reported that allocations for the support of scientific research and development from the Government of Taiwan have increased substantially since 1964 to the present level of about 2 percent of the gross national product. Numerous institutional ties have been established between Chinese and U.S. universities and institutes in both the private and public sectors. The graduate research centers have awarded several hundred masters degrees in the sciences and a few doctorates in physics and engineering. The establishment of a Science Documentation and Instrumentation Center was undertaken by the Chinese in 1970.

Scientific and Technical Information

With funds made available from the International Foundation, a workshop on "Scientific and Technical Information Needs and Resources in the Republic of China" was held in Washington, April 25-27, 1973. The workshop addressed a number of areas relevant to the development of an effective national scientific and technical information system, including: national policies for scientific and technical information; manpower and educational needs; information technologies; scientific and technical information systems and services; aspects of the information systems design and use; and bilateral, regional, and international cooperation in the development of scientific and technical information systems.

Industrial Innovation and Product Development

A workshop on "Industrial Innovation and Product Development" was held in Taipei, August 11-18, 1975. The past industrial history of Taiwan involved the production of such items as shoes and television sets. In each case, the product is made on assembly lines that are either purchased outright from other countries such as the United States, Japan, and West Germany and set up under license, or actually set up and managed by subsidiaries of foreign companies. Rarely does the product involve Chinese development of Chinese-owned patents.

The purpose of the workshop was to consider possible directions in product development and innovation for three of Taiwan's important industries--electronics, petrochemicals, and machine tools. Participation by the Chinese included representatives of many private companies, as well as government research institutes, universities, and appropriate government agencies; NAS participants had significant practical industrial experience.

The workshop generated interest at the highest levels of the national government. Premier Chiang spent nearly an hour with the NAS participants getting their views on Taiwan's industrial opportunities and problems. The minister of economic affairs and the chairman of the National Science Council have been active in pursuing the workshop recommendations and subcommittees on the implementation of recommendations for different industries have been established.

Science Industry Park

At the request of the National Science Council, a BOSTID advisory team visited Taiwan January 17-26, 1977 to make recommendations on a proposal for a new "science industry park." The park (which the team feels might better be called an industry technology park) is designed to attract more technologically sophisticated industries to Taiwan, thereby helping create not only a sound economic investment but also a growth of local capabilities in some new areas of technology.

The advisory team reviewed the overall concept of the park, made recommendations on two possible sites, investigated the possibilites of fruitful interaction between existing universities and research institutes with possible new industries, and considered possible financial and administrative incentives that might facilitate investment in the park.

Regional Land-Use Planning

A workshop on regional land-use planning was held in Taipei, January 5-12, 1978.

The island of Taiwan presents complex and challenging land-use problems. Because much of the mountainous central portion of the island is not suited for agriculture or other productive uses, Taiwan's population is settled in the densely populated coastal regions. In the past, agriculture was the most important sector of the island's economy, but industrialization and urbanization have been the major trends of the past decade. Consequently, there are many competing demands for the use of land, and effective land-use planning and management are critically important to economic and social development on the island.

The National Science Council (NSC) has been given responsibility for analyzing land-use planning issues and needs in Taiwan and for coordinating more effective ways of addressing these problems. As an important step in analyzing the land-use planning and decision-making process, the NSC requested Academy participation in a workshop on regional land-use planning. The workshop had four major objectives:

1. to examine future land-use requirements in Taiwan;

2. to consider the institutional framework and the decision-making process for land-use planning;

3. to examine the geo-information data base for land-use planning;

4. to discuss the advantages and disadvantages of possible alternatives for future allocation of land in the context of population and development policy, rural land-use policy, and environmental issues.

A panel of 13 persons participated in the workshop on behalf of the Academy, meeting with a Chinese group of approximately 35 participants from government ministries, planning offices, and universities.

The next scheduled activity is the annual meeting of the Sino-American Science Cooperation Committee, to be held in Taiwan in June 1978.

INDIA

Although informal contacts with the Indian scientific community began in the 1950s, the NAS did not establish a relationship with India's principal scientific society, the Indian National Science Academy* (INSA), until 1968. Indian interest in an NAS workshop activity similar to those in other cooperating countries, particularly on industrial research, resulted in the first workshop, "Management and Organization of Industrial Research," held in Baroda in March 1970. The workshop brought together an NAS panel of 10, under the chairmanship of National Academy of Engineering Foreign Secretary

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* Formerly the National Institute of Science of India (NISI)

Bruce Old, and approximately 40 Indian senior research administrators of private or public industries and national laboratories. NAS panelists were R&D vice-presidents of major industries and contract-research organizations. The workshop stimulated Indian participants to recommend the formation of an Indian association for industrial research patterned on the Industrial Research Institute (New York City) or the National Conference on Industrial Research. This recommendation led to the creation of an Indian Planning Committee to form a society to promote better management of applied research laboratories, although the committee disbanded after some months without action.

The second workshop, "Water in Man's Life in India," held in New Delhi in September 1971, considered the interrelationship of water resources and environmental factors. NAS Deputy Foreign Secretary Roger Revelle chaired the NAS panel of 12 specialists in water resources planning, sanitary and environmental engineering, hydrology, and ecology. The following discussion topics were included:

- -- quality of water resources in urban and rural settlements;
- -- economic aspects of clean water supply;
- -- sewage disposal problems;
- -- disposal of industrial effluents;
- -- use of fertilizers and pesticides and their bearing on water pollution;
- -- estuarine pollution and its effect on marine life; and
- -- problems of siltation.

Indian interest in the workshop, due in part to preparations for participation in the U.N. Conference on Human Environment (Stockholm, 1972) and in part to the intrinsic importance of the subject matter, was demonstrated by the participation of over 90 specialists and government officials, including the minister of power and irrigation and the minister for planning. Indications are that the workshop and the informal discussions and consultations between U.S. and Indian scientists had a sizable impact on Indian thinking about problems of the environment; for example, the constructive formal positions of the Indian delegation at the Stockholm conference.

Other bilateral activities projected with INSA included a workshop on National Technology Policy and a visit to Washington. The purpose of the visit was to familiarize the leadership of the Indian Academy with the organization, operations, and advisory relationships of the NAS-NAE-NRC with the federal government and its agencies. It was hoped that this exposure would assist INSA in strengthening its own capabilites to perform similar tasks for the Government of Inda. These events were postponed as a result of the strife in East Pakistan (now Bangladesh), the resultant political tensions between India and the United States, and the termination of the AID program in India.

In January 1974, the U.S. Pugwash Committee (supported by the NAS, with financial sponsorship from several foundations) cosponsored a meeting in Hyderabad with the Indian Pugwash Committee, which brought together leading scientists and technologists from the two countries to examine the future of Indo-U.S. scientific/technical cooperation. The Pugwash Group identified problem areas in agriculture, technology, environment, and energy in which collaboration between Indian and American scientists would be of mutual interest and benefit. The recommendations of the Pugwash Group had significant influence on the deliberations of the Indo-U.S. Joint Subcommission on Science and Technology, which met in Washington, D.C., in January 1975.

In December 1975, a member of the BOSTID staff visited India to look into the possibility of future collaboration between INSA and NAS in the event AID to India resumed. The two academies agreed that joint workshops, symposia, and conferences provided the most appropriate media for their collaboration. They agreed, further, that they would take up subjects not otherwise treated in the collaborative programs involving their countries' scientific and technical agencies, in other words (1) matters of public policy relative to the application of science and technology to development, and (2) scientific advances in which both countries are engaged and that hold the promise of fruitful interaction and potential collaboration.

In this regard, the two academies tentatively identified the following subject areas as candidates for joint activity with the understanding that actual selection of topics, to be done at a later date, would be subject to further refinement of the areas indicated, determination of their order of priority, and availability of funds:

Development-related science & technology	Basic science
Integrated pest control	Plate tectonics
Water resources management	Radio astronomy
Information systems	
Exploitation of marine resources	
Population and fertility control	
Food losses	

In 1977, INSA asked the NAS to sign a bilateral agreement promoting scientific cooperation between the two academies. Inasmuch as this agreement may appear to be too official in nature and conflict with any government-to-government agreement, discussions are in progress to downgrade the level of signatures.

In addition, with the change of Government in India and the resumption of U.S. aid to India a program development visit by a BOSTID staff to India is being planned for early 1978.

INDOCHINA

In light of political and military developments in Indochina during 1972, the NAS began to consider possibilities for collaboration with local scientists in the postwar period. BOSTID staff members gathered background material and held discussions with a number of people who had expertise on Indochina or were connected with organizations involved with possible postwar development efforts in the region.

Under a special grant from the NAS president's program initiation funds, and not as a part of contractual arrangements with AID, former NAS Foreign Secretary Harrison Brown convened an ad hoc meeting on April 9, 1973 to consider the role of the NAS in the reconstruction and development of Indochina. Participants in the meeting included members of the National Academy of Sciences and the National Academy of Engineering, chairmen of relevant National Research Council committees, and several other individuals with specialized knowledge of social, political, and economic conditions in Indochina. The group discussed the kinds of scientific contacts the NAS should explore in Indochina, along with mechanisms for carrying out the exploration.

The ad hoc group suggested that it would be useful and appropriate to investigate the possibilities of bilateral activities with South Vietnam. When the president of South Vietnam's Scientific Research Council, Professor Le Van Thoi, visited the NAS in April 1973, it was agreed that it would be useful for a BOSTID staff member to visit Saigon on a subsequent Southeast Asian trip. The breakdown of the ceasefire, however, precluded such a visit.

With regard to other program possibilities in the Indochina area, Staff Director Victor Rabinowitch and staff member John Hurley met with an official of AID/Laos in Bangkok on two separate occasions. Discussions were held on the possibility of conducting an NAS study of specific development strategies relating to the abundance of hydroelectric power in Laos. It was agreed that AID/Laos would contact the NAS with a further definition of the problem if they wished to pursue the possibility of a study or workshop.

Events in Indochina have rendered any further initiative by or on behalf of BOSTID impossible.

INDONESIA

In 1946, the NAS Pacific Science Board established relations with the Council of Sciences for Indonesia (MIPI). In 1960, at the request of MIPI, one of its staff officers served as an intern in science administration in the NAS Office of International Relations. Relationships were maintained with MIPI and Indonesian scientists during the latter years of the Sukarno regime when most other U.S. relationships with Indonesia were suspended. The NAS-AID book program, for example, operated without interruption during the entire period of strained U.S.-Indonesian relations.

In 1966, the Indonesian Institute of Sciences (LIPI) replaced MIPI as the primary governmental scientific body. In early 1968, as U.S.-Indonesian relations improved, AID agreed to support NAS participation with LIPI in a joint workshop on food, which was held in May 1968. Following the workshop, several key recommendations were incorporated in Indonesia's First Five-Year Economic Development Plan; the targets recommended for minimum caloric and protein requirements were incorporated into a national nutrition policy. A direct outcome of the workshop was a study conducted by a joint U.S.-Indonesian team of agricultural scientists to formulate a plan for a national agricultural research system, integrating the universities, field stations, and research institutes.

In 1969, the senior LIPI administrative officer came to Washington to serve as an intern with the NAS Office of the Foreign Secretary (OFS) and the Smithsonian Institution while completing a graduate degree in science policy at George Washington University. He returned to Indonesia in 1972 and assumed responsibility for LIPI's science policy studies.

In January 1971, the NAS and LIPI held a workshop in Jakarta, "Industrial and Technological Research." The workshop produced recommendations dealing with research organization and management, technical information, standardization, fiscal incentives, patents, small-industry extension services, and major industrial sectors (such as chemicals, pharmaceuticals, food, textiles, and pulp and paper). As a result of the workshop, the Indonesians initiated a program to improve the management and organization of industrial R&D institutes. They held an intensive management-development course in Indonesia, and two senior R&D administrators visited R&D institutes in the United States, spending seven weeks in one institute and one week each in four others. This experimental program formed the basis for a more extensive training program for Indonesian R&D managers.

In March 1972, representatives of LIPI participated in an NAS regional workshop "Use and Protection of Water Resources in Southeast Asia in Singapore."

The third joint activity, a workshop on natural resources, was held in Jakarta September 11-16, 1972 with the following major objectives:

1. to suggest policies and procedures for strengthening the integrated planning and utilization of natural resources;

2. to suggest scientific and technological inputs relevant and useful to the planning and utilization of natural resources; and

3. to provide a forum for a coordinated and constructive exchange of views by key scientists, policymakers, and administrators concerned with natural resources in Indonesia.

Seven NAS panelists participated in the workshop with about 90 Indonesian panelists and 12 observers from various Southeast Asian and European countries. Five working groups--on land and soil resources, forest resources, water resources, ocean resources, and mineral resources--addressed detailed sectoral problems. Participants also met in plenary sessions to consider overall cross-sectional issues.

The recommendations of the workshop were submitted to the National Development Planning Board (BAPPENAS) for consideration and use in preparation of the Second Five-Year Development Plan (1974-1979). A summary of the conclusions and recommendations was presented to President Suharto and his cabinet ministers responsible for economic and natural resources programs.

There have been a number of interesting follow-up activities since the workshop. In October 1972, President Suharto established a National Committee on the Environment, thereby implementing one of the 10 overall recommendations of the workshop. As a direct result of the workshop, in late 1972 the Indonesian Armed Forces held a meeting on the security aspects of natural resources and presented a report to the Security Council of the Government of Indonesia. With regard to problems of data acquisition and dissemination and the integrated planning of water resources, both important workshop topics, UNESCO advisors went to Indonesia during 1973 to work with BAKOSURTANAL (the survey and mapping agency), the Indonesian National Commission on Water Resources, and the Ministry of Public Works.

Since the workshop, BOSTID staff members have visited Indonesia to discuss further follow-up activities and to explore new project ideas. However, several important changes have taken place in the Indonesian government's scientific structure. Dr. Sarwono Prawirohardijo, chairman of the Indonesian Institute of Sciences, retired in September 1973 and was succeeded by Dr. Bachtiar Rifai, former director-general of the Ministry of Education. About the same time, a new ministerial post--the Minister of State for Research--was created, with responsibility for coordinating all government-supported research. The minister is Dr. Sumitro Djojohadikusomo, former minister of commerce.

While the functional relationships between LIPI and the Ministry of Research were being worked out, no new activities between NAS-NRC and LIPI were carried out. A visit to Indonesia by a staff member of AID's Office of Science and Technology, however, indicated that major program opportunities now exist.

In addition, a science advisor was attached to the AID mission in Jakarta to oversee S&T programs there financed by AID.

A BOSTID staff member visited Jakarta January 24-28, 1977 to discuss possible NAS involvement in a series of workshops in Indonesia over the next several years. Support for BOSTID participation in the workshop would come from a science and technology loan that AID will make to the Indonesian government. In advance of the loan-sponsored workshop program, AID/Indonesia requested BOSTID to organize a workshop on national standards policy, and it was originally scheduled for September 1977. However, this workshop was subsequently postponed indefinitely because of pending ministerial changes in the Indonesian government.

KOREA

The NAS has maintained a program of scientific cooperation with Korea since 1969. In 1969, the anticipated phase-out by 1972 of the U.S. AID program in Korea prompted AID to seek the advice of NAS on actions it should take before that date to ensure Koreans continued access to U.S. technical resources in support of development objectives. Specifically, NAS was asked to identify Korean long-term needs for technical assistance, appropriate mechanisms for the transfer of technical assistance, and cooperative linkages between U.S. and Korean institutions.

A panel of five persons visited Korea in July 1969 and subsequently submitted its report. The panel report advocated the establishment, as a successor to the AID mission in Korea, of the Korean-American Development Institution (KADI), a foundation-type organization to be financially supported by both countries on a long-term basis. The panel recommended that KADI be established as an autonomous, nongovernmental institution with a broad mandate to support cooperative programs and activities that will help Korea achieve balanced economic growth, develop its intellectual and human resources, and further its social and civil modernization.

The panel's recommendations have not been implemented so far because the U.S. government decided to extend the life of the AID mission in Korea for several years. However, the concept of the bilateral foundation-type instrumentality for technical cooperation has received attention, both within and outside AID, as a unique way to achieve technical assistance objectives. A variation of this concept was advocated by the BOSTID ad hoc Committee on the International Development Institute as a central element in its recommendations for the future conduct with officials of the Korean Ministry of Science and Technology (MOST). The panel's purposes were (1) to advise informally on the development of long-range policy for science and technology; (2) to suggest ways to strengthen and improve the governmental structure for science and technology; and (3) to review the organization and functions of research and development institutions and suggest modifications where appropriate. The recommendations of the panel resulted in a number of significant initiatives and changes in the policy and organizational structure of MOST and other scientific and technical institutions.

Korea's minister of science and technology, Dr. Choi Hyung Sup, expressed a strong interest in putting NAS-MOST cooperation on a regular basis. Following visits by BOSTID staff to Seoul in 1973 and by Minister Choi to Washington, agreement was reached on the outlines of a NAS-MOST program of scientific cooperation. A joint continuing committee on scientific cooperation, which meets annually, has been established to address the broad issues of the application of science and technology to Korean development and recommend possible ways to strengthen problem areas. The first three meetings of the committee took place in Korea in 1973 and 1975 and in the United States in 1974. The first meeting laid the groundwork for the science cooperation program and identified energy and marine resources as topics for subsequent workshop activities. The second meeting reviewed progress and discussed the development of a new science town. Korean members expressed interest in obtaining advisory assistance from the committee for overall planning of the science town. During their stay in the United States, the Korean members visited a large number of educational and research institutions. The third meeting reviewed progress of the science town and proposed new advisory activities aimed at (1) the structure and organization of a Korean science foundation, and (2) the development of greater systems analysis capability in Korea.

Seminars on Industrial Energy Conservation
and Solar Space Heating and Cooling

These seminars were held in Korea in November 1974, jointly sponsored by the NAS-NRC and MOST, in conjunction with a number of Korean organizations--the Korean Energy Management Association, the Industrial Advancement Administration of the Ministry of Commerce and Industry, and the Korean Atomic Energy Research Institute (KAERI). A large number of Korean scientists, engineers, businessmen, and government officials participated. Specific conclusions regarding energy conservation included the need for better monitoring of industrial processes, improvement of existing processes and equipment, and training of industrial managers with respect to energy management. Government and industry were urged to collaborate on long-range energy planning, and to establish channels between the United States and Korea for the exchange of information on energy research.

It was agreed that solar space heating has promise of very useful applications in Korea, and that in this regard the research program at KAERI is highly significant. Recommendations were made for future research and for communication and collaboration with research programs both in Korea and elsewhere.

Marine Resources

The new Korea Oceanographic Research and Development Institute (KORDI) has been established and the director and staff are laying plans for a new research facility to be built at Dae Duk Science Town. In late 1974, a two-man NAS-NRC team visited Korea to explore ways in which the MOST-NAS Joint Committee might help strengthen marine sciences research and education in the future. Their recommendations currently are under consideration by MOST.

Science Town

In April 1975, a two-man NAS advisory team visited Korea for preliminary discussions of planning and development for Dae Duk Science Town. Their observations and recommendations were submitted to MOST. As a result of joint discussions on Dae Duk, the planner of the science town made a two-month visit in 1976 to research facilities and new towns throughout the United States.

Third Annual Meeting

The annual meeting of the Korea-U.S. Joint Continuing Committee for Scientific Cooperation was held October 10-11, 1975 in Seoul, Korea. It was agreed that there is an urgent need to create new mechanisms to stimulate and support scientific and technological research in Korea, and that one important mechanism is the establishment of a national science foundation in Korea. Since U.S. AID technical assistance to Korea will greatly diminish or cease in the near future, it is also deemed essential that scientific and technological interchange with the United States be continued in some manner. While some of these relationships can take place through a Korean science foundation, a variety of other institutional and individual activities must be developed and supported. In addition, the Joint Committee agreed on the importance of maintaining an active interest in future advisory activities in the development of Dae Duk Science Town and its individual research institutes, in marine sciences research and education, and in the systems analysis work of the new Bureau of Information Industry in the Ministry of Science and Technology. Emphasis was placed on the importance of forming collaborative linkages between these new institutions in Korea and appropriate institutions in the United States and elsewhere.

Korea Science and Engineering Foundation

As a result of the third annual meeting, NAS and MOST decided to form a joint advisory team on strengthening scientific research and manpower development through a new Korean funding organization having functions similar to the U.S. National Science Foundation. The joint advisory team met in Seoul, Korea, May 30 - June 5, 1976 and concluded that a Korea Science and Engineering Foundation was an important and timely addition to the base of scientific and technical activities needed to support the long-range security and economic development of the Republic of Korea. Some fundamentals of the foundation would be:

1. To alter the older, arbitrary support-style by instituting research grant procedures based upon submission of research proposals, peer review and evaluation, and award of grants to the most meritorious proposals on the basis of objective and predetermined criteria.

2. To organize the foundation as an autonomous body, linked to the government but not directly subject to a specific ministry.

3. To stress the elements of independence and long-term stability by creating an endowment fund, the income from which would be entirely targeted for grants and other operations.

Fourth Annual Meeting

The fourth annual meeting of the MOST-NAS Joint Committee for Scientific Cooperation was held in Seattle, Washington on November 4-5, 1976. The main topics considered at the meeting included: a review of the progress of Dae Duk

Science Town and a report on the establishment of the Korea science and engineering foundations, engineering education, and cooperation with industry; systems development in Korea; marine sciences; and the technology transfer center of Korea Institute of Science and Technology (KIST).

Workshop on Systems Development

The purpose of the workshop, which took place in Seoul July 12-15, 1977, was to assist the Burea of Information Industry in its program to foster systems analysis in Korea, and in particular to focus on the systems aspect of energy, environment and transportation planning. The BOSTID participants were to provide an understanding of the current status of systems analysis in the chosen topics, both in the U.S. and elsewhere.

The workshop was planned as an educational exercise, with potential for catalyzing further Korean efforts to apply systems analysis. It provided a forum in which to bring together Korean scientists, engineers, economists, and officials, who, though they share a concern with the same problems, have not worked together in an integrated approach to problem analysis. Instead of aiming at formal recommendations, the organizers planned that the workshop would help establish a framework to increase appreciation of (1) the complexity of the problems to be addressed, and (2) the prerequisites for sophisticated analysis, including governmental and institutional support and cooperation.

NEPAL

A BOSTID staff member visited Katmandu in September 1976 to participate in a seminar on science and technology for the development of Nepal. The seminar was organized by the Southeast Asia Development Advisory Group (SEADAG) of the Asia Society and by the National Research Council of Nepal.

PAKISTAN

Discussions took place between BOSTID staff and Pakistani officials, both before and after the Indo-Pakistan war, regarding the possibility of collaboration between the NAS-NRC and the Pakistani science organizations. These discussions led to a request from the Pakistan Science Foundation for an advisory team from the United States with representatives from the NAS, the National Science Foundation, and the American Association for the Advancement of Sciences (AAAS) to assist the Foundation in the development of its program. At the same time, the National Science Council established an ad hoc committee to discuss priority areas on which a program of collaboration might be based, including science policy, agricultural research and economics, industrial research, and oceanography. In anticipation of a request to organize a joint workshop with the National Science Council on science policy, BOSTID declined to participate in the discussions with the Pakistan Science Foundation.

In response to an invitation from the Pakistanis, a BOSTID staff member visited Islambad in December 1975 to lay the groundwork for a joint workshop in Pakistan under the joint sponsorship of BOSTID, the Pakistani Ministry of Science and Technology, and the Pakistan Science Foundation. The workshop participants were asked to pursue several broad objectives:

1. Review and make a critical analysis of the sectoral priorities of R&D in the light of various constraints and make recommendations for the efficient development of Pakistan's scientific and technological capabilities for more effective use in support of national economic and social development.

2. Discuss and propose an action plan for implementing the proposals for national science and technology policy, in phases and with suggested financial inputs.

3. Develop a chapter on science and technology for inclusion in the five-year plan, relating it to the country's development goals in the context of the overall national plan and thereby highlighting the government's priorities for using science and technology more effectively in support of development.

To carry out the objectives of the workshop, the participants held their discussions both in plenary and in sectoral working groups. The working groups examined detailed and specific issues involving:

1. Food, agriculture, and water resources

2. Industries and minerals

3. Energy

4. Health

5. Physical planning, housing, and environment

6. Transport, telecommunications, and space technology

7. Scientific support services.

THE REPUBLIC OF THE PHILIPPINES

In October 1964, the chairman of the Philippine National Science Development Board (NSDB) requested that the AID mission in Manila ask the NAS to sponsor a joint workshop dealing with development problems of Philippine science. The NAS agreed and coordinated preparations for the workshop through its Pacific Science Board.

The first Philippines-U.S. Workshop on Scientific and Technological Cooperation and Development, held in Manila in November 1965, was deliberately broad and exploratory, focusing on the challenges and potential for science and technology in the Philippines, scientific personnel needs, requirements for applied and basic science facilities, and mechanisms for increasing scientific cooperation between the Philippines and other countries.

In November 1966, a second joint workshop, at Asilomar, California, recommended four specific problem areas as the subject of further cooperative activity: ndustrial research, oceanography and fisheries, food and nutrition, and demography. In December 1967, a third workshop in Manila addressed the topic of fisheries and oceanography. In January 1969, a fourth joint workshop in Manila considered problems of industrial research.

The first two workshops alerted the NSDB and the Philippine government to two major problems: (1) the inadequacy of support for science and technology in both education and research, and (2) the disproportionate allocation of resources between basic research and applied research related to the country's needs. Workshop participants from the Philippine Congress, Administration, and the NSDB succeeded in obtaining congressional passage of new revenue-producing legislation specifically to support Philippine science, thus significantly increasing the NSDB's grant-making resources. Concurrently, the NSDB undertook a reexamination of its allocations for research, aiming at a ratio between basic and applied research activity more in conformity with the experience of the industrially advanced countries.

In 1966, the NAS-NSDB science cooperation program received unusual recognition in the joint communique of Presidents Johnson and Marcos on the conclusion of Marcos's official visit to the United States. The communique commended the program and expressed hope for its continuation and expansion. However, due to the reorganization of the NSDB and to a misunderstanding regarding AID's role, this effort was delayed. The misunderstanding arose because the NSDB viewed the workshops as a key to AID funding of projects. This confusion was not cleared up until 1972 when a visit was made to the United States by the new NSDB chairman, Gen. F. A. Medina, who expressed a keen interest in future collaborative activities with the NAS. These discussions, carried further when NAS-NRC staff members visited the Philippines in 1972 and 1973, resulted in mutual agreement that a workshop on education and training needs for environmental programs in the Philippines be held in Manila in May 1974, sponsored by the NAS, the NSDB, and the National Pollution Commission.

The workshop brought together Philippine and American scientists, engineers, educators, and administrators with the following broad objectives:

1. To identify both immediate and long-term requirements for the professional and technical personnel needs for planning, management, and regulation related to national goals for conservation and quality of the environment.

2. To consider the estimated supply of trained environmental personnel in both the public and private sectors and to suggest ways of dealing with oversupply or shortages.

3. To suggest ways to:

   a. strengthen existing education and training for environmental professionals and technicians, emphasizing interdisciplinary approaches to environmental planning and problem solving;

   b. begin needed environmental training programs that are not now offered in the Philippines;

   c. develop new kinds of environmental training programs that stress conditions and need in the Philippines and maximize cost/benefit ratios of the training;

   d. develop greater public awareness, especially among businessmen and industrialists, of the physical, social, and economic consequences of environmental damage.

Considerable progress has been made in carrying out the workshop recommendations. The NSDB has established a Special Committee on Environmental Programs to coordinate implementation. This committee has subcommittees on (1) education, (2) industry and business, and (3) public information and continuing education.

New courses in environmental engineering have been established at the University of the Philippines at the M.S. level, and a new doctoral program in environmental sciences is being developed. The National Pollution Commission is working on plans for master's degree programs in water quality, management engineering, and air resources engineering, and also on developing courses for environmental technicians. The NSDB, in cooperation with the President's Task Force on Human Settlements and the National Manpower and Youth Council, is making an assessment of environmental manpower needs in government and the private sector and will make a survey of specialized environmental equipment and facilities in government, industry, and educational institutions.

Environmental topics are being included in science teacher in-service training courses offered by the Department of Education and Culture, the University of the Philippines, and the NSDB. The Science Education Center of the University of the Philippines has been requested to place greater emphasis on environmental concepts in the science textbooks, manuals, and guides it prepares for elementary and secondary schools.

The chairman of the NSDB also asked the NAS to consider the possibility of providing a small advisory team that would make recommendations on how to improve the structure, programs and policies, training programs, and R&D plans of the Philippines' environmental protection administration. And he asked the NAS to consider the establishment of a joint scientific cooperation committee with the NSDB.

When BOSTID staff members visited Manila in January 1976, discussions were held on possible future programs involving BOSTID. Plans were made for an international meeting in Los Banos in September 1976 to consider the plant Leucaena leucocephala (ipil-ipil), a fast-growing, multiple-use legume. The proceedings of this meeting, coordinated by the Philippine Council for Agriculture and Resources Research (PCARR) and NAS, have been published by PCARR, and a study of the potential of Leucaena has been published and distributed by the BOSTID Advisory Committee on Technology Innovation (ACTI). More detailed information on Leuceana can be found in the section on ACTI studies.

SINGAPORE

As Singapore is not an AID recipient, program opportunities are limited, although Academy relations with the Science Council of Singapore and particularly its former chairman, Dr. Lee Kum Tatt, have been extraordinarily good. The council did an excellent job of organizing the 1972 Southeast Asia regional workshop on water resources, environment, and national development. The Council also invited the NAS to participate in a workshop on corrosion in tropical climates, but this was not possible because of difficulty in obtaining non-AID funding. Dr. Lee subsequently was a participant in the 1975 Peru workshop on industrial research management.

In January 1976, BOSTID staff members visited Singapore and met Dr. Choo Seok Cheow, the new Science Council chairman, and Dr. Lee, chairman of the Singapore Institute of Standards and Industrial Research (SISIR). Dr. Lee suggested that SISIR and BOSTID sponsor a workshop in 1976 on small supporting industries. The idea was not explored any further since a source of funding seemed remote.

Southeast Asia Regional Workshop on Water Resources, Environment, and National Development (Singapore)

In collaboration with the Science Council of Singapore, the NAS-NRC was joint sponsor of a Southeast Asia workshop on water resources, environment, and national development held in Singapore in 1972. Participants from six Southeast Asian countries--Singapore, Malaysia, Thailand, Philippines, South Vietnam, and Indonesia--and a panel of 10 NAS representatives participated.

The workshop provided a forum for discussion of specific problems shared by the six countries, problems that in some cases are not confined by national boundaries. Singapore has had a particularly strong concern for environmental protection, within its own boundaries and throughout the entire region, and has led in proposing a regional environmental council.

The workshop was intended to assist in the development of greater cooperation on environmental matters among the countries of the region. Because water problems have serious environmental and developmental aspects throughout the area, it was agreed that a workshop emphasizing water problems would be a useful first step towards regional cooperation on other environmental problems. Part of the workshop also was directed toward identification of other critical environmental concerns that might benefit from regional action.

SRI LANKA

Following the 1970 workshop on industrial research management in India, a group of NAS participants visited Sri Lanka to renew contacts with Ceylonese scientists. Subsequent discussions and exchange of correspondence led to a request by the National Science Council of Sri Lanka to the NAS to sponsor jointly a workshop on natural products development. The workshop, held in Colombo in June 1975, focused on underexploited plant resources of Sri Lanka and the research needed to bring them to commercial production.

The workshop, which brought together botanists, agronomists, natural products chemists, administrators (including two cabinet ministers), and businessmen from both Sri Lanka and the United States, considered topics such as plants containing industrial raw materials, essential oils, medicinal plants, and foods. The group surveyed a wide variety of plants that could become important to Sri Lanka's economy. Blending local awareness of what is feasible with the experience of the NAS panel, the workshop made recommendations regarding the most promising species for priority attention.

The workshop also developed a proposal for a consortium of chemical societies (from countries such as the United States, the United Kingdom, and the Federal Republic of Germany) to cooperate in a novel venture to provide the contacts, journals, and supplies that Ceylonese scientists now lack.

All of these proposals are being forwarded to the Sri Lankan government for approval before proceeding with possible implementation on the part of the National Science Council in cooperation with the NAS.

THAILAND

Thailand Seminar on Protein Food Promotion

The AID mission in Thailand requested NAS participation in this seminar at the invitation of the Institute of Food Research and Product Development of Kasetsart University and the Thai Department of Health. The seminar, held in Bangkok in November 1970, included an NAS panel of seven persons among the 25 participants.

The AID program in Thailand had a three-year project aimed at improving human nutrition in rural areas through the development of inexpensive high-protein food supplements for weanlings and preschool children. The first phase of the project, research and development of food supplements, was carried out by the Institute of Food Research and Product Development. Phase two, field testing, was conducted by the Department of Health. Phase three, undertaken by the Institute, was aimed at stimulating the promotion and marketing of these products by local industry.

The seminar on "Protein Food Promotion" was part of phase three. Sponsored jointly by AID/Thailand and the two local agencies, the seminar brought together representatives of the Thai scientific community, the Thai government, local and international industry, the Food and Agriculture Organization (FAO), World Health Organization (WHO), and overseas nutritionists, agriculturalists, and food technologists. The NAS helped plan the seminar.

The meeting exposed Thai scientists and food industry representatives to the latest information on food and nutrition problems, with particular reference to protein. Senior government officials took part in the conference, including--at one half-day session--the prime minister of Thailand.

The seminar produced varied recommendations on research needs, problems of market research and new materials supply, and government policies to encourage production of high-protein foods and to strengthen national food and nutrition policy.

The recommendations were submitted to the cabinet of the Government of Thailand, which forwarded them to appropriate agencies for action. The cabinet also adopted a National Nutrition Policy and established a National Institute of Nutrition, which conducts nutrition research and acts as the coordinating body for all nutrition-related activities in Thailand.

Workshop on Science Policy and Planning in Thailand

During the course of several contacts in 1971 and early 1972, the secretary-general of the Thai National Research Council, Dr. Pradisth Cheosakul, discussed with BOSTID Thai interest in holding a bilateral workshop to help identify key problems and issues relating to science policy and to suggest possible means of strengthening problem areas.

Participation in the workshop consisted of eight NAS panel members led by then Foreign Secretary Harrison Brown, 50 official Thai participants from government ministries, universities, research institutes and economic and planning organizations, and 15 to 20 observers from organizations such as UNESCO, AID and SEAMES (Southeast Asia Ministers of Education Secretariat). The deliberations of the meeting were conducted both in plenary sessions and five working groups: industry and engineering; natural resource utilization; agricultural production; medicine, public health, and environmental quality; and academic sciences.

Sectoral recommendations were made in the five working groups, and three overall recommendations were made by the workshop. The overall recommendations highlighted the following needs:

1. a high-level government committee to develop proposals for an effective government administrative structure for planning and implementing national policy in science and technology;

2. detailed analysis of the problems related to science, technology, and national development, and integration of the analysis into the third five-year plan;

3. improvement of existing personnel policies relating to careers in science and technology.

Two important developments occurred in relation to the implementation of the major workshop recommendations. Late in 1972, the Thai national Executive Committee (cabinet) appointed a Subcommittee on Science Organization of its National Committee on Government Reorganization. This subcommittee moved quickly to develop proposals for a new, streamlined government organization to relate economic and social development needs to science policy and plans. At the same time, and complementary to the reorganization subcommittee work, the National Economic and Social Development Board formed a Science and Technology Policy Subcommittee, which will plan a strong role in the day-to-day integration of economic and scientific planning.

As a follow-up to the workshop, the NAS sponsored a visit to Thailand by Dr. Brewster Denny, dean of the Graduate School of Public Administration at the University of Washington and a member of the earlier NAS workshop panel. In February 1973, Dr. Denny visited Bangkok to provide further encouragement and advice related to implementation of the workshop recommendations and to explore ways for the NAS to engage in continuing helpful collaboration with the Thais.

During 1973, however, there were significant changes in Thailand and in its major science planning and policy organizations. Overshadowing other events, a new government assumed responsibility for the leadership of Thailand in October 1973. In September, Dr. Pradisth Cheosakul retired as secretary-general of the Thai National Research Council and was succeeded by Dr. Sanga Sabhasri, former vice-rector of Kasetsart University. About the same time, the Subcommittee on Science and Technology was established under the auspices of the National Economic and Social Development Board. The subcommittee, chaired by the minister of communications, was given responsibility for analyzing the scientific and technological implications of the government's overall development plans.

Dr. Denny visited Bangkok again in November 1973, along with a BOSTID staff member. They called on Thailand's new deputy prime minister, the new secretary-general of their National Research Council, the minister who heads the National Economic and Social Development Board (NESDB) subcommittee, other Thai officials, and officers of the AID mission in Bangkok. A variety of possible future activities with the U.S. NAS was discussed. Subsequently, Dr. Gerard Rohlich visited Thailand in December 1974 at the invitation of AID and the NESDB to advise on Thai environmental policies and plans, especially relating to water. This visit resulted in several recommendations on the structure and functions of a new environmental unit in the National Economic and Social Development Board.

In mid-1975, the head of the Technology and Environment Planning Division of the NESDB requested NAS collaboration in holding a workshop on coastal zone environmental problems around the Gulf of Thailand. The rapid increase in population and industrial activity on the Gulf coast is creating a number of serious environmental problems, including adverse effects on fisheries production. After discussions in January 1976 with Thailand's new National Environment Board (NEB), agreement was reached that BOSTID and the NEB would sponsor a series of three small workshops to analyze the environmental impact of planned development in three geographic areas of the Gulf coast. The first workshop was to have been held in the last quarter of 1976. However, the workshops have been postponed indefinitely since the Thai Department of Technical and Economic Cooperation (DTEC) was unwilling to fund them from AID technology transfer funds, and other funding was not available.

AIT/NAS Ferrocement Workshop

A workshop on ferrocement technology, jointly sponsored by the Asian Institute of Technology (AIT) and the NAS, was held on the AIT campus in Bangkok, Thailand, November 1974.

AIT, Southeast Asia's premier institution for graduate studies in engineering, has a distinguished record of achievement in education and research, along with an institutional commitment to use its resources to further both the understanding and the exploration of solutions to development problems.

Ferrocement technology was an especially apt topic for collaboration between AIT and the NAS because the Academy has published a report on ferrocement, while the Division of Structural Engineering and Mechanics at AIT conducts extensive ferrocement research.

The workshop brought together engineers, scientists, administrators, and businessmen and gave them the opportunity to share views and experiences regarding ferrocement. The workshop's basic purposes were:

-- to survey the state-of-the-art of ferrocement technology and applications important to Southeast Asia;

-- to provide information on ferrocement research and development taking place in Asia and to share the knowledge and experience gained thus far;

-- to discuss the most promising methods of introducing ferrocement technology to Asia from the point of view of effectiveness, cost, and social acceptability; and

-- to recommend areas of technical and social research that need to be carried further with respect to ferrocement.

Demonstrations of ferrocement construction were held during the workshop. Sixty participants from 16 countries attended. Immediately following the workshop, a demonstration was organized for the benefit of some 50 village heads from several districts in Pratumtani province.

LATIN AMERICA

ARGENTINA

The idea for a bilateral workshop on science and technology for economic development was first suggested by the Argentines in 1966. That same year plans were further advanced when the NAS foreign Secretary visited Buenos Aires for discussions with members of the Argentine Academy of Exact Physical and Natural Sciences and the National Council for Scientific and Technical Research (CONICET). Because of a subsequent change in government and unsettled conditions in the universities, the president of CONICET late in 1966 suggested an indefinite postponement in the joint planning. It was not until 1969 that planning was resumed; the workshop itself was held July 28 - August 1, 1969 at Mar del Plata, Argentina.

The Argentines identified four major areas of science and technology related to economic development as having high priority in their national development plans. These areas were (1) food technology, (2) groundwater hydrology studies of the pampas, (3) scientific information systems, and (4) agricultural research and training. The workshop addressed each of these problem areas and recommendations for follow-up steps were made.

In June 1970, the NAS, CONICET, and the AID mission in Argentina ag agreed to continue follow-up activities in food technology, hydrology of the dry pampas, and science information.

As the bilateral activities were developed, CONICET gave preference to the analysis of scientific information needs in Argentina. A joint study group formed by the two cooperating parties suggested:

1. the creation of a telex network linking scientific libraries and documentation centers in Argentina to facilitate improved use of scientific and technical information resources and to provide direct access to the United States, Europe, and Latin America; and

2. the development of a computer-based literature information service--initially in the chemical sciences--to serve academic, governmental, and industrial scientists in Argentina.

In 1971, the science information telex network was installed, linking 14 Argentine institutions. Under the NAS-CONICET program, the manager of this network received an orientation and training visit to selected U.S. and

Canadian information centers. A six-month program was begun whereby the John Crearar Library of Chicago provided subsidized photocopying services as the North American link to the Argentine network. Later, arrangements were made to include other U.S. libraries in the project with services in the fields of agriculture, medicine, and industrial technology. The science information telex network is still operating, but, because of high costs in a time of limited foreign exchange, CONICET has been unable to install in Argentina a comprehensive computer-based literature information system in the chemical sciences.

In September 1970, a joint study panel on underground hydrology of the dry pampas met in Argentina and drew up guidelines for an intensive study of salinity and water management problems of that region. In 1972, one U.S. panel member returned to Argentina to work with his colleagues on the more detailed feasibility study and research proposal. Again, for reasons of the lack of local funding, the project was not implemented by CONICET.

A joint study group on food technology met in Buenos Aires in mid-1971 to review Argentine training and applied research programs. Several specific projects were recommended and applied R&D outlined in the areas of (1) vegetable protein concentrates, (2) processing of dairy products, and (3) fish protein materials for human consumption.

Since 1972, further joint activities have not been possible, principally because the budget and the operational authority of CONICET has been greatly curtailed by unsettled political and economic conditions in Argentina. Unfortunately, many Argentine officials have viewed NAS collaboration as a means of obtaining technical assistance and direct grants for programs in science and technology after the departure of bilateral programs of AID. At the present time, no new BOSTID programs with Argentina are being discussed.

BOLIVIA

In 1972, during a visit to La Paz, Bolivia, an NAS staff member met with the president of the Bolivian Academy of Sciences to explore possibilities for a joint project. After the initial conversations in La Paz, the BOSTID office anticipated a request from the Bolivian Academy for a workshop program on natural resource development; however, the request was limited to narrow research interests on Lake Titicaca. Because of the restricted focus of the Bolivian Academy's inquiry, the proposed project did not fit into BOSTID's development-oriented criteria. Although correspondence continues with the president of the Bolivian Academy of Sciences and the AID mission, no specific activities are planned in the near future.

BRAZIL

The bilateral program in Brazil was initiated by the former NAS Latin America Science Board (LASB) and the Brazilian National Research Council

(CNPq). At one of the LASB's meetings in Rio de Janeiro in 1965, exploratory talks were held on potential mechanisms and areas for Brazilian-U.S. cooperation. It was decided that a workshop should be convened to consider this matter further.

The first Brazil-U.S. workshop, "The Contribution of Technology to Science and Brazilian Development," sponsored by the CNPq, the Brazilian National Academy of Sciences, and the NAS, took place in 1966 in Itatiaia, 50 miles from Rio de Janeiro. Recommendations adopted at that meeting concerned agriculture, public health, mineral resources, industrial research, communication and transportation in geographic integration, and manpower development. Brazilian-U.S. study groups recommended by the workshop were later formed to examine, in depth, (1) industrial research; (2) norms, measurement, and testing; (3) agricultural research; (4) agricultural economics; and (5) mineral sciences.

The second workshop was held at the NAS in Washington, D.C., in 1968. A special two-day seminar on science policy, chaired by Carroll L. Wilson of MIT, included participants from the National Science Foundation, the Federal Council of Science and Technology, Bureau of the Budget, and the Departments of Agriculture, Commerce, and the Interior. The discussions of Brazilian plans in fields of science and technology related to national goals were based on a five-year plan (1968-1972) prepared by the CNPq for the president of the Republic. This document had utilized some of the advice generated by the study groups functioning in the interim between the two workshops.

In pursuing the subject of manpower training discussed at the first workshop, the fields of chemistry and computer sciences were recommended for more detailed analysis.

The third workshop took place in Rio de Janeiro in 1969. In view of the interest aroused by discussions on U.S. science policy at the second workshop, the Brazilian CNPq presented a similar seminar involving representatives from the Ministry of Planning, the National Bank of Economic Development (BNDE), the National Department of Mineral Production (DNPM), and the Ministry of Agriculture.

Much of the workshop discussion focused on joint study group activities, and especially on the report of the industrial research panel. The agricultural research and agricultural economic groups reported on their progress. The chemistry group proposed a major bilateral program for the development of graduate research in two Brazilian universities. Other areas of concern included research in transportation and training and research in the earth sciences. The workshop also proposed that Brazil sponsor an international conference on patent policy.

The fourth CNPq-NAS workshop (Washington, D.C., November 1971) reviewed program results over five years. William Ellis, then AID mission Director in Brazil, discussed Brazil's remarkable rate of economic development, commended the participants for their successful joint efforts, and specifically noted the CNPq's dramatic growth since the program was begun.

Highlights of Brazil's scientific growth over the 1966-71 period were reported as follows:

1. The CNPq played a major role in establishing a governmental base for developing science and technology in Brazil.*

2. Scientific and technological research was given prominent attention in the Ministry of Planning's Program for Aims and Bases of Government Activities, primarily in health, agriculture, industry, and in overall strengthening of scientific and technological manpower resources.

3. Investments in science and technology, as reflected by the CNPq budget, increased substantially. Expenditures for science and technology by the CNPq totaled Cr$54,881,458 in 1970, an increase of more than 260 percent over 1968, a rate of growth far higher than the rate of inflation.

Because the Brazilian government had recently given higher priority to the agricultural sector, the workshop recommended that two separate study groups be formed under the purview of the agricultural research group. One group was to conduct a study on establishing an educational research center in agricultural engineering; the other, to study research possibilities in the Brazilian campo cerrado.

The NAS experimental project on identifying technologies applicable to underdeveloped countries was discussed. The workshop agreed that a Brazilian member would be invited to the advisory committee that oversees this project and that the committee should consider a visit to Brazil.

A half-day seminar on the management and administration of R&D was held during the workshop, with the following principal speakers: George Herbert, President, Research Triangle Institute of North Carolina; Donald Collier, Vice-President for Research, Borg Warner Corporation; Edward Roberts, Sloan School of Management at MIT; and Karl Fetters, Vice-President for Research (retired), Youngstown Steel Company.

Several study groups have been held as a result of various workshops.

Industrial Research

In accordance with a recommendation of the first workshop, a study group on industrial research comprising 10 Brazilians and 10 Americans from research institutes, universities, industry, and government was formed in April 1967. This group was asked to formulate recommendations for developing Brazilian industrial research capabilities that would contribute to economic growth. The group's final report recommended actions ranging from budgetary considerations by government and private entities to fiscal incentives, elimination of import restrictions, training, patent reform studies,

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* A presidential decree of May 1972 gave the CNPq central authority for coordinating national scientific and technological development plans, thereby clarifying its role vis-a-vis the Ministry of Planning.

establishment of a "model" research institute, and a national system of information and documentation.

Since the report was issued in 1968, it has been widely disseminated in Brazil and has been discussed at various meetings between representatives of universities, industry, and government. Several measures to implement recommendations in the report have been taken. During 1969-1971, the CNPq created working groups to advise it on food technology, ceramic (retractory) materials, steel, cellulose, and paper. In May 1971, the Council sponsored a three-day meeting attended by 140 participants from 46 industrial research institutes and 31 agencies that engage in applied technological research. A high-level coordinating panel was established to advise the CNPq on support for industrial research.

Many individual recommendations on the organization and management of research have been adopted by the Food Technology Institute (ITAL), the Technological Research Institute of Pernambuco (ITEP), and the National Research Institute (INT). The consultant services of Lawrence Bass were especially helpful in this respect. His book on research management needs of developing countries has been translated into Portuguese.*

Other developments have resulted from Brazilian efforts to implement joint recommendations: for example, an institute was created in the Ministry of Industry and Commerce to study patent legislation and collect information on foreign patents. The INT and the National Industry Confederation agreed to create a technological information center. The Brazilian Pharmaceutical Industry established a foundation to support a research center fashioned on the model outlined in the industrial research report. The CNPq was asked to establish a working group for the pharmaceutical industry. In Sao Paulo, the Roberto Simonsen Institute of the Federation of Industries sponsored meetings between universities and the chemical, cellulose, and paper industries.

The CNPq has supported research on national technological problems and has also substantially increased the number of postgraduate scholarships at the masters and doctorate levels in engineering and supporting areas. In 1970, CNPq also began publication of the Revista Brasileira de Tecnologia, which it distributed without charge to 5,000 professionals.

Norms, Measurement, and Testing

A recommendation at the first workshop called for a study on the problem of developing standards and testing procedures for Brazilian industry. A study group of 11 persons addressed this problem, and within a year, after meetings in both countries that included visits to appropriate institutions, the group submitted its report to the CNPq. New systems of standards

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* Lawrence Bass (1965), The Management of Technical Programs, with Special Reference to the Needs of Developing Countries. Translated into Portuguese by Andre Tosello, University of Campinas, Sao Paulo, Brazil. New York: Praeger.

and the establishment of a research laboratory in standards and testing were recommended. Internal policy considerations within Brazil prevented implementation; however, the report, published in Portuguese, has been widely circulated.

Agricultural Research and Agricultural Economics

The goal of the joint study group on agricultural research was to recommend improvement in Brazilian agricultural research management and planning. The first meeting of the six-man group was held in January 1968. The U.S. members visited institutions, mainly in northern Brazil, for three weeks. They proposed an inventory be carried out over a 12-month period to provide detailed information regarding research programs, manpower resources, training facilities, and support for agricultural research and extension services.

The agricultural research group also met with members of a six-man study panel on agricultural economics. They agreed to promote the use of agricultural economics as an integral and prominent part of agricultural research and training.

In February 1969, the two study groups met again in Rio de Janeiro. The agricultural research group meeting included a one-week international seminar on administration of research sponsored by the CNPq and the Ministry of Agriculture. During 1969, several Brazilian agricultural economists visited institutions in Brazil and in the United States, and at subsequent meetings, the agricultural economics study group proposed a project to strengthen agricultural economics research and analysis in Brazil's agricultural research stations. Patterned after the CNPq-NAS Chemistry Program, the plan called for NAS fellowships to allow a carefully chosen group of U.S. doctoral candidates to conduct their research on Brazilian agricultural development problems.

Following visits by the study group to agricultural research centers in southern Brazil, a second seminar on agricultural research administration was held in Campinas, Sao Paulo State in July 1970. It was attended by 150 representatives from state, federal, and agricultural institutes. According to Brazilian participants, these seminars improved communications and coordination between the diverse, widely dispersed agricultural research efforts of the states and the federal government.

Agricultural Engineering

An NAS-CNPq agricultural engineering education study group was created by the fourth workshop. CNPq suggested that three U.S. agricultural engineers, two under NAS auspices and one under FAO sponsorship, collaborate with Brazilian experts in conducting the study.

The Joint Study Group met July 24 - August 12, 1972 in Brazil. Members visited 16 teaching and research institutions as well as experimental farms, a major agricultural colonization project in the northeast, and government agencies. Their purpose was to assess the need for greater engineering inputs into agricultural development, study current training of agricultural engineers, observe research projects, and evaluate alternative plans to the establishment of agricultural engineering as a discipline and profession in Brazil. A report, Study for Agricultural Engineering Development in Brazil, was issued. The major recommendations of the study group were (1) that recognition under Brazilian law be given to agricultural engineering (engenheiro agricola) as a profession, (2) that CNPq appoint an Agricultural Engineering Commission to guide the development of the new profession, and (3) that emphasis be given immediately to the preparation abroad of a cadre of Brazilian agricultural engineers who would return to carefully selected institutions for teaching and research.

Another recommendation of the agricultural engineering education and research study was that a representative group of Brazilians visit U.S. universities to study current education and research in agricultural engineering. That visit was made in June 1973.

In late 1973 the Brazilians created a Brazilian Agricultural Engineering Commission to recommend measures to strengthen the application of teaching, research, and agricultural engineering to development. At the request of the CNPq, Dr. Carl Hall, chairman of the BOSTID agricultural engineering panel, visited Brazil in late November of that year. Discussions on a new agricultural engineering career and degree program to be offered by Brazilian univeristies were held in Rio de Janeiro and Brasilia with the Ministry of Education's coordinators for the Commission on Agricultural Sciences Education and the Commission on Engineering Education.

Campo Cerrado Study

A region receiving increasing attention from the Brazilian government is the campo cerrado. At the fourth workshop, the CNPq asked that an ad hoc committee of four members (two from each country) be established to work out a five-year program of research priorities for rational exploration of the cerrado.

The chairman of the NAS panel for this study visited Brazil in November 1973 with a BOSTID staff member for discussion with CNPq, the Empresa Brasileira de Pesquisas Agropecuaria (EMBRAPA), and AID mission officials regarding the terms of reference and arrangements for the proposed project. At the same time, it was determined that the project would take the form of a workshop on agricultural research to recommend research and development alternatives based upon technical considerations. It was anticipated that the joint recommendations on a concerted research approach to dealing with limiting factors in agricultural production would include soil fertility, cereal grains, soybeans, and pasture management for livestock production. The meeting was tentatively scheduled to be held in Brasilia in May 1974; however, EMBRAPA and CNPq asked that it be postponed.

In December 1975, a letter was received from the director of the newly created Center for Cerrado Agricultural Research, Dr. Wencestau Goedert, inviting BOSTID to participate in the IV Cerrado Symposium to be held in Brasilia, June 21-24, 1976. The objectives and agenda for the symposium, which was to be a purely scientific meeting, differed from the original terms of reference for the joint NAS/CNPq-EMBRAPA Workshop on the campo cerrado, which was also to deal with development problems and strategies for increasing agricultural production from the region. It was later agreed that discussions of the cerrado research situation would take place in association with the symposium.

The IV Cerrado Symposium was held in Brasilia, June 21-25, 1976. It brought together an estimated 800 Brazilian scientists and planners, including a large number of students. In addition to the NAS-NRC panel, a small number of representatives from Europe and the private agricultural sector in Brazil participated in the meeting.

From the discussions during the symposium and the joint analysis of the principal problem areas, a number of critical R&D needs were identified:

-- long-term experimentation on soil fertility;

-- research on insect control;

-- general economic analysis and systems analysis of production systems alongside technical research;

-- development of deep-rooted varieties for moisture stress resistance;

-- technical manpower.

Nitrogen Fixation

In mid-1974, as a result of informal discussions with a Brazilian panelist for the campo cerrado study, Dr. Johanna Dobereiner of the Instituto de Pesquisas Agropecuaria do Centro-Sul (IPEACS), and the NAS was invited by the CNPq to participate in an international meeting to discuss recent advances in knowledge about associative symbioses in tropical grasses involving nitrogen fixation. The AID mission agreed to the use of funds from their contract with the NAS to provide travel for three NAS panelists to a meeting at IPEACS and the adjacent Universidade Federal Rural de Rio de Janeiro (UFRRJ), in which Brazilian, British, Canadian, and Australian scientists also participated. This meeting reviewed the work of the joint IPEACS-UFRRJ group on nitrogen fixation in tropical grasses and legumes and made recommendations for the priority areas of research to be pursued. Plans were also drawn up for continuation of the international advisory activity, in which periodic meetings of the international committee and visits by foreign scientists for short periods would be arranged. Research and teaching fellowships of from six months to two years were to be arranged as well. The research program was also aimed at involving young Brazilian scientists who would be able to work for a Ph.D. in microbiology from the UFRRJ, with the long-term objective of increasing the level and extent of Brazilian competence in this field. Fellowships were also to be available to a few students from other tropical countries.

EMBRAPA (the parent organization responsible for IPEACS) and the CNPq agreed to support the Brazilian costs of the program. AID agreed to continue to support BOSTID participation in the program through 1975, with existing funds available in the Task Order. In addition, the Agricultural Office agreed to support BOSTID's continued participation in this program for a 32-month period. This support permitted periodic visits by the NAS-NRC representatives on the International Advisory Committee to collaborate with their Brazilian counterparts in the research and training program, provided travel and equipment grants for and miscellaneous costs of U.S. postdoctoral fellows assisting in the conduct of research and in the training of Brazilian students, and provided funds for Brazilian committee members to spend short periods in the U.S. working at U.S. institutions.

Although contract arrangements had not yet been completed, the first postdoctoral fellow, Dr. John Tjepkema, travelled to Brazil on AID invitational travel in January 1976. A grant was received from AID effective June 24, 1976 covering a three-year period.

The International Symposium on Nitrogen Fixation was held in Brasilia July 18-22, 1977. This was followed by a meeting of the International Advisory Committee on Nitrogen Fixation, July 23-26. To summarize the main technical points that arose, much progress has been made in understanding the symbiotic associations between legumes and rhizobia bacteria, and grasses and cereal grain crops and what are now characterized as bacteria of the new genus Azospirilla. In the case of the legumes, major papers were presented describing nutrient deficiency problems of growing feijao and soybeans, and their solution using various kinds of spray treatment, particularly with molybdenum. One important finding was the apparent doubling of feijao yield when nitrate fertilizer is applied after the plant flowers.

Regarding tropical grasses and cereal grains, in addition to the work on classifying the bacteria, microbiology, biochemistry, and physiology has been employed to improve understanding of the conditions under which the bacteria fix nitrogen. The biggest question still remains: how much do the bacteria contribute to the nitrogen in the plants under field conditions, and what is the potential for increasing this by selection, etc.? One of the major efforts of the International Advisory Committe was to design an experiment to be carried out concurrently in Brazil, Australia, and Wisconsin and Florida in the U.S. which would make this important estimation at these four locations.

In sum, the nitrogen fixation program continues to be an impressive effort which is making progress under difficult working conditions. The potential contribution to Brazilian agriculture is considerable, mainly in the legume/rhizobial research.

Earth Sciences

The study group on mineral resources, created after the Itatiaia meeting, proposed a plan for improving higher education in Brazilian schools of geology, primarily through increased assistance for the cooperation program between the Brazilian National Department of Mineral Production (DNPM) and the U.S. Geological Survey. Subsequently, an AID loan of $8.4 million was made for the DNPM-USGS program in collaboration with the U.S. Geological Survey. This made possible basic training in field geology, mineral evaluation, statistics, and mining technology--all contributing to the general objectives of the bilateral program.

In 1967-68, the CNPq made a survey of Brazilian universities to determine needs for graduate education in geology. The following year, assistance was provided for graduate courses begun in Porto Alegre, Sao Paulo, and Rio de Janeiro. At the 1969 workshop in Rio, two sessions were devoted to earth sciences, with presentations by U.S. members on geochemistry and geophysics. Brazilians presented papers on geochemistry, tropical soils, and general geological studies. A study group was proposed to examine ways of improving the teaching of geochemistry, geophysics, and geomathematics--fields considered important for the long-term development of the mining industry. North American study group members visited Brazilian universities in late 1969 and mid-1970.

The proposal presented at the fourth workshop (1971) outlined a cooperative training program that would include long-term assignments of U.S. geoscientists to Brazilian universities for teaching and research. The project did not fit into the general NAS-CNPq pattern of activities. Efforts to modify objectives and focus upon planning-coordination of graduate training and research proved to be inconvenient to some of the principal Brazilian universities. Funds were therefore assigned, with approval of AID/Brazil, to the nitrogen fixation program.

Transportation

At the third workshop, a study group was proposed to consider training and applied research in the transportation sector. In mid-1970, a two-member U.S. panel made a preliminary visit to Brazil to discuss specific terms of reference for a detailed study group project. Because the panel proposed a study that was to be limited solely to a review of proposed research projects in highway transportation, the CNPq and the NAS decided it did not fit its overall objective, and the study was discontinued.

Computer Sciences

In 1968, at the request of the CNPq, a preliminary study of computer facilities in Brazilian universities was made. In 1969, the third workshop endorsed creation of a computer sciences study group to consider training and research aspects in Brazil. In 1972, the joint study group proposed a specific plan to strengthen graduate computer science education at the Catholic University of Rio de Janeiro, the Graduate School of Engineering of the Federal University of Rio de Janeiro, and the University of Sao Paulo. This proposal, submitted to CNPq and to the AID mission in Brazil, was accepted by both organizations, and grant funding at a level of US$730,000 over a four-year period was requested from AID. In March 1973, this request, approved by the AID/Brazil mission, was reviewed in Washington and declined on the basis of the U.S. phaseout of technical assistance activities in Brazil beginning in FY 1974.

Chemistry Program

The Joint CNPq-NAS/NRC Program for Brazilian Development of Postgraduate Teaching and Research in Chemistry was initiated in October 1969. This program, now in its sixth year, is an experiment in transplanting to Brazil an advanced research capability in selected fields of chemistry regarded as important to Brazilian development. It is the only operational project currently conducted under BOSTID auspices.

The idea for a collaborative undertaking in chemistry grew out of discussions in the second CNPq-NAS/NRC workshop held in Washington, D.C., in February 1968. A review of the 5-Year Plan for Brazilian Scientific and Technical Development revealed the need to improve chemistry education and research. It was recommended that a binational chemistry committee be established to study ways in which this need could be satisfied. The committee, formed in 1968, concluded that the most effective means of improving the quality of research and graduate teaching in Brazil would be through a program in which American postdoctoral fellows in chemistry, with the guidance of their U.S. professors, would pursue their own research in leading Brazilian universities in collaboration with Brazilian faculty and postgraduate students. An experimental program for an initial five-year period was proposed by the committee to the third U.S.-Brazil workshop, held in Rio de Janeiro in April 1969.

The basis of this recommendation was: (1) recognition by the Brazilian government of the importance of science and technology to Brazil's economic development (especially chemistry, which is required for many industries such as chemicals, textiles, and pharmaceuticals); (2) agreement that institutional capacities and capabilities needed expansion in order to serve the growing demand for higher education in Brazil; and (3) realization that long-term scientific ties between Brazil and the United States would foster a better understanding between both countries, as well as promote the growth of science.

The CNPq-NAS/NRC program in chemistry was begun with 10 research projects in advanced fields of chemistry, initiated in successive stages. These projects were selected by a committee of 10 senior U.S. professors from Stanford University, the University of Michigan, and the California Institute of Technology, and 10 Brazilian professors representing the Federal University of Rio de Janeiro, the University of Sao Paulo, and Centro Brasileiro de Pesquisas Fisicas. Subsequently, three additional professors from Indiana University, Northwestern University, and Caltech joined the program. Funding for NAS costs was provided by an AID host country contract with the CNPq from NSF and from a number of private sources.

The basic operation of the program can be described briefly. Senior Brazilian chemists propose cooperation with U.S. colleagues with whom they feel a productive research program might be established, based on compatability of interests and availability of graduate students, instrumentation, and laboratory space. With approval of the joint committee, young U.S. Ph.D. chemists are then selected by the U.S. and Brazilian scientists to conduct research and teach in Brazilian universities for two to three years. The positions they assume in Brazil are equivalent to those of assistant professors in the United States. The U.S. senior professors participate in the scientific aspects of each project through semiannual visits to Brazil and through continuing communication with their Brazilian counterparts and the young Americans for whom they are responsible. The joint CNPq-NAS/NRC committee recommended that this program be undertaken for a minimum of five years, recognizing that effective evaluation could only be undertaken after the graduation of the first Brazilian Ph.D. candidates.

One of the unique aspects of the program is that 13 eminent U.S. chemists have committed themselves to this binational experiment in graduate training and research. If successful, it may serve as a prototype for future cooperative ventures in the transfer of advanced scientific capabilities to developing countries. In recognition of the importance of this program the NAS has, for the first time, given its name to the Overseas Research Fellowships awarded to the young American scientists.

Another aspect of the program is the emphasis placed on training Brazilian doctoral candidates in Brazil rather than abroad. However, certain requirements of the Ph.D. program cannot yet be satisfied in Brazil. Therefore, the U.S. committee has undertaken to place up to 10 Brazilian students per year in U.S. universities for one year of specialized training. The U.S. committee will also accept up to five students annually in the members' laboratories for intensive short-term (up to three months) research.

At the beginning of the program, it was recognized that certain key problems associated with teaching and research in Brazil would have to be solved. These were: increasing the number of graduate students, increasing the salaries of Brazilian professors, and decreasing the isolation of the scientist in Brazil. The program has contributed to some improvement in the situation with respect to these problems in the area of chemistry. Statements from officials at the CNPq, the Brazilian and American universities, and the Brazilian Ministry of Economic Planning indicate that this program is recognized as an important element in Brazil's efforts to improve its capabilities in science and technology related to Brazilian economic development. Moreover, it is looked upon as a significant mechanism for strengthening U.S.-Brazilian scientific cooperation, not only at the usual level of senior scientists but at the level of young Ph.D. graduates as well.

It is expected that during the life of this program enough doctoral candidates will have completed their training to staff the chemistry departments of institutions in which the program is operating. Also, the program will inceease the number of graduate students in chemistry at two leading institutions of higher learning, establish advanced research capability in avant-garde fields of chemistry, and create a channel between the United States and Brazil for sharing advanced chemistry research on a continuing, sustained basis. To date, after six years of operation, considerable progress has been made in meeting the original objectives of the program. Research groups have been established, some of which are self-sustaining programs. Program participants have been awarded 27 master of science degrees and nine doctorates; 51 master of science candidates and 20 doctoral candidates are currently enrolled. Many of the graduates have taken teaching positions in the university system in Brazil. While the majority in Sao Paulo and Rio de Janeiro still remain in their training institutions, other universities--Rio Grande do Sul, Fortaleza, Maringa, and the Federal Rural University of Rio de Janeiro--have employed professors trained in the program. Additionally, because the University of Sao Paulo is a training center for the Organization of American States, other Latin American countries are benefiting from the program.

The quality of the research being conducted by these groups is consistently high: two books have been published, 88 papers have been published in international scientific journals, and an additional five are in process of being published.

Brazilian industry is beginning to benefit from the program, and PETROBRAS (the Brazilian national oil company) has created a research group composed entirely of graduates from the program.

An International Polymer Symposium, organized by the polymer group of the chemistry program, was held in Rio de Janeiro in July 1974 under the auspices of the International Union of Pure and Applied Chemistry and sponsorship of the Brazilian Academy of Sciences, the CNPq, and the Secretariat for Science and Technology of the State of Guanabara. It attracted more than 700 scientists from around the world and was highly successful, as measured by the quality and extent of scientific participation, numbers of papers presented, and recognition by the international scientific community.

In 1974, the recognition of the fact that the program had started rather more slowly than had been hoped (due largely to the problem of attracting good students to an unknown and experimental program), the joint chemistry committee agreed to continue the program for an additional two years, to produce sufficient graduates to ensure the self-sufficiency of all of the research groups. Funding for this extension came almost entirely from Brazilian sources.

The formal program between the CNPq and the NAS in chemistry ended December 31, 1976. At the last meeting of the NAS-CNPq committee held in Rio and São Paulo November 16-20, 1976, they thought it essential to review the progress of the program and discuss various ideas for the continuation of individual projects. The conclusion and recommendations of the joint group follows:

1. Considering that the several projects of the program are fully functional with a total of about 100 graduate students and researchers actively engaged in their scientific and technological investigations, and considering that to protect the capital and efforts already invested and produce the desired results of training of personnel at a level of international competence it is essential that this research should continue, it was emphatically recommended that the CNPq continue annual funding of the same order of magnitude.

2. It was recommended that resources be allocated for the continuation of interaction between scientists at a national and international level in the form of bilateral visits of researchers who are of interest to the program.

3. It was recommended that an assessment of the total impact of the program be done in two or three years.

4. Since in some of the projects conditions may exist to permit a partial funding of work through specific bilateral agreements with foreign agencies, it was recommended that pursuit of such agreements be encouraged.

Workshop on Modern Science and Technology in the Development of Agriculture of the Semiarid Region of Brazil

In 1973, the Brazilian Planning Ministry and the Brazilian Academy of Sciences requested NAS assistance in convening a workshop to explore the utilization of science and technology in the development of agriculture in the dry northeastern part of Brazil. Conducted in Brazil and funded entirely by the Brazilian government, this workshop was convened in two phases in 1974 (March and September). Participants agreed on the need for the following:

1. The awarding of contracts to foreign institutions to conduct research in their country and to train a small core (three to five) of Brazilians. One advantage of this method is the possibility of solving an urgent problem while simultaneously training Brazilians to carry on the work when they return to Brazil. A disadvantage is the high cost of paying for the research and the salaries and living expenses of the Brazilian trainees, as well as the need to provide laboratories and associated equipment when the trainees return to Brazil.

2. The initiation of a fellowship program to bring researchers from other countries to Brazil to undertake specific projects related to problems of the semiarid region. These fellowships would be attractive to many researchers if they provided adequate salaries, laboratories, living conditions, and recognition by the Brazilian government as well as by the Brazilian scientific community. The latter might be realized if the fellowship were identified formally as "The Brazilian Academy of Sciences Research Fellowship."

3. The establishment of a dry land institute in the northeast, which would initiate projects with many countries such as the CNPq-NAS/NRC chemistry program in Brazil.

Recent information shows that suggestion #3 has been fully accepted by Brazilian authorities, and the design of the institute is now being undertaken.

Joint NAS-CNPq Continuing Committee

In 1975, the CNPq and NAS agreed to establish a joint continuing committee, with the first meeting scheduled in July 1975. However, the highly fluid economic situation in Brazil has prevented the issuance of the Government of Brazil's Science and Technology Plan, which was to have been the main document to be considered by the continuing committee. Subsequently, the meeting was held June 28 - July 2, 1976. The agenda included specific areas of science and technology suitable for U.S.-Brazil cooperative activity and recommended appropriate institutions, agencies and/or organizations in the United States and Brazil for cooperation. The CNPq's Scientific Committee was the NAS counterpart organization for this meeting.

Humid Tropics of the Amazon

The Amazon region of Brazil was selected by the Brazilian government as an area for extensive development. The government recognized the need to proceed with caution because the ecology of the area is not well understood. Moreover, the Brazilians were aware of the concerns expressed about the possible effects of development activities in the region on the global climatic system, and thus they tried to allay these fears by organizing a research effort to provide guidance for the economic development of the region.

In order to secure needed scientific data on the flora and fauna of the Amazon region, the CNPq, at the direction of the Brazilian government, upgraded the status and the funding of the Instituto Nacional de Pesquisas da Amazona (INPA). This institute is responsible for conducting an expanded research program and coordinating all the research in the Amazon region being carried out by other Brazilian agencies. The largest research efforts of the institute are in its present program, "Ecology of the Central Amazon," which operates under INPA's Division of Biology. INPA has five other divisions--Information, Medical Sciences, Agronomy, Technology, and Geography. The ecology program includes: botany, soil biology, limnology and climatology, and wood technology and plant chemistry.

The CNPq requested that NAS establish a joint CNPq-NAS Subcommittee on the Humid Tropics to review in detail the formulation and direction of the ecology program and to advise on the overall program of the institute. This joint subcommittee met in Manaus December 6-10, 1976. The major recommendations resulting from the meeting were:

1. A joint project be established between INPA and the Laboratory of Chemical Biodynamics in Berkeley (LCB) to focus on (1) a survey of existing knowledge about latex and exudate-producing plants to select a few promising species for study, (2) a detailed study of the plants selected from the survey, and (3) an exchange of scientists and graduate students between LCB and INPA.

2. A joint project be established between INPA and the University of California at Santa Cruz to focus on resins from the genus Copaifera.

3. A workshop be held at INPA to establish contacts and exchange viewpoints about the status of research in tropical diseases, i.e., hanseniasis, maleria, gastrointestinal diseases, and illshmaneasis. U.S. scientists knowledgeable in these tropical diseases should be identified for short-term visits to INPA.

4. Establish a project to strengthen the postgraduate course in freshwater biology and fisheries at INPA; expand the program on fisheries biology and the present work on agriculture; and enlarge the program on fish technology.

Semiarid Tropics of Northeast Brazil

In September 1974, BOSTID joined with the Brazilian Academy of Science to conduct a workshop in the northeast of Brazil on problems of that semiarid area (see write-up on page 66). Subsequent to that workshop, a Panel on Climatology in Regions of Drought and Frost in Brazil was formed to review the current status of research in these areas and to offer advice on their further development to the Government of Brazil. The panel was specifically asked to perform its assignment in conjunction with the International Seminar on Climatology of the Southern Hemisphere, held during September 5-10, 1977 at the Agronomic Institute in Campinas, Sao Paulo, Brazil.

Recommendations made include the following:

-- Priority research attention in Brazil should be given to (1) solution of practical agrometeorological problems of drought and frost mitigation, (2) development of selected crop growth models and a yield surveillance system, (3) development of improved weather forecasting systems, including the use of numerical models for both forecasting and research applications, and (4) development of a climatic data bank.

-- Increased attention should be given to the training of agrometeorologists with specific needed specialties.

-- Program should be developed for the training of specialists in crop growth and yield modeling, including the adaptation of simulation techniques developed elsewhere to Brazilian conditions.

-- Efforts should be made to further training opportunities in numerical weather prediction techniques, regional numerical modeling, and modeling of the southern hemispheric circulation for climate sensitivity studies.

-- Efforts should be made to increase the contact, exchange, and coordination among the various research groups in agrometeorology and climatology in Brazil, as well as with corresponding groups abroad.

-- In view of the limited resources available, the unique capabilities, interests, and resources of the research groups in Brazil should be recognized and each group encouraged to develop a different specialty or expertise as part of a coordinated national research policy.

Brazil Flora Project

The Humid Tropics Program of the CNPq encompasses a number of subelements, one of which is a flora project. This project will provide as complete an inventory as possible of the country's natural plant resources. In recognition of the immensity of the task and believing that prompt action is needed to survey the flora of the Brazilian Amazon River Basin, the CNPq invited BOSTID, in the context of its overall cooperative program, to participate in the planning and execution of the flora project.

An inventory of the Amazon flora was given highest priority because of the alarming rate at which one of the world's most diverse and biologically complex forest ecosystems was being destroyed and because this rate may well be accelerated by population growth and by implementation of Amazon development plans. The inventory was to be directed toward collection of unknown plant species and toward an understanding of the Amazon ecological system essential for development of a rational land-use policy. A meeting of U.S. scientists was held in late March 1976 to assist BOSTID in evaluating the desirability, feasibility, and possible scope of a proposed joint project between U.S. and Brazilian scientists to conduct research on the flora of the Amazon Basin. As the second step, a group of U.S. scientists met with their Brazilian counterparts in early April 1976. The U.S. National Science Foundation, as of September 1977, has taken the responsibility for carrying out this project.

Steroid Program

One recommendation from the first CNPq-NAS workshop which seems to have gained significant momentum without further NAS involvement has been the production of steroid raw materials from seisal waste products. During the first workshop, a small joint subcommittee (Drs. Carl Djerassi and Walter Mors) recommended the establishment of a pilot plant in the northeast of Brazil to separate steroidal sapogenins (notably hecogenin and tigogenin) from seisal waste as a mechanism to make available an indigenous source of raw materials for the production of steroid products. A pilot plant was subsequently established and more recently two large European firms have approached the Brazilians about establishing an operation in the northeast for the isolation and manufacture of steroid sapogenins on a large scale.

Investigations are now being conducted by the Institute of Natural Products and the Institute of Technology (both in Rio) about the further elaboration and transformation of the sapogenins to finished steroid hormones. This could make Brazil partially independent in this area.

CENTRAL AMERICA

One of the newer factors of AID policy in foreign assistance is a balanced concern for the environmental consequences of development. The report of the NAS ad hoc panel on International Aspects of Man's Effect upon the Environment (January 1970) led the AID Regional Office for Central America and Panama (ROCAP) to express interest in sponsoring a Central American regional workshop on the environment and development. The Central American Research Institute for Industry (ICAITI) had already been engaged in measuring pesticide residues in cotton-growing areas and, when approached by AID, was enthusiastic about cosponsoring a workshop. The Central American Bank for Economic Integration later joined ICAITI and the NAS in this endeavor.

Major objectives of the workshop were (1) to provide a forum for discussion environmental problems in Central America, and (2) to recommend action programs for governments and regional organizations to alleviate environmental problems associated with social and economic development.

The seminar, held in August 1971, was attended by representatives of planning offices from each Central American country and by observers from the World Bank, the Inter-American Development Bank, the General Secretariat of the General Treaty for Central American Economic Integration, the Organization of American States, and the Inter-American Institute of Agricultural Sciences. Recommendations dealt with demography and population statistics, criteria for pesticide use, industrial potential for tropical forest products, economic modeling as a tool for planning in Central American integration, and environmental research.

Pesticide Management

Early in 1973, ICAITI and BOSTID formed a study group on pesticide management problems that recommended a two-year environmental and economic investigation of the consequences of pesticide use in the Central American cotton-producing region (the Pacific coastal plain of Guatemala, El Salvador, Honduras, and Nicaragua). A proposal for the study, prepared by the study group, pointed to the changing conditions in Central American cotton production since chemical pesticides were first introduced in the early 1950s. Within 10 year, major economic effects were being felt in the region; insecticides were exacerbating pest control and environmental problems in ways not fully understood in Central America. Equally serious were the effects on public health, which could be documented in terms of human poisonings (about 1,800 annually); loss of fish, shrimp, and other animals; and evidence of mounting pesticide residues in livestock and food crops. The number of insecticide applications in some cotton-growing regions had increased from eight to 40 per season. This increase represented the only available response of the cotton farmer to increasing insecticide resistance and to the loss of natural predators. However, even with the higher frequency of applications, pest control was <u>not</u> satisfactory. By the early 1970s, alternatives to complete reliance on chemical pesticides were being sought for environmental, public health, and economic reasons.

The purpose of the study designed by the NAS-ICAITI group was to develop a <u>systems management program</u> to reduce the quantity and thereby the attendant environmental effects of pesticides in cotton production. The study included the following aspects:

- Determination of environmental impact on selected cotton-growing and control areas through the comparison of pesticide contamination of human and animal food sources, of water, and of wildlife.

- Demonstration experiments of integrated pest control in selected cotton-growing areas of Guatemala, El Salvador, Honduras, and Nicaragua. This phase of the study had as its goal the reduction of pesticide treatments from an average of 30 to about 10 per season.

- Careful analysis of economic aspects of pesticide use in cotton production and, wherever possible, the economic side effects on production of meat and other food products.

- Collection of data relating pesticide use to environmental health of workers and their families in the cotton-growing regions.

The environmental systems study is being conducted by a special full-time team of economists and physical, biological, agricultural, and medical scientists, and by part-time consultants directed by ICAITI. Funding ($300,000) was made available for the two-year period May 1974-1976 from the United Nations Environmental Programme (Nairobi). BOSTID involvement is at the invitation of ICAITI and consists of membership on the executive advisory committee for the overall study. NAS-appointed members of that committee are Dr. David Pimental, Professor of Entomology and Ecology, Cornell University and Dr. Louis Falcon, Cotton Entomologist, University of California (Berkeley). Expenses for their participation in advisory committee meetings and in occasional consulting assignments are borne by ICAITI under the UNEP grant.

Under the AID/OST agreement, BOSTID provided staff support to the Advisory Committee. A mid-project report in Spanish and English was submitted to UNEP in late 1975; a two-year report was published in January 1977.

Results from the first year indicate that the integrated approach to pesticide use in cotton production can be highly beneficial economically. For example, insect control by conventional spray-by-calendar methods required an average of 21 applications, whereas on the integrated control plots only 14 sprays were used--a 33 percent reduction in quantity. Since each spray costs about US$10 per application per hectare, the net saving is about $70 per hectare. Furthermore, using this integrated approach yields were maintained at the same levels or were slightly increased, thereby providing an added incentive for adopting integrated pest control techniques. With the reduced quantity of insecticide being used, environmental effects and incidence of human poisonings are also reduced.

Because the application of the results of an environmental project of the kind being done by ICAITI depends upon education, extension, cooperation among cotton growers, and cooperation of the Central American governments, an application was made to UNEP for continuing the program through two additional years. During this period, ICAITI proposed to extend data-gathering aspects of the study, refine methods for reducing human poisonings from pesticides, implement more widely the integrated control approach, extend economic investigations and, through education-extension methods, help the Central American governments adopt the techniques that the study has shown to be so beneficial. Unfortunately, the UNEP was unable to finance the proposed activities. Some local education and field extension work, however, was continued by ICAITI with the Central American Cotton Growers Front.

CHILE

In spring of 1970, the Chilean National Commission for Scientific and Technological Research (CONICYT) requested technical assistance from the AID mission. Eventually, the request resulted in a jointly sponsored CONICYT-NAS workshop organized to review technical areas suggested by the Chileans. The workshop, held in Santiago, January 1971, was organized into five working groups--national science policy, nutrition and food technology, marine sciences, computer sciences and applied mathematics, and research and development in copper technology. Each group made recommendations in its particular field.

The working group on food and nutrition adopted over 20 recommendations. Among them were proposals for creating a national nutrition office and for using the expertise of governmental, industrial, and university representatives for formulation of a national nutrition policy. The group urged that a thorough study of the food industry be made so that rational policies to improve food production could be developed.

The working group in marine sciences examined a wide range of topics on the exploitation of marine resources--the upwelling phenomenon, fish resources in the distinct ocean regions along Chile's coast, marine pollution, ocean-air interaction, and marine geology. Recommendations called for the development of institutional coordination of all activities in the marine sciences and improved communication among Chilean and international institutions.

The working group on copper technology and the group on mathematics and computer sciences concluded that the most critical problem was a lack of qualified personnel; the group recommended specific steps for improvements at all levels of the educational system.

Immediately after the workshop, the Allende government reorganized the administration of CONICYT. Nonetheless, CONICYT officials proceeded to develop policies influenced by the workshop recommendations in at least three areas--marine sciences, applied mathematics and computer sciences, and nutrition and food technology.

The interest of the Chileans in copper technology prompted cooperation between the United States and Chilean participants. During the summer of 1971, Albert Schlecten, one of the U.S. participants, arranged for two U.S. professors to give short courses at the University of Chile on the use of the computer in the "analysis optimization and control of mineral processes." Following these courses, the U.S. professors were invited to the University of Concepcion to confer on the curriculum of the Department of Metallurgical Engineering.

In May 1971, Hellmuth Sievers, a marine scientist at the Chilean Naval Hydrographic Institute and a workshop participant, visited NAS to discuss the workshop's marine science report. A CONICYT policy planning group had met in early May and had accepted the entire report. Follow-up activitiy with NAS was discussed, particularly concerning the upwelling phenomenon, meterology, and marine pollution.

At the invitation of CONICYT, an NAS staff member visited Chile in July 1971 and met with the new chairman, Victor Barberis. At that time it was learned that a national office of nutrition had been set up. According to a CONICYT staff officer, three of the recommendations on mathematics were being implemented. In September 1971, Max Rutman, a Chilean food technologist and a workshop participant, visited the NAS. He reported on the creation of a National Protein Committee in Chile, and proposed collaborative activity between the two bodies.

Subsequently, although there were other modest follow-up efforts on an individual basis by NAS staff, the general political climate and lack of funding made it impossible to establish joint projects or study groups.

In 1974, Ing. Enrique d'Etigny, pro-rector of the University of Chile, proposed a joint workshop between the University of Chile and the NAS on renewable natural resources--agricultural research, forestry utilization, and marine (fisheries) development. Dr. Juan Valencia, University of Chile, was appointed chairman for the Chilean group. When he visited the United States for a two-month period early in 1975, extensive discussions were held on the agenda, possible participants, and physical arrangements for holding the workshop in Santiago in September 1975. Because of a lack of funds, BOSTID participation was impossible.

The Chileans, however, decided to hold a local workshop in preparation for a more comprehensive bilateral activity with the NAS. This workshop was held in Santiago, September 29 - October 2, 1975.

In September 1975 and again in January 1976, the Government of Chile intervened in the University of Chile by removing administrative officials and detaining a number of professors and students. These activities eventually resulted in the replacement of the pro-rector, several deans of faculties, and the heads of departments. Because of the unsettled conditions, workshop planning was suspended by NAS even though partial support for U.S. participants had been offered by a private foundation.

COLOMBIA

In 1967, a study of foreign assistance programs in Colombia commissioned by the International Technical Cooperation and Assistance Panel of the President's Science Advisory Committee (PSAC) was undertaken by a team headed by the NAS Foreign Secretary. On that occasion, discussions were also held with Colombians and U.S. Embassy and AID officials on the role of science and technology in the development process. These discussions led to the creation of a joint Colombian-U.S. workshop cosponsored by the Colombian Ministry of Education and the NAS and held in Fusagasuga, February 26 - March 1, 1968. Recommendations were formulated on education, industry, agriculture and natural resources, and national science policy planning.

In the implementation of workshop resolutions, Colombians gave priority to the establishment of (1) a cabinet-level Council for Science and Technology to deal with policy questions, and (2) an operating agency within the Colombian government for the strengthening of science and technology. To pursue these objectives, the minister of education requested consultant services from UNESCO for guidance on the structure and functions of an organization for science and technology. The NAS Foreign Secretary undertook the mission; UNESCO submitted that report* to the government of Colombia in the fall of 1968. In December, a cabinet-level Colombian National Council for Science and the Colombian Fund for Scientific Research and Special Projects "Francisco Jose de Caldas" (COLCIENCIAS) were created by presidential decree. COLCIENCIAS was placed organizationally within the Ministry of Education, but given legal status as an operating agency with a budget for supporting scientific research, manpower training, and special studies.

One immediate result of the first workshop was the assembling of Colombian industrial leaders in Medellin to explore ways to strengthen applied research in industry. This, in turn, led to a seminar in August 1969 on the administration of scientific research, sponsored by COLCIENCIAS and the Colombian Institute of Cultural Integration and assisted by the OAS, the West German government, and AID. An NAS consultant conducted a course on administration during the seminar. Also during the seminar of 1969, COLCIENCIAS coopted the services of an NAS staff member to assist in administrative and organizational planning.

Early in 1970, representatives of the NAS, COLCIENCIAS, the Colombian National Planning Office, and the Institute for the Development of Higher Education (ICFES) met in Washington and agreed to sponsor a series of joint studies on the potential for graduate education and research in chemistry, biology, mathematics, physics, earth sciences, and engineering in Colombian universities.

The timetable for the individual studies was as follows:

1. Chemistry. The joint panel met in Colombia, February 22-27, 1971, and visited the National University (Bogota), Antioquia University (Madellin), and the University of the Valley (Cali).

2. Mathematics. The joint panel met March 15-20, 1971; visits were confined to universities in Bogota--National, Andes, Javeriana, and National Pedagogical.

3. Engineering and Applied Sciences. The joint panel first met in February 1972 in Bogota and then divided into separate groups along disciplinary lines as follows:

    a. Chemical engineering. The universities of Antioquia (Medellin), Valley (Cali), and the Industrial University of Santander (Bucaramanga).

    b. Industrial and systems engineering. The universities of Medellin, Valley, Andes, and National (in both Bogota and Medellin).

    c. Mechanical engineering. The universities of Andes, Valley, and National (Bogota), the Industrial University of Santander, and the Technological University of Pereira.

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* Harrison Brown (1968) Report on Colombian science policy mission. In: Preliminary Report on Science Policy. Paris: UNESCO.

d. Physics, electrical and electronics engineering, and telecommunications. The universities of the Valley, Andes, National (Bogota), Cauca (Popayan), and the Industrial University of Santander.

e. Geology, mining engineering, and metallurgical engineering. The universities of Antioquia, Free (Bogota), and National (both Bogota and Medellin).

f. Civil engineering. The universities of the Valley, Cauca, Antioquia, Andes, and National (both Bogota and Medellin).

4. Biological Sciences. The joint panel met in Colombia May 29 - June 13, 1972, visiting Javeriana, Andes National Pedagogical, Jorge Tadeo Lozano, and National universities (Bogota), the University of the Valley (Cali), and Antioquia University (Medellin), as well as the Colombia-German Research Institute at Santa Marta, the joint marine laboratories in Cartagena of the University of Bogota "Jorge Tadeo Lozano," and the Naval School.

A multidisciplinary review panel met in Bogota on October 30-31, 1972 to examine each of the four studies and discuss summary conclusions. The review panel recognized that implementation of the studies on graduate education and research in Colombian universities was the responsibility of Colombian authorities. Furthermore, limited resources of highly trained manpower and of funds, and larger considerations of Colombian economic development would determine both the priority and the strategy for implementation of a national graduate education-research program.

Specific conclusions were:

1. Graduate programs in Colombia must be closely correlated with stated national priorities for social and economic development.

2. Before new graduate programs may be started in the universities, the need for highly trained persons in various specialties should be ascertained to ensure insofar as possible that job opportunities will exist.

3. Because of the importance of the National Information System and the Documentation Centers, especially in relation to graduate education and research, planning for graduate programs should include the use of these facilities.

4. A strong correlation between undergraduate and graduate programs was recommended.

5. Coordination of university graduate programs and manpower needs of industry are important to both the university and the industrial sector. Wherever possible, graduate theses should be related to industrial projects.

6. Exchange programs and better use of existing human resources can be strengthened through cooperative programs and opportunities for transfer of students among the Colombian universities.

7. Graduate programs should prepare new professors and also raise the level of in-service professors in the university system.

8. Along with graduate programs, there is need for an integrated system of maintenance and construction of instruments and equipment.

9. The minimum elements and criteria that distinguish a graduate program from other courses of advanced (nondegree) training need to be clearly identified.

10. Students in graduate programs could work to a greater degree than at present as teaching assistants in undergraduate courses, thereby benefiting both graduate students and the undergraduate programs of the universities.

Subsequently, the BOSTID staff director visited Colombia in February 1974 for program discussions with Dr. Efraim Otero, second director of COLCIENCIAS and William Ellis, then director of the AID mission. It was agreed that a joint COLCIENCIAS-BOSTID workshop would be held about July 1974. The workshop was to cover a broad range of topics of concern to Colombian authorities to be followed by joint study groups in priority areas.

1. Food and Nutrition. Review of a proposed Colombian research program in food science and technology and national nutrition policy.

2. Energy. Review of the potential for exploiting and using Colombia's substantial coal reserves, for both domestic purposes and foreign exchange earnings.

3. Industrial Research. Review of ways to step up the pace of Colombia's industrialization efforts by strongly linking government research, university investigations, and applied research activities.

4. Environment. Beginning of a rational Colombian governmental policy toward environmental problems by studying U.S. experience and participating in a general exchange of information on air and water pollution. Intensification of agriculture and industry and the rapid pace of urbanization have made environmental degradation increasingly evident.

The workshop, however, was not held. COLCIENCIAS turned its attention increasingly to international programs in which grants-in-aid are offered. NAS and COLCIENCIAS continued to maintain contacts and exchange information on program activities, but no joint projects are currently planned.

COSTA RICA

In October 1976 two BOSTID staff members visited Costa Rica in the course of a program development trip to Central America. Since Costa Rica has had favorable long term economic and social progress and about 30 years of U.S. foreign assistance totalling nearly $500 million, the U.S. was considering termination of its concessional economic assistance by 1981. The AID mission is concerned that significant joint activities continue after the end of assistance programs so that traditional cultural and economic ties remain and are strengthened, to perpetuate the long history of friendly relations between the two countries. The mission, responding to initiatives from the Costa Rican government, agreed that science and technology programs are one area of emphasis for continuing programs.

The discussions with the mission and with the Costa Rican National Research Council(CONICIT) resulted in agreement on the benefit of holding a joint workshop on science and technology planning and economic development in specific areas of interest to the Costa Rican government, such as natural resources utilization and conservation, marine resources exploitation, formulation of scientific manpower and agro-industrial development.

Possible follow-up activities in applied agricultural areas (utilization of forest products, further work on agro-industrial development, a pilot experiment on tropical plants) were also discussed.

A second staff visit to Costa Rica scheduled for May 1977 for further discussions about the proposed workshop had to be postponed for reasons unrelated to the Costa Rica program. At that time, the Costa Rica AID mission director informed BOSTID that CONICIT was still interested in the joint workshop, but not in the immediate future. Both the mission director and the Director of CONICIT met with BOSTID staff in Washington during summer 1977, but no firm date for a workshop was established. Since that time, the mission, CONICIT and BOSTID staff have been focusing upon the area of energy development, particularly an evaluation of non-petroleum potentials such as biomass conversion, geothermal resources, wind energy, and hydro-power development. CONICIT has formed a Costa Rican task force to assess each of these; a report is due by late 1978. A new series of discussions and planning for a joint workshop will then be held by BOSTID and CONICIT.

The AID mission informed BOSTID that it has a tentative project in the planning stage for applied science and technology in Costa Rican economic development. BOSTID was asked, in principle, if it would assist through a workshop late in 1978 along the lines of that which was originally suggested in 1976.

DOMINICAN REPUBLIC

The director of the Dominican Institute of Technological Research (INDOTEC), an agency of the Government of the Dominican Republic established to encourage national industrial development, visited the NAS in June 1974 to explore possibilities for a cooperative program with BOSTID. In September 1974, BOSTID advisor William J. Lawless and a BOSTID staff officer visited Santo Domingo to explore in greater depth the possibilities for a joint program. INDOTEC was created by the Central Bank of the Dominican Republic and is directly funded by the Bank as a semiautonomous agency. It has considerable operating flexibility, assured funding for the period 1974-79, and direct access through its governing board to the highest policy and administrative officials of the Central Bank.

Agreement was reached to hold a workshop in 1975, but the activity was postponed because INDOTEC was constructing its new technical and administrative facilities. Early in 1976, an invitation was extended by the Institute director, Ing. Alfonso Gutierrez, to resume planning. In March, Dr. C.O. Chichester, Vice President, Nutrition Foundation, and Professor of Resource Chemistry, University of Rhode Island, serving as an advisor to BOSTID, went to INDOTEC in Santo Domingo accompanied by a staff member to make final plans for the workshop. The workshop itself was held October 18-22, 1976 at INDOTEC headquarters and had as its purpose an examination of the opportunities for agro-industrial development in the Dominican Republic as well as the strengthening of INDOTEC's role in the industrialization of food.

The conclusions and recommendations arising from the workshop were directed toward INDOTEC's role in that sector of the economy as follows:

- INDOTEC, because of its specialized personnel and facilities, is uniquely equipped for technical-economic studies on the industrialization of nontraditional agricultural products such as mangos, avocados, papaya, cashews, guayaba, tamarind, and vegetable crops.

- INDOTEC, through its training division can strengthen the agro-industrial sector through organization of conferences, short courses, seminars, and other special programs.

- In the marketing of low-acid processed foods in the U.S. and Europe, new and more stringent regulations will soon be required. INDOTEC can assist Dominican food processors in training and certification of supervisors and production workers in these low-acid food processing industries.

- INDOTEC is uniquely equipped to assist Dominican small and medium industries in selection of equipment, plant location, plant layout, and other technical design aspects of food processing manufacture.

- INDOTEC can assist government agencies and industry in setting realistic agro-industrial quality standards.

- INDOTEC, together with other Dominican groups, both public and private, could collaborate in developing new local products of low cost and high nutritive value for the Dominican domestic market.

GUATEMALA

At the request of the AID mission director, Robert Culbertson, Dr. Harrison Brown visited Guatemala in August 1972 to explore possibilities for a bilateral program beginning with a workshop on science and technology in national development. Discussions with representatives of the Guatemalan National Economic Planning Council and the Ministry of Agriculture indicated considerable interest in a workshop focused on natural resources and their development in Guatemala. Representatives of the Guatemalan Academy of Medical, Physical, and Natural Sciences were brought into these discussions; the Guatemalan Academy at that time was reorganizing its structure and functions to assume a wider role as a nonpartisan, nonpolitical group that would be available, on request, to advise its government.

Talks with Guatemalan officials continued over a period of one year but did not lead to a specific joint project. In November 1973, the president of the Guatemalan Academy, Dr. Alberto Viau, visited Dr. Brown in Washington. The reorganization of the Guatemalan Academy had occurred, and that group was looking for funds to undertake a feasibility study of community development through health-agriculture and nutrition improvement. The Guatemalan Academy was anxious to demonstrate its ability to relate to a neglected area of the Guatemalan economy in a practical and specific manner. The goal was to enlarge the scope of public health centers already being established by the government (with an AID health sector loan) in over 300 small villages throughout the country by including a nutrition project and a self-help agricultural activity. Members of the Guatemalan Academy felt that the public health centers offered a unique opportunity to provide nutritional education and agricultural extension services to the rural population. The idea required study and discussion with rural leaders and Guatemalan government officials. To accomplish the task, the Guatemalan Academy needed approximately one year and US$10,000 for study expenses. Neither private funds or a government contract was available to the Guatemalan Academy. Dr. Viau appealed to the NAS as a sister institution to help in this situation.

The Tinker Foundation gave a grant of US$10,000 to the NAS on behalf of the Guatemalan Academy of Sciences for the rural health-agricultural extension feasibility study. The NAS agreed to assist informally in a review-evaluation of the feasibility study when it was completed.

In June 1974, the work began. Subcommittees on public health, nutrition, agriculture and animal husbandry, education, economics, and rural sociology were created. The work was undertaken on a voluntary basis by individual members of the Guatemalan Academy, and funds were expended for meeting and study expenses, travel and field collection of data in the rural areas of the country, and for secretarial-administrative services.

An initial report was written in July 1974 to indicate the methodology for the feasibility study. In October 1974, a progress report was sent to the NAS. By late March 1975, a rough draft of the feasibility study was available. The study was provisionally entitled "A Program for Health and Agricultural Development in a Small Community." It recommended pilot programs at each of four rural health centers where nutritional education was available for expectant and nursing mothers in the village (population: 1,000-1,500). By organizing a community garden project in conjunction with the health centers, food could be grown to supplement the diets of the expectant and nursing mothers and their preschool children. Thus, the nutritional education program, which was an established part of the health centers would be extended to provide food supplements under the supervision of medical-nutritional professionals. Furthermore, the community garden would be used as a place to demonstrate to the villagers a practical example of the growing of nutritious foods not normally included in their diets. Through cooperation with the Ministry of Agriculture, distribution of seeds and agricultural extension agents would help diffuse the knowledge gained from the community garden to the wider village and community. The goals were: (1) immediate nutritional-health benefits to expectant and nursing mothers and preschool children, (2) nutrition education to the villagers, and (3) agricultural education and services to the villagers.

Although the pre-feasibility study indicated promise and interest in Guatemala for the health-agricultural community development project as described above, funding of the definitive design stage proved to be impossible in 1975. The Guatemalan Academy proposed to continue the program on a pilot demonstration basis, but the earthquake in February 1976 intervened and rural reconstruction programs took precedence over all other activities.

In October 1976 a program development trip was made to Guatemala by BOSTID staff, who met with both mission and ROCAP officials. Neither the ROCAP or mission directors suggested ways in which BOSTID could become involved in their programs. ROCAP is primarily concerned with strengthening the Central American regional integration program, with agriculture and human resource development as the main emphases. The Guatemala mission is focusing its attention on the small farmer. This has taken the form of an agricultural loan to make credit more readily available to the smallest producers and to help them through improved extension services. A second loan, in the medical and health area, has established a training program for rural health technicians and provides facilities as well as back-up services in the implementation of a rural health care program on a countrywide basis.

GUYANA

In 1972, Dr. Ptolemy Reid, deputy prime minister of agriculture of Guyana, indicated to the AID mission in Georgetown his own interest and that of his government in applying the latest scientific and technical knowledge to converting the vegetation clogging Guyana's waterways into useful products. The National Science Research Council (NSRC) of Guyana and AID, in turn, requested NAS support for a workshop on the management and utilization of aquatic plants.

The joint NSRC-NAS workshop, held in Georgetown, March 15-17, 1973, was charged with making recommendations, for implementation by local authorities, on:

-- dealing with the aquatic weed problem, particularly by utilizing the vegetation for products such as animal feeds and soil additives needed by Guyana; and

-- developing outlines of integrated systems of aquatic weed management in Guyana using biological, physical, and chemical methods.

The workshop was opened by the prime minister of Guyana, the Honorable L. F. S. Burnham. At the conclusion of the workshop, practical demonstrations were arranged at the Bel Air Dairies on the outskirts of Georgetown. A press designed by one of the NAS panelists was used to remove moisture from water hyacinth--the first step in producing animal feed and soil additives-- and the pressed cake was fed to cattle and made into hay.

The participants concluded that no single method of management or control will be a panacea for Guyana's aquatic weed problems; most beneficial to Guyana as a whole will be a blend of different methods in which the benefits of each are maximized and its limitations minimized. For example, harvesting weeds may be satisfactory in accessible waterways where one species of plant predominates, but in less accessible waters, or in those with mixed stands, biological agents or herbicides may be preferable. In other cases, existing stands may be too dense and woody for a biological agent to be effective, so the best approach may be to attack the stand either by using herbicides or by harvesting and then using a biological agent as a follow-up to keep down regrowth.

In general, all methods of aquatic plant control complement each other and should not be considered competitors. When appropriately controlled, aquatic plants have many constructive roles in the aquatic environment:

1. producing oxygen;

2. serving as food, nest-building material, and sites for egg attachment for aquatic insects and fish;

3. protecting small organisms from predation;

4. converting silt and dissolved nutrients in the waterway to potentially usable organic matter;

5. serving as food for birds and land animals; and

6. anchoring soil in place.

Benefits are proportional to plant density to only a certain limit; when the plants form dense or extensive stands, detriments outweigh benefits and the plants become an economic burden.

Aquatic weed management should be aimed at maximizing and capitalizing on the benefits the plants bring to the country. Thus waterway clearing should be conducted to an extent appropriate for fishing, public health, navigation, drainage, and use of plants as a vegetable resource and water purification tool.

These goals do not often call for eradicating the plants. Moreover, few weed control methods can destroy the roots, tubers, and rhizomes of submerged weeds and emergent weeds buried in mud. Such rooted structures can be reached only by a few animals that dig them out or by complex machinery. At present, eradication of submerged and emergent weeds is almost impossible.

The following joint recommendations emerged from the workshop:

1. The NSRC of Guyana should create a continuing committee on aquatic plant management with membership from all organizations that have authority over, or are interested in, the country's waterways.

2. Guyana should institute extreme efforts to protect against the introduction of any aquatic vegetation that could worsen the existing problem, and take measures to prevent plants from spreading from infested to noninfested areas within Guyana.

3. Specific research projects and studies should be devised for the utilization of processed and unprocessed aquatic weeds.

4. Local fisheries scientists should determine the potential of certain fish to survive, grow, and control weeds in different types of waterways in Guyana.

5. Trials to use manatees for practical weed control in carefully selected canals, lakes, and permanent reservoirs should be instituted.

6. Methods for biological controls should be investigated as follows:

   a. Propagules of three species of spikerush (Eleocharis coloradoensis, E. acicularis, and E. parvula) should be brought to Guyana from the United States and studied under quarantine conditions for their potential to displace harmful weeds.

   b. Waterfowl can help remove vegetation from waterways; their husbandry could become important in Guyana as a self-supporting adjunct to conventional aquatic weed management.

   c. Although the utilization of insects as controls for aquatic weeds in Guyana is remote, the water hyacinth weevil Neochatina eichhornii, currently a leading candidate for the biological control of water hyacinth, is found in the interior of Guyana.

7. Controlling aquatic weeds with herbicides has proven effective on sugar estates in Guyana. However, a proposal was made that Guyana set up a pesticide committee or authority to monitor pesticide levels in water used for domestic purposes. The workshop also acknowledged that herbicides should not be considered a long-term solution, and that if adequate alternative controls can be found, their uses should be encouraged.

8. All electric power in Guyana is now produced in thermal power stations; yet many potentially valuable hydroelectric sites exist in the interior,

and schemes to utilize them are under consideration. Because of the probable development of costly weed infestations, hydroelectric plants in Guyana should include preventative measures to ensure that dammed water does not become infested with aquatic weeds.

An International Manatee Research Center

A separate recommendation emerged from the joint workshop panel to explore the possibility of establishing an international manatee research center in Guyana. Almost nothing is known about the breeding habits and reproduction of the manatee. It has never bred in captivity, and a complete physiological and reproductive study is needed if its breeding is to be understood. Research is urgently required to find ways to stimulate and speed up manatee reproduction so that what is a slow reproductive process at present can be made more regular and more productive.

Guyana is a most logical place to conduct this research. The Caribbean manatee and the Amazonian manatee are both native to Guyana. Guyanese scientists have had more experience with manatees than any others, and the physical conditions are ideal.

In conjunction with the International Development Research Centre of Canada and the NSRC of Guyana, the NAS cosponsored a workshop in Guyana, February 7-13, 1974. Scientists from eight countries, representing 23 research institutions, considered in depth the status, utility, conservation, and biology of manatees. The participants included internationally recognized scientists with experience and knowledge encompassing manatee research, mammology, veterinary science, reproductive physiology and endocrinology, wildlife management, nutrition, organization of science institutions in developing countries, operation of international organizations, and the utilization of manatees for weed control.

It was concluded that research on manatees is urgently needed and is critical to the survival and utilization of the species. Intensive involvement is required of a wide range of scientific disciplines including physiology, ecology, behavior, and conservation. This can best be accomplished through the establishment of a relatively small international center for manatee research. Despite some difficulties, Guyana offers incomparable opportunities as a location for such a research center.

Objectives of the proposed research center include increasing manatee numbers; promoting their conservation and husbandry; investigating the use of manatees for aquatic weed control and food; and contributing to mammology and tropical scientific research.

An interim steering committee has been appointed to consider the institutional structure and actions necessary to establish and operate a manatee research center.

Workshop on Improving Standards and Quality Control in Locally Processed Foods

During the past several years, discussions have been held with Ms. Eileen Cox, a nutritionist who is chairman of the Standards Section of the NSRC, and

Dr. Patrick Munro, the newly appointed executive director of the NSRC, about the possibility of a joint workshop on quality control in foods. Ms. Cox visited the U.S. in November 1975 and BOSTID arranged various meetings with members of the Food and Drug Administration as well as the National Research Council. At that time, it was decided that as a first step a BOSTID staff member should visit Guyana, accompanied by an expert to determine the type of panelists needed and the agenda, and to talk with U.S. AID officials.

In attempting to arrange such a visit, in March 1976, BOSTID staff was informed by the AID/OST office that the U.S. Bureau of Standards was already in communication with Dr. Dennis Irvine regarding assistance in weights, measures, and standards. They did not know whether that program would also extend to quality control in foods. After discussing the situation with staff members of the Bureau of Standards, BOSTID wrote to the NSRC to determine whether there would be an overlap in the two potential programs.

HAITI

During a brief visit to Port-au-Prince in March 1973, made at the request of AID Washington, NAS staff called on an official of the Haitian National Research Council and the AID office to determine the interest in and desirability of establishing a cooperative program. Since AID had recently been reestablished in Haiti over an eight-year hiatus, no specific project ideas were developed; however, it was agreed that AID officials would inform the NAS if any program areas of possible mutual interest developed.

As a result of the AID evaluation of BOSTID's program in 1975, it was decided that BOSTID staff should visit Haiti, which they did in October 1976. They identified several areas in which BOSTID could work effectively, such as:

-- participating with local groups and international organizations in small, appropriate technology activities in rural areas;

-- organizing with local Haitian groups a seminar on natural products utilization and development; and

-- participating with the AID mission in erosion and aridity studies which will suggest means to return land to productive agriculture.

MEXICO

The NAS has had continuing contact with the Mexican scientific community for several years. However, in 1373 the Mexican National Council for Science and Technology (CONACYT) formally asked the NAS to cooperate in sponsoring a workshop on industrial research in Mexico that would focus on:

-- planning for research;

-- management of research;

-- information systems;

-- research extension;

-- links between universities and industry;

-- the relationship of government laboratories to industries; and

-- the role of industrial research in national development planning.

It was hoped that a bilateral program would emerge from the first workshop with emphasis on industrial research. The initiation of this program has been delayed for some time now due to problems of funding NAS participation.

PERU

The bilateral program with Peruvian scientists emerged from activities of the Latin American Science Board, which met in Lima in 1964.

In April 1966, an ad hoc group of Peruvian scientists participated with the NAS in organizing the first U.S.-Peru workshop on the Role of Science and Technology in Peruvian Economic Development, held in Paracas. The workshop considered ways of improving scientific and technological research and education in Peru. In the discussions, participants gave highest priority to the creation of a Peruvian National Research Council (PNRC).

Subsequently, a panel of four Peruvians met with NAS colleagues in Washington to formulate the basis for the proposed organization. Charters and statutes of several national research councils were studied and compared in the context of Peruvian needs.

Legislation necessary for the creation of the PNRC was delayed until 1969. During the interim, however, other efforts to examine and improve Peruvian science took place. UNESCO advisor Jacques Ruffie consulted with the Peruvian Ministry of Education between mid-1967 and 1968 and submitted recommendations for the creation of an office for scientific and technical affairs and a PNRC. In June 1967, a team headed by the NAS Foreign Secretary studied the foreign assistance implications of scientific and technical needs in Peru for the International Technical Cooperation and Assistance Panel of the President's Science Advisory Committee, Executive Office of the President. At that time, plans were already underway for a second workshop, which took place in November 1967, sponsored by the NAS and the Peruvian Academy of Sciences. At this workshop the Peruvians founded, on their own initiative, the Peruvian Association for the Advancement of Science (APAC). A grant from the Ford Foundation helped this organization get started. The NAS arranged for the APAC's first president to visit the United States in 1968 to meet with officers of the AAAS and other U.S. science institutions, and to attend the second NAS-Brazil workshop in Washington.

The PNRC was finally brought into being in January 1969. The Council, essentially as recommended by the workshop, had as its first chairman Alberto Giesecke, director of the Geophysics Institute of Peru and one of the prime organizers of the two workshops. Because of strained political relations following the military coup in 1968, the initiation of formal cooperative projects with the newly established research council was delayed. However, fairly frequent contact between U.S. and Peruvian scientists continued.

An NAS staff member visited Peru in July and December 1971 to meet with representatives of the PNRC, the National Council of the Peruvian Universities (CONUP), the National Engineering University, Cayetano Heredia University, and the AID mission. At the invitation of the Peruvian National Planning Office, the NAS helped plan a joint workshop to consider Peruvian national nutrition plans. This proposed workshop, scheduled for mid-May 1972, was postponed indefinitely at the request of Peruvian authorities because of lack of funds and difficulties caused by changes in the Planning Office.

In 1973, Dr. Isaias Flit, director of the Institute for Technological Research and Standards (ITINTEC) of the Peruvian Ministry of Industry and Commerce, expressed an interest in convening a workshop concerned with assessment of priorities in industrial research.

A Workshop on Industrial Research Programming and Management with ITINTEC was held January 23-28, 1975 in Lima, Peru. U.S. and other foreign participants first visited ITINTEC and several industrial sites where research and development activities were actively pursued. Peruvian workshop participants came from ITINTEC, a government research support organization for the mining sector of Peruvian industry, the national steel company, private manufacturing firms (textiles, food processing, and metal working), and two other government agencies. Although formal papers were not prepared by the participants, resource persons did make presentations on aspects of industrial research and development of particular concern to the Peruvians including:

1. linking research to local problems;

2. research and development information resources and services;

3. evaluation of research proposals and ongoing research;

4. training of personnel for research and development;

5. financial management;

6. establishment of criteria for relating research and development to larger national goals; and

7. generation of research and development beyond immediate industrial problem-solving activities.

A distinctive feature of the workshop was the opportunity for free, extensive discussion of research and development problems in the Peruvian context.

Although no formal document presenting conclusions and recommendations was prepared at the workshop, the following issues were identified as being of particular concern to ITINTEC:

-- Manpower. Critical to the entire question of performing applied research is the supply of trained manpower at all levels. The need for multidisciplinary research in Peru clearly exists, but there is a dearth of educational and training institutions involved in preparing the needed manpower.

-- Facilities. At present, there are no general industrial research institutes in Peru. Although this situation has certain advantages, there is a need for one or more imaginatively organized and well-staffed applied research organizations with strong ties to Peruvian industry. Only with local capabilities in research and development can dependency upon imported technologies be significantly reduced.

-- Information Resources and Facilities. An adequate information resource base does not yet exist in Peru. Until such a facility is operating, <u>no</u> research and development activities can be fully effective.

-- Planning. Neither at the interface between industry and government nor within government does a planning mechanism exist that currently analyzes the allocation of scarce resources for industrialization. One of the opportunities ITINTEC provides is that of relating government policy to industrial development and communicating these policies to universities so that a local, independent science and technology capability can be created in Peru that is on a par with that of more industrialized nations.

Several aspects of the 1975 workshop are worthy of note. First, it represented a renewal of BOSTID activities in Peru; although there has been considerable informal contact, no formal projects have been undertaken since 1967. Secondly, the workshop showed that the scientific-technical groups do bridge gaps and, in spite of diplomatic-economic differences, hold mutually productive joint discussions. The NAS expects that follow-up activities will be possible A third positive result demonstrated by the workshop is that unstructured meetings possess merit and can be as productive as the more formal workshops or seminars normally preferred by the NAS. Finally, the workshop topic "industrial research" bore on the larger questions of technology transfer and "appropriateness" of technologies, which are of growing concern within the hemisphere.

VENEZUELA

Discussions have been underway for several years with officials of the Venezuelan National Council of Scientific and Technological Research (CONICIT) and the Venezuelan Academy of Sciences regarding a cooperative science program with the NAS. The Venezuelan government, through its national planning authority CORDIPLAN, designated health, metallurgy, petroleum, and agronomy as priority science and technology areas for 1973-1978. A graduate program in metallurgical engineering and materials sciences is being undertaken at the Central University in Caracas; BOSTID was asked informally to assist in a review of the teaching program and research goals.

In addition, discussions regarding possible cooperative programs were also held with representatives of the Venezuelan Institute of Scientific Research (IVIC). IVIC, which until recently concentrated its efforts in basic research, has established a technology center and has begun to offer postgraduate training in the basic sciences and social anthropology.

In response to a number of informal Venezuelan requests for programs, BOSTID proposed a general workshop on science and technology to establish priorities for areas of collaboration and to discuss institutional arrangements, especially between CONICIT and IVIC. Implementation of this proposal was not carried out due to the unavailability of funds to support NAS participation.

Workshop on Science and Technology for the Urban Poor

The workshop on "Science and Technology for the Urban Poor," held in Caracas, March 6-11, 1977, focused attention on three areas--small-scale industries, recycling waste, and urban farming.

The following conclusions were made:

Small-Scale Industries

1. The Venezuelan Foundation for Community Development (FUNDACOMUN), with the assistance of Habitat, ORAP and other community agencies, should conduct a resource assessment and analyses of each of the barrios in Caracas.

2. Feasibility studies should be performed by competent experts to define the desirability, organization, costs, and related elements of small-scale industries in the following areas:

   silk screen print production

   paper recycling

   solid waste recovery

   urban farming

cable television

technical training

building materials supply

building construction

3. Demonstration projects should be undertaken to validate the feasibility analysis and to permit modifications at low cost.

4. FUNDACOMUN should establish a registry of Venezuelan technology experts who are willing to assist in all phases of project development.

5. Beginning with the resource assessment process, the technical assistance function should be gradually transferred to barrio organizations, thus permitting the intermediate organizations to move into more sophisticated project analysis and project development.

6. Small-scale industries owned and operated by barrio development organizations should not be restricted to barrio locations. The barrios are essentially residential settlements, where land use is already intensive and highly productive in economic and social terms. Hence barrio-owned and -operated enterprises should be located throughout the broader metropolitan area and the criteria for the selection of sites should be for efficiency demands of the enterprise. Further, this approach will facilitate the establishment of economic linkages between small-scale barrio industries and the major industrial sectors of the national economy.

7. FUNDACOMUN should begin to plan for the creation of community development corporations at the barrio level once entry-level industries are established. These nonprofit corporations will ultimately take on project planning and program management functions.

Funds should be provided to private agencies who are prepared to involve barrio residents in the conduct of these studies.

Urban Farming. The following should be undertaken in the barrios in Caracas:

1. The collection and exchange of information on urban farming systems should be stimulated.

2. FUNDACOMUN should organize and support an ad hoc group on urban farming.

3. An experimental program should be established in one or more barrios in Venezuela.

4. All projects should be related to educational programs in areas of nutrition, ecology, and health.

5. Efforts should be made to form small cooperations in the barrios for the production of flowers and food.

6. Consideration should be given to reserving space for urban farming in future barrio remodeling.

7. A follow-up information exchange between the U.S. and Venezuela should take place in six months.

Water Recycling

1. A study should be made of the feasibility of having household garbage separated into organic and inorganic portions within the house.

2. Demonstration experiments should be provided in the barrios on waste recycling, especially for gas and fertilizer production as well as the fabrication of metal utensils.

3. An experimental project should be developed in one barrio to study the functioning of a complete ecosystem.

Middle East and North Africa

EGYPT

During 1974 and 1975, BOSTID members and staff held discussions with the president and other officials of the Academy of Scientific Research and Technology (ASRT), Arab Republic of Egypt, concerning a joint workshop on policy issues relating science and technology to Egyptian economic development. In a somewhat parallel effort, the government-level Egyptian-U.S. Joint Working Group on Technology, Research, and Development recommended at its first meeting in Cairo, in November 1974, that a symposium on research and development planning and management be held early in 1975. Because the two subjects are so closely related, and because of advantages occuring from an activity involving a broad spectrum of scientists, economic planners, engineers, and other development specialists, BOSTID, the U.S. National Science Foundation, and the Egyptian Academy joined together to organize and convene:

1. A symposium on science policy planning to explore means of strengthening Egypt's reorientation of research and development toward national economic and social goals. U.S. participants were H. Guyford Stever (Director, NSF), George S. Hammond (Foreign Secretary, NAS), and Roy L. Lovvorn (Administrator, State Cooperative Research Service, USDA). Egyptian participation was led by M. A. El-Guebeily (Minister for Scientific Research and Atomic Energy), A. M. Abou El-Azm (President, Egyptian Academy), and M. Hassan Ismail (President, Cairo University). The symposium was held at the National Research Center, Cairo, April 30-May 1, 1975.

2. A workshop on science and technology policy, planning, and management to examine Egypt's research management practices in its applied research institutes and universities. This activity was also held in Cairo, at the headquarters of the Academy of Scientific Research and Technology, May 3-8, 1975. U.S. participation was headed by Franklin A. Long (Cornell University) and included eight additional persons from universities, private research institutions (Rand Corporation), and industry (Exxon and Du Pont). The Egyptian group was headed by A. M. Abou El-Azm and Mohamed Kamel (Director, National Research Center).

The workshop departed from usual bilateral activities in that Egyptian participation averaged 50 persons per session. Unfortunately, the Egyptian Academy was unable to restrict official participation and therefore interaction between U.S. participants and Egyptian groups was more formal than is usually the case in BOSTID workshops. Nevertheless, Egyptian participants were extremely open and candid concerning restrictions and their adverse effects upon research in the Egyptian applied R&D system.

Foremost among the conclusions reached was recognition of the need to increase the effectiveness and efficiency of Egypt's applied research laboratories. The government looks upon these laboratories as a major vehicle for accelerating social and economic development. Both sides agreed to the formation of a BOSTID-Egyptian working group on industrial research management similar to those organized by BOSTID in Brazil, Taiwan, and Korea. The AID mission director in Cairo expressed interest in assisting a follow-up project.

Additional conclusions and recommendations focused upon activities that the Egyptians themselves must undertake to improve research and development planning and management. These included:

-- a reexamination of the applied research institutes aimed at defining the goals and mission of each more explicitly, determining the needed physical and manpower requirements, and linking the institutes closely with specific development programs;

-- the elimination of university-oriented thesis research in applied research laboratories;

-- adjustment of promotion and salary procedures to be more realistic to R&D;

-- establishment of R&D management training programs;

-- strengthening the universities' research facilities and providing adequate resources to the universities to do their own research programs;

-- strengthening manpower inventory and planning activity of their Academy; and

-- the formulation of a national science plan within the framework of the nation's overall economic plan.

The Egyptians have taken steps to implement a number of these recommendations.

Aquatic Weed Seminar

Following the November 1975 regional workshop on aquatic weed control management and utilization in Khartoum, members of the NAS panel visited Cairo for discussions with Egyptian scientists and planners under the sponsorship of the Egyptian Academy of Scientific Research and Technology. Discussions focused on biological control techniques in the extensive irrigation canal system. Of particular interest to the Egyptians were spikerushes (which form underwater "lawns" of short dense grass which crowd out the longer-stemmed plants) and the grass carp, an aquatic weed-eating fish that also produces edible flesh.

Two panelists returned to Egypt, May 20-27, 1976, taking with them spikerush seed and grass carp fry. While there, the panelists visited several research stations and ponds to determine the best conditions and quarantine circumstances. They also presented talks to Egyptian scientists and technologists on how grass carp and competitive plants could be used for aquatic weed control in Egypt.

Applied Science and Technology Research

In May 1977, the AID mission director in Egypt invited NAS to send someone to Egypt to discuss a new effort to improve R&D policy planning and management within the Egypt science and technology system. The program directly follows from recommendations of the 1975 NAS-NSF-ASRT workshop.

Basically, AID has asked NAS-NRC, through BOSTID, to assume responsibility for the following program elements:

1. Policy Planning and Management. With the Egyptian Academy, BOSTID will establish a Joint Consultative Committee (JCC) which will serve in an advisory capacity to the president of ASRT. The JCC will consist of three U.S. scientists and three Egyptian scientists and will meet at approximately six-month intervals to provide overall guidance for the program. The JCC will also have a review and evaluation function for its projects and will be responsible for preparing a program plan for the succeeding three-year period for AID review before the end of the second year.

2. Technical Assistance for Management of R&D Projects with ASRT. BOSTID will recruit and provide logistic support in Egypt to a resident advisor to the president of the ASRT. The advisor will assist in program conceptualization, make recommendations for U.S. consultants, work with the consultants when they are in Egypt, and serve as the principal American link to the JCC. Funds will be made available for training of Egyptians in well-planned, short-term programs (1-4 months) in Egypt and in the U.S. Within the funds available in years 1 and 2, approximately three to five specific R&D pilot projects will be selected for program support. The support may include consultants, training, and other resources. BOSTID will rely upon its previous experience in other areas of the world, tailoring the technical assistance "delivery" mechanisms to include advisory panels, study groups, workshops, and seminars. Equipment funds from a separate NSF contract with AID will also be provided directly to the ASRT for the R&D projects.

3. Technical Assistance for Management of R&D with the National Research Centre. This aspect of the program parallels that described in Part 2 above, including a resident advisor to the director of the National Research Centre. One broad multidisciplinary R&D "pilot" project with the Centre has already been selected by the Egyptians and included in the AID program. The pilot project is called "More and Better Food" and is directed to a study plus field program to strengthen food pro-

duction, food processing technology, and a field nutrition aspect for mothers and young children in a specific rural location. There is to be a careful study and data analysis aspect to the "More and Better Food" program during the entire five-year life of the program. During years 1 and 2, project design and preliminary baseline data are to be gathered. Field work and village level nutrition projects will follow during years 3 through 5.

IRAN

Discussions took place in 1974 and 1975 with Iranian officials of the Ministry of Science and Higher Education and Arya Mehr University regarding possibilities of collaboration with NAS on the exchange of scientists between the two countries, workshops on science policy, and the development of the graduate studies in societal technologies at the new campus of Arya Mehr University in Isfahan. It is anticipated that some activity of this nature may be undertaken in the near future, possibly with AID/STS support for BOSTID's involvement in the initial stage. The details of the collaboration are still under discussion.

JORDAN

A BOSTID staff member visited Amman in late April 1977 for discussions with AID mission and Royal Scientific Society (RSS) officials. The RSS was created in 1970 and has been expanding both in terms of staff and research programs at a rapid rate. While officials of the RSS as well as of AID appeared to be interested in a joint NAS-RSS program, RSS officials felt that without firm financial support from AID there was little purpose in continuing discussions. A UNESCO-supported science policy workshop will be held in Jordan in February 1978, at which the relationship of the RSS and S&T to national development will be discussed. BOSTID has been invited to attend the workshop.

TUNISIA

BOSTID's first cooperative activity in Tunisia was a workshop on "Systems Analysis and Operations Research (SA/OR)," which was cosponsored by the secretariat general of the Tunisian prime minister's office and held in May 1977. The 1976 NAS report, Systems Analysis and Operations Research: A Tool for Policy and Programming for Developing Countries, had aroused the interest of Tunisian authorities, particularly as to the applicability of

SA/OR in addressing problems of government decentralization and administrative reform. At the request of the AID mission, Dr. Philip M. Morse, chairman of the BOSTID panel that authored the SA/OR report, visited Tunis in November 1977 to confer with Tunisian officials about their problems and needs and the objectives of administrative reform. General agreement was reached that an SA/OR capability could, by improving administration, aid the government's efforts to further development goals. The prime minister's office requested AID's assistance in establishing an SA/OR program.

Subsequently, BOSTID was asked to appoint a small panel to participate in a joint workshop in Tunisia which would (1) further explore the problems that might be undertaken by an SA/OR group in Tunisia, (2) facilitate a broader understanding among administrators of SA/OR and its potentials, and (3) provide advice as to which components of an SA/OR program might be funded by AID. Dr. Morse was appointed to chair the BOSTID panel of four SA/OR experts. A panel member and BOSTID staff person visited Tunis in April 1977 to formulate the schedule and agenda with the Tunisian coordinator, Mr. Mohamed El Habib Ben Abdessehem, Deputy Inspector General, Administrative Services, Office of the Prime Minister.

Within the general framework of applying SA/OR to administrative reform, the workshop (May 23-26) focused on three illustrative subtopics: (1) organization and structure, (2) personnel management, and (3) interagency coordination against pollution. Prior to the workshop, the BOSTID panelists visited academic centers to familiarize themselves with Tunisian resources in the disciplines necessary for SA/OR undertakings. More than 50 Tunisians participated in the workshop sessions, which were divided along the lines of the three subtopics. The activity served a catalytic function by bringing together government officials, administrators, research scientists, and university professors to share in exploring the utility of SA/OR methods.

Each of the three workshop subgroups recommended that SA/OR be used in future planning and stressed theneed for a comprehensive approach to the problems confronted. The prime minister's office was viewed as the logical base for SA/OR planning relating to administrative reform; the BOSTID panel offered suggestions as to the composition, mode of operation, and responsibilities of a small SA/OR groups in that office.

The Tunisians responded enthusiastically to the workshop, and the prime minister's office is proceeding with the establishment of an SA/OR group. Support for this effort, including funding of an American senior advisor and a BOSTID liaison panel, has been included in the AID mission's science and technology budget for the next two years. Future BOSTID assistance in other areas (e.g., science policy, energy, pollution) integrating science and technology with development planning is encouraged by the mission, but specific activities and Tunisian counterpart organizations have not been identified.

TURKEY

In November 1971, the BOSTID staff director met with the Secretary General of the Scientific and Technical Research Council of Turkey (TUBITAK) and the president of the Middle East Technical University (METU) at the request of the director OST/AID. In the course of these discussions, agreement in principle was reached on a joint Turkey-NAS workshop on the role of universities and research institutes in stimulating industrial development. The underlying purpose was one of coordination. As is the case in many countries in which similar functions are divided among goverment, university, and private groups, internal planning and communication among interested groups in Turkey tends to be limited. At the time of this visit, the local AID mission was in agreement with the NAS-TUBITAK initiative and a workshop in April 1972 seemed certain.

Early in 1972, when an NAS staff visit to Turkey was planned together with that of the director of the Research Triangle Institute, the mission's attitude toward the proposed workshop changed abruptly. The AID view that:

1. METU's needs for specific technical assistance on internal R&D planning and management had priority over an NAS-TUBITAK workshop. Accordingly, the Denver Research Institute was given a contract for a seminar with METU.

2. AID was not prepared to support any activities with TUBITAK; therefore, holding a workshop, even with AID Washington funds, would raise unrealizable hopes. The mission specifically withdrew its endorsement of a proposed NAS-TUBITAK workshop for at least one year.

During 1972, efforts were made to reopen the matter of an industrial research planning and coordination, but the mission was adamant in its decision. In 1973, the mission's preoccupation centered on questions of poppy growing and the illicit drug trade. No attempt has been made since to reopen the question of the NAS-Turkey workshop with the mission; TAB/OST in Washington advises that the situation has not changed.

YEMEN

In response to a request from the mission director, a BOSTID staff member visited San'a for a week in late 1975. Discussions focused on problems of water resource management policies in this semiarid highland agricultural country. There is evidence that the traditional, highly sophisticated system of rainfall harvesting to support sorghum production, the national grain staple, is in danger of breaking down due to shortage of manpower resulting from employment opportunities in the neighboring oil-rich states. Studies of groundwater by AID, British ODA, and the IBRD are underway, and it is hoped that the results will provide the basis for an AID-funded workshop on water-use policies in the future.

ADVISORY COMMITTEE ON TECHNOLOGY INNOVATION

While a developing country is generally well aware of its development problems, it frequently is not in a position to avail itself of all the benefits advanced technologies can offer toward solving these problems. Indeed, these technologies may often be inappropriate to the particular circumstances in developing countries, and it has become fashionable to identify or devise "appropriate," "intermediate," or "adaptive" technologies for such situations. What often is more to the point, however, is to identify those technologies that may be dormant or used in a different fashion in the United States or other developed countries but that could be applied quite usefully in developing countries. This problem of identifying and transferring innovative uses of technology--and of fostering the related research and development--to developing countries remains, for the most part, unsolved. This is responsible for a very serious gap in the assistance programs provided by developed countries.

To respond to this need, an Advisory Committee on Technology Innovation (ACTI) was established by BOSTID at AID's request. This committee was organized in 1971 and held its first meeting in September of that year.

The program supervised by this committee had two specific objectives: (1) generating ideas for innovative applications of present-day technological developments to immediate problems of developing countries; and (2) identifying areas of research where concerted effort can drastically shorten the time lag characteristic of the normal progression of scientific advance to potential application.

The committee and staff, in selecting projects of interest, attempt to stay continually aware of the activities of other technology-oriented development groups, and an approach to problem-solving that is amenable to realistic implementation. The approach evolved by ACTI is, in principle, the progression from (1) initial idea exploration by the committee to (2) ad hoc advisory group studies to (3) in-depth study by expert panels to (4) project recommendation. This progression, however, is altered to suit particular cases, and the value of maintaining flexibility has been amply justified by experience thus far. The subjects considered by the committee originate with the staff, the committee, or with AID. Some suggestions have been rejected by the committee; some are considered by ad hoc advisory groups; and some are taken directly to expert study panels.

A significant characteristic of the committee is the broad range of its members' backgrounds, which extends from international organizations, to engineering, to botany, to food technology. Equally important to the committee's operation, as its activities unfold, is the participation of members from developing countries. One means of achieving such participation is exemplified by the fourth Brazil-U.S. workshop of the National Academy of Sciences. A presentation of the goals and mode of operation of the committee elicited considerable interest from the Brazilian participants and led to a strong recommendation by the workshop that a formula be developed to ensure formal Brazilian representation on the committee and involvement with its activities. The committee is eager to intensify such participation by establishing counterpart innovation groups in developing countries with whom the committee would maintain close liaison and share ideas and information. Steps have been taken to this end in Brazil. The committee considers this type of exchange one of the most important aspects of its work because it represents a direct way in which approaches and solutions originating in developing countries not only can be disseminated, but also can affect the committee's own programs.

The specific activities undertaken so far and their status are shown in Table 2. Descriptive material on each activity follows.

Table 2. Studies of the Advisory Committee on Technology Innovation, Sources of Funding, and and Status of Studies

STUDY	Sources (s) of Funding	Status	Total Number Copies Printed
Ferrocement: Applications in Developing Countries	OST/AID	Completed	11,000
Mosquito Control: Some Perspectives for Developing Countries	OST/AID	Completed	7,000 (out of print)
Food Science in Developing Countries: A Selection of Unsolved Problems	OST/AID	Completed	23,000 (out of print)
Roofing in Developing Countries: Research for New Technologies	OST/AID	Completed	5,000 (out of print)
More Water for Arid Lands: Promising Technologies and Research Opportunities	OST/AID	Completed	16,000
Underexploited Tropical Plants with Promising Economic Value	OST/AID	Completed	21,000
The Winged Bean: A High Protein Crop for the Tropics	OST/AID; TA/AGR	Completed	13,000
Products from Jojoba: A Promising New Crop for Arid Lands	OBO; HEW; OST/AID*	Completed	2,000 (out of print) (overrun copies only)
Energy for Rural Development: Renewable Resources and Alternative Technologies	OST/AID	Completed	17,500
Methane Generation from Human, Animal and Agricultural Wastes	OST/AID	Completed	10,000
Making Aquatic Weeds Useful: Some Perspectives for Developing Countries	OST/AID	Completed	12,000
Guayule: An Alternative Source of Natural Rubber	BIA; OST/AID** USDA	Completed	6,400
Tropical Legumes: A Resource for the Future	TA/AGR OST/AID	In Progress	10,000 planned
Leucaena: Promising Forage and Tree Crops for the Tropics	TA/AGR OST/AID	Completed	12,000
Firewood Crops: Bush and Tree Species for Production	OST/AID	In progress	10,000
Underexploited Microbial Processes of Potential Economic Value	OST/AID	In progress	10,000

*Funding for overrun copies for distribution to LDCs.
**International participation and partial publication costs.

Table 3. Individual requests filled for selected* ACTI reports, through May 1, 1978

	LEAST DEVELOPED COUNTRIES	OTHER DEVELOPING COUNTRIES	DEVELOPED COUNTRIES	U.S.	TOTAL
GOVERNMENT					
ministry/agency	788	1,174	392	1,669	4,023
research institute	543	763	411	622	2,339
USAID	309	839	10	1,396	2,554
other	271	274	151	792	1,488
UNIVERSITY/SCHOOL					
indiv. professor	587	1,469	1,094	3,720	6,870
library	186	1,355	379	636	2,556
course use	103	139	172	965	1,379
student	66	139	187	739	1,131
other	161	387	243	1,229	2,020
PRIVATE ENTERPRISE					
research institute	219	419	440	1,076	2,154
bookseller	32	55	175	234	496
consulting firm	68	94	165	428	755
individual	341	986	713	2,644	4,684
other	203	587	641	1,725	3,156
INT'L ORGANIZATIONS					
UN & related	138	187	217	243	785
development banks	11	45	26	409	491
other	88	656	104	402	1,250
CHARITABLE/RELIGIOUS ORGANIZATIONS	272	152	263	274	961
OTHER	50	17	33	74	174
TOTAL	4,436	9,737	5,816	19,277	39,266

Table 4. Distributed copies* and multiple requests of selected ACTI reports, through May 1, 1978

	LEAST DEVELOPED COUNTRIES	OTHER DEVELOPING COUNTRIES	DEVELOPED COUNTRIES	U.S.	TOTAL
More Water for Arid Lands: Promising Technologies and Research Opportunities		(no record kept)			
Underexploited Tropical Plants with Promising Economic Value	859	1,373	218	1,523	3,973
The Winged Bean: A High Protein Crop for the Tropics (excludes first printing of 3,000 copies)	20	170	160	292	642
Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries	623	1,441	650	1,956	4,670
Making Aquatic Weeds Useful: Some Perspectives for Developing Countries	385	727	364	916	2,392
Guayule: An Alternative Source of Natural Rubber (excludes 750 copies from second printing distributed by USDA)	163	283	93	1,885	2,424
Leucaena: Promising Forage and Tree Crop for the Tropics	360	752	565	1,011	2,688
TOTAL	2,410	4,746	2,050	7,583	16,789

* Distribution includes USAID Mission Directors, AID/W, appropriate developing country government ministers, U.S. Ambassadors, BOSTID Address Bank, panelists and contributors to the study, participants in related activities, ACTI members, and BOSTID members.

is still highly endemic; it is estimated that at least 100 million cases occur annually and result in one million deaths.

Mosquito control today is in a state of crisis. For the past 30 years, mankind has been almost completely dependent on synthetic organic insecticides. Today, the very properties that made these chemicals so useful (long residual action and toxicity for a wide spectrum of organisms) have brought about serious environmental problems. Moreover, mosquito resistance to chemical pesticides has caused the failure of many vector control campaigns.

The Academy convened an expert panel to examine innovative mosquito control methods suited to developing countries. The report reviews current knowledge in the field of mosquito control and identifies several specific areas in which further research might produce results of great benefit to developing countries.

To summarize: the following is a brief listing of control techniques and how they work:

Larvivorous Fish. In pools, ponds, marshes, etc., various minnow-sized fish have controlled mosquito breeding by eating mosquito eggs, larvae, and pupae.

Invertebrate Predators. Prominent among these predators is a group of large, nonbiting mosquitoes whose larvae devour the larvae of other mosquito species that are disease vectors. The predatory mosquito larvae may be especially effective in reducing post-mosquito production in tree holes and other containers such as tires, tin cans, household water jars, and flower vases.

Genetic Control. Mosquitoes with altered genetic material may be used to control their own species.

Parasitic Nematodes. Several species of parasitic nematodes attack certain mosquitoes in the larval state. These minute roundworms can be mass-produced, and field trials are underway to determine their potential for mosquito control.

Parasitic Protozoans. In nature, microsporidians, a group of spore-forming protozoans, are common pathogens of mosquitoes; if their number can be increased or their effectiveness improved, they may contribute even more to mosquito control.

Parasitic Fungi. Many fungi, especially members of the genus *Coelomomyces*, kill a wide variety of mosquito larvae in a broad range of aquatic environments.

Pathogenic Bacteria. A spore-forming bacterium *Bacillus thuringiensis* (strain BA-068) is highly lethal to certain mosquito larvae. It can be mass-reared and applied to aquatic habitats.

Juvenile Hormone Mimics (Insect Growth Regulators). Insect juvenile hormone mimics hinder and derange the normal development of immature mosquito stages. Applying low doses of these compounds to aquatic habitats prevents the mosquito from completing its life cycle.

Larvicidal Plants. Various larvicidal plants, including the rooted algae of the family Characeae, can, under certain environmental conditions, prevent mosquito breeding by exuding a toxin into the water. Also, certain seeds that exude mucilage may drown larvae that become stuck to them.

About 7,000 copies of this report have been distributed to ministers of health and researchers in over 100 countries. It has led directly to research projects by the U.S. Department of Agriculture and by the Government of the Netherlands Antilles. It is likely that other projects were stimulated or helped by the report.

The report has been used as a textbook or reference at Yale University, Instituut voor Tropische Geneeskunde (Leiden, the Netherlands), University of Agriculture Malaysia (Selangor, Malaysia), World Health Organization (Manila, Philippines), Center for Disease Control (Atlanta, Georgia), Koninklijk Instituut voor de Tropen (Amsterdam, the Netherlands), Victoria University of Wellington (New Zealand), Memorial University (St. John's, Newfoundland), University of Notre Dame, and the International Centre for Insect Physiology and Ecology (Nairobi, Kenya).

Copies were distributed by the National Institutes of Health, the World Health Organization (Geneva), the Department of Defense (to military entomologists throughout the world), Center for Disease Control (Savannah and Atlanta, Georgia), Research Unit on Vector Pathology (Memorial University), Czechoslovak Academy of Science, and others.

A press release on the report was carried nationwide by UPI and appeared in many of the nation's newspapers and technical publications. NBC News featured the report on a nationwide evening newscast.

Representatives Charles Vanik and James Symington and Senator Mondale each requested copies.

Food Science in Developing Countries: A Selection of Unsolved Problems

The Advisory Committee on Technology Innovation was interested in mounting a series of projects that would bring priority R&D issues concerned with socioeconomic development in nonindustrialized nations to the attention of scientists and technologists. ACTI hoped to stimulate research, in both the industrialized and nonindustrialized nations, on problems whose solutions would have the greatest immediate potential for beneficial impact in the developing countries.

The committee was aware of the warm reception the U.S. scientific community gave two volumes on problems in environmental health and food science and technology that were supported by grants from the U.S. Public Health Service. They therefore felt that a similar approach directed to problems of immediate concern to developing countries would be useful. The committee selected the fields of food science and nutrition for a pilot study and sent solicitations to more than 300 people, primarily in developing countries. The resulting publication, Food Science in Developing Countries: A Selection of Unsolved Problems, is a compilation of 42 problems selected primarily by scientists and other workers in the less developed countries as topics worthy of immediate examination. ACTI feels it is particularly significant that the problems represent "their" priorities, not necessarily "ours," and it proposes to follow this principle in other fields.

The object of publishing this compendium was to stimulate the interest of research workers and technologists in solving these and similar problems. Each problem in this collection is organized under the following headings:

Problem Description

Background Information

Possible Approaches to a Solution

Special Requirements

Bibliography

Key Contacts.

The section, "Special Requirements," is intended only as a guide in situations where the approach suggested involves specialized activity that may be new to the reader. The bibliography lists publications that the contributor and the editing committee feel are useful sources of information on the background and status of research on the particular subject, and on the useful and necessary techniques involved in the investigation suggested. Key contacts are experts who have agreed to cooperate in this project by acting as personal contacts for the interested reader who may need advice and information while getting started on the research suggested in this volume or during the course of the investigation.

The volume and problems in the volume are divided into four parts as follows:

I. New Foods

II. Food Processing

III. Food Composition

IV. Nutrition and Health.

The overall long-term impact of such a project is difficult to assess because of the nature of research and the "ripple" effect. Research results are frequently a long time in coming and appear either as reports in scattered journals or simply as improvement in diet that may or may not be acknowledged in written reports. The ripples generated by an idea dropped into the pool of scientific endeavor may not only stimulate a reaction directly, but, by being "reflected" from an active mind, may generate subsidiary "ripples" that in turn stimulate their own reactions. Sufficient response has been received nevertheless, and the committee is convinced that the project is worthwhile indeed.

In the initial printing, 20,000 copies were produced and distributed as follows:

1. U.S. and Canadian members of the Institute of Food Technologists (the professional organization of food technology in North America), approximately 11,000 copies.

2. Foreign members of the mailing list of the Nutrition Foundation, 2,000 copies.

3. General BOSTID mailing list, approximately 2,000 copies.

4. U.S. and Canadian universities, approximately 1,000 copies.

5. Mailing list compiled from sources such as:

   a. Roster of Scientists for the Major Food Crops of the Developing World;

   b. field representatives of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), approximately 1,000 copies.

6. Direct requests from both developed and developing nations (ratio of about 1:2) (including many for multiple copies), approximately 3,000 copies.

Because of the large volume of requests received after the initial 20,000 copies were distributed, an additional 3,000 copies were printed.

Among the hundreds of requests received, there are dozens of letters attesting to the usefulness of the publication in a variety of ways. The committee is particularly pleased that the publication has been included as a text and as resource material in the curricula of many universities. For instance, the Department of Human Nutrition of the Agricultural University in Wageningen, the Netherlands, has used it in two ways: in the International Course in Food Science and Nutrition (mostly foreign students), and as required study for Dutch students who are candidates for the master of science degree in human nutrition with specialization in problems of developing countries.

In the United States, Purdue University, the University of Florida, and MIT have been using it in their food science and technology courses for undergraduates. In Canada, the Northern Alberta Institute of Technology has been using it to train African students who are sponsored by the Canadian International Development Agency (CIDA). Many other universities have distributed copies to graduate students and faculty members as a source for research ideas.

The publication has been used in many international seminars and training courses. Among those we know of are:

-- "Applying In-Country Food Science to Feeding People Better," a workshop conducted by the League for International Food Education (Washington, D.C.) in Madrid, September 1974 (150 copies distributed to people in Asia, Africa, Latin America);

-- UNESCO/IRCO/UNEP training courses on conservation and use of micro-organisms for waste recovery and indigenous fermentation, held at the Institute of Technology, Bandung (we learned of this from several participants who subsequently requested copies);

-- "Food Science and Technology--Its Constraints in Assisting the Nutritional Development in the Third World," a conference sponsored by the Nutrition Foundation in conjunction with the Madrid meeting of the International Union of Food Science and Technology (150 copies went to participants).

Besides requests for copies to be sent to various international research organizations we have also been aware of a rather surprising interest on the part of industry. Finally, one of the more gratifying responses to the publication of this collection was received from the University of Ife in Nigeria. There a faculty member and two of his students became so interested in two of the problems that he was arranging for his students to do collaborative research with the key contacts listed for the problems.

In sum, the committee is pleased with the results of the project to date and may follow it with similar efforts in other fields.

Roofing in Developing Countries: Research for New Technologies

The full impact and implication of the roofing problem currently experienced by developing countries cannot be realized without some familiarity with the overall housing problem. More than 80 developing countries suffer from an acute housing shortage, principally because of the ever-increasing need for new housing created by expanding populations and the periodic large-scale loss of housing from natural disasters. The most serious obstacle to low-cost housing in the developing countries, regardless of setting or sophistication, is the lack of a low-cost roofing material that will provide satisfactory performance for a reasonable time under many adverse conditions. Usually, roofing for low-cost housing in developing countries is not the product of any organized building industry or process. Instead, it is constructed with local self-help labor using rudimentary processes and materials. Most roofs made of low-cost, indigenous materials such as thatch or unfired clay lack durability and can be hazardous to health and safety. The materials often are subject to moisture-induced decay; they harbor vermin and insects and are particularly dangerous during fires, windstorms, earthquakes, and other disasters.

In view of the magnitude and complexity of the roofing problem in developing countries, the Agency for International Development asked BOSTID to review the practicality of a major research effort to develop new solutions to roofing problems in developing countries. BOSTID invited the Academy's Building Research Advisory Board (BRAB) to conduct the review.

A BRAB committee reviewed past and current research and development activities directed at solving particular roofing problems of developing countries, as well as more general roofing R&D in other countries throughout the world. The committee found that most such R&D deals with the problems associated with roofing materials now in common use, or aims at improving a specific material or product, or seeks better use of materials or products already available but used for purposes other than roofing.

During its investigation, the committee identified a wide variety of materials that researchers could consider in a search for new roofing systems for developing countries. Since developing countries differ so widely in their needs, climates, and available materials and resources, each must determine independently which materials and avenues of research are most promising. The committee believes, however, that an organized, systematic approach to the establishment and direction of R&D programs within the developing countries could lead to early results of immediate use for most, if not all, countries. The committee made the following recommendations:

1. A standing advisory committee should be established under appropriate international auspices.

2. Roof-covering research, development, and demonstration programs should be directed toward the use of existing, commercially available unsaturated polyester and related polymers for binding combinations of indigenous materials (such as vegetable fibers, earth, and fabrics) of selected developing countries.

3. A pilot project should be undertaken to process foamed plastics suitable for roof-covering materials and to develop a mobile, small-scale, foaming equipment system that developing countries could produce economically.

4. Sulfur should be given serious consideration as a material for binding mixtures of other indigenous materials, as a valuable coating and jointgrouting material, and as a material from which small-size roofing products, such as tiles, can be made.

5. A laboratory research and field demonstration program should be conducted on the transformation into low-cost, lightweight roofing sheets of carbonized and expanded, nonfood, high-starch plant products that have been combined with unsaturated polyester resins and related polymers.

6. An intensive program should be initiated to develop economical processes for manufacturing resins from native agricultural products (e.g., natural vegetation, bagasse) for use primarily as binders.

7. Wastes from primary industries and wastes such as fly ash and blast furnace slag from the steel industry should be investigated as they have properties that make them suitable as cementitious binders. Red mud, a copious by-product from bauxite refining which gluts many developing countries, merits serious consideration, as do metallic wastes from the production of iron and steel.

8. An analytical and laboratory testing program should be undertaken to develop more appropriate and economical reinforced concrete products.

9. A research program should be undertaken to develop methods for improving the general performance and range of applications of clay-based roofing materials.

10. The suitability and effectiveness of waste raw materials from textile and other fiber industries (based on such fibers as jute, sisal, hemp, kenaf, and cotton) common in developing countries as a blend in a composite material for roofing components should be explored.

This report was favorably reviewed in Technology Review, November 1974. Mailing lists were supplied by the United Nations (Centre for Housing, Building, and Planning), AID, and the U.S. Department of Housing and Urban Development. The report was used as a text at the Food and Agriculture Organization (FAO) Consultation on Wood-Based Panel Products, in New Delhi, February 1975.

In total, 5,000 copies of the report have been distributed. Though a few requests are still received each week, the report is now out of print.

More Water for Arid Lands: Promising Technologies and Research Opportunities

Another problem that has assumed major importance in recent years and is of great current concern to AID is the improvement of technologies for the collection and use of water in arid lands. Today, arid regions face more difficult problems than ever before. The world's sand deserts appear to be enlarging, and droughts are contributing to the economic devastation of whole nations. The six drought-stricken Sahelian nations provide an extreme illustration, but inadequate technology affects industrialized and developing countries alike, and both suffer from the crisis.

Nevertheless, arid lands have underexploited agricultural potential. We should learn that this potential can best be developed by applying concepts and methods specifically suited to dry regions. Water practices developed for temperate climates may not work as well in arid regions for technological, environmental, economic, and cultural reasons. We need fresh, innovative approaches to water technologies, particularly those designed to meet the needs of arid regions in the less developed world, where there has often been improper application of practices developed in regions with higher rainfall or more abundant water supplies. Also, we need to reconsider practices developed in arid regions by ancient agriculturalists. Basically, there are two approaches: increasing the supply of usable water, and reducing the demand for water. Supply and demand, as well as delivery, have to be considered as an integral system.

Following the recommendation of experts in the field, ACTI convened a study group to write a report aimed at drawing the attention of agricultural and community development officials to opportunities for small-scale water development and conservation.

The report outlines a number of often neglected but important concepts of water management, and presents details of specific technologies in two general categories as follows:

I. Technologies for Enhancing Water Supplies

Rainwater Harvesting: Rainwater collected from hillslopes and man-made catchments can create new supplies of low-cost, high quality water for arid lands.

Runoff Agriculture: Runoff agriculture involves rainwater harvesting; the water is used directly in agricultural systems specifically designed for the purpose.

Irrigation with Saline Water: Saline water is widely available but rarely used because it restricts plant growth and yield. Evidence is now accumulating that with care and under certain favorable conditions saline water can be profitably used for irrigation.

Reuse of Water: Increasing demands on water make it necessary to greatly increase water reuse. Technical developments such as recycling and advanced waste treatment may have great importance in the future.

Wells: Hand-dug wells, a technology begun thousands of years ago, is regaining popularity with the help of new materials and construction equipment.

In addition to the above, one chapter briefly mentions groundwater mining, desalting, solar distillation, the use of satellites and aircraft for detecting water in arid lands, rainfall augmentation, the possibility of using icebergs as a source of water, and dew and fog harvesting.

II. Technologies for Conserving Water and Reducing Demands

Reducing Evaporation from Water Surfaces: Because evaporation is invisible, it is seldom regarded as a serious drain on stored water, but annual evaporation losses, particularly in arid lands, are very great.

Reducing Seepage Losses: Seepage causes serious water losses in canals and impoundments. Modern materials and techniques can reduce or eliminate seepage, but costs are still high.

Reducing Evaporation from Soil Surfaces: Water losses resulting from evaporation from soil surfaces can be reduced by covers or mulches. In many cases the covers also serve complementary functions such as stopping desert encroachment or promoting runoff agriculture.

Trickle Irrigation: This newly developed irrigation method uses a system of plastic pipes placed on the soil among the plants. Water carried in the pipes drips onto the soil beside each plant at a rate carefully matched to the plant's needs. Compared with conventional irrigation, excellent crop yields have been obtained with a minimum of water.

Other Innovative Irrigation Methods: Some simple irrigation methods, with potential benefit for arid lands but neglected in technical manuals or textbooks, are presented pictorially.

Reducing Cropland Percolation Losses: Large areas of sandy soil in arid lands are not used for agriculture because the water sinks below the root zone too rapidly and the extra irrigation water needed to compensate for this problem is not available. Techniques are now being developed to produce artificial underground moisture barriers to prevent or restrict water and nutrients from percolating away.

Reducing Transpiration: About 99 percent of the water absorbed by plant roots is released into the air from leaf surfaces. If practical means to reduce this process can be found, major savings can be realized in the amount of water needed to raise a given crop.

Selecting and Managing Crops to Use Water More Efficiently: Relatively little has been done on designing water-efficient systems for arid-land agriculture. Numerous research opportunities--from plant genetics to engineering--remain to be explored.

Controlled-Environment Agriculture: When crops are grown within watertight but transparent enclosures, the amount of water normally lost can be greatly reduced, and the atmosphere around the plants can be manipulated to maximize productivity. These are costly systems, but high agricultural productivity can be achieved with small amounts of water in very inhospitable regions.

This report has received much domestic attention. The U.S. Geological Survey, the Texas legislature and the governor of Texas, and representatives and senators from California, Arizona, New Mexico, Utah, Nevada, and Texas all asked for copies.

The report is being used as a textbook in classes at the University of Arizona, Texas Tech University, Utah State University, The Volcani Institute (Bet Dagan, Israel), and the University of Oxford (England).

Many technical assistance agencies have asked for multiple copies for their own distribution. These include FAO, CIDA, IDRC, CARE, American Council of Voluntary Agencies for Foreign Service, Inc., and the Intermediate Technology Development Group.

A number of AID officers have requested multiple copies and have expressed their enthusiasm for the report. These include Princeton Lyman (AFR/DS), Howard P. Johnson (AID/Jordon), and Madison Broadnax and Ambassador William O. Brewer (both Sudan). AID's Africa Bureau is processing a task order with the NAS for translating and printing the report in French for training technicians in Sahelian countries.

Of the initial printing of 10,000 copies, about 4,000 copies were sent to AID missions, AID/W, USIS libraries, foreign embassies, developing country administrators, technical assistance agencies, universities, and agricultural research institutes. These generated much interest and individual requests for about 4,000 more copies. BOSTID still receives requests for about 30 copies each month, and in 1976 6,000 additional copies were printed to fill the incoming requests. The report has been translated to French, with 4,000 copies printed.

Underexploited Tropical Plants with Promising Economic Value

The strain on world resources posed by rapid population growth, dwindling supplies of nonrenewable resources, and shortages of food puts economic botany in the mainstream of human concern. Today, most of the people in the world are fed by about a dozen crops--three cereals (rice, wheat, and maize), two sugar plants (sugar cane and sugar beet), four root crops (potato, sweet potato, yams, and cassava), two legumes (the common bean and the soybean), and two tree crops (coconut and banana). These plants are the main bulwark between mankind and starvation.

Yet, as the prospect of food shortages becomes more acute, people must depend increasingly on plants rather than animals for the protein in their diet. To help feed, clothe, and house a rapidly increasing world population, it is timely to consider neglected or little-known plant species.

An ad hoc panel on Underexploited Tropical Plants with Promising Economic Value was appointed to:

- identify neglected but seemingly useful tropical plants, both wild and domesticated, that have economic potential;
- select plants that showed most promise for wider exploitation throughout the tropics; and
- indicate requirements and avenues for research to ensure that selected plants reach their fullest potential.

The 36 plants described in the panel's report were selected from among 400 nominated by plant scientists around the world in response to a written inquiry. Each plant chosen for inclusion satisfied several criteria, the most important of which are: (1) that it can be grown in the tropics; (2) that it has significant potential as a source of food, forage, or industrial raw material; and (3) that it can help make developing countries (or areas within) more productive. The report provides a brief introduction to the plants selected. Each plant is presented in a separate chapter, arranged in the following order:

Description of the Plant and its Advantages

Limitations and Special Requirements

Research Needs

Selected Readings (significant reviews, general articles)

Research Contacts and Germ Plasm Sources (individuals or organizations known by the panelists to be involved in relevant research or to have appropriate seeds, cuttings, or rootstocks).

The information in this report is only a starting point for what may prove to be laborious and troublesome projects.

The panel members also felt that certain points concerning the status of tropical botany and the urgency of preserving germ plasm were so important that, although not part of their formal mandate, they made specific recommendations regarding these areas. A summary of these recommendations included the following:

-- Most agricultural scientists are unaware of the scope and potential offered by tropical botany. The discipline suffers largely because the major centers of scientific research are located in temperate zones. There is an urgent need for plant researchers to become acquainted with tropical plant life.

-- A massive effort is needed to ensure the survival of endangered plant species throughout the world. It comes as a surprise to most non-botanists to learn that one out of every 10 plants is either extinct or in imminent danger of extinction. Careful preservation and thorough cataloguing are particularly important for little-known plants. To this end, the number of botanic gardens, field stations, and habitat reserves containing natural vegetation types must be increased. In addition, the number of personnel trained in tropical plant science must also be increased.

-- Agriculture in the tropical world suffers from a lack of mechanisms for systematically and routinely introducing and investigating little-known but potentially useful tropical plants. Because most tropical countries are poor, their experiment stations cannot afford to devote time and money to lesser-known plants. To alleviate this problem, development agencies and foundations concerned with agriculture should consider sponsoring a system of horticultural facilities (in tropical and subtropical developing countries) where agronomic research and extension on lesser-known indigenous and newly introduced species could be pursued. In part, such facilities could be extensions of the network of international agricultural research institutions already in existence.

Some examples of the plants chosen for their exceptional merit are:

-- Grain Amaranths (Amaranthus spp.) The seeds of these almost totally neglected Central American grain crops have extremely high levels of protein and of the nutritionally essential amino acid, lysine, which is usually deficient in plant protein.

-- Chaya (Cnidoscolus aconitifolius and Cnidoscolus chayamansa). The leaves of these fast-growing, prolific shrubs are a nutritious, spinach-like, green vegetable. Known only in Central America, Chaya deserves testing elsewhere in the tropics.

-- Wax gourd (Benincasa hispida). This large, melon-like vegetable is easy to grow and can yield three crops per year. Its outstanding feature is that the fruit can be kept without refrigeration for as long as 12 months.

-- Pejibaye (Guilielma gasipaes). The chestnut-like fruit of this palm is probably the most nutritionally balanced of tropical foods. It contains carbohydrates, protein, oil, minerals, and vitamins. Suited to the wet tropics, the trees, once established, require little care and yield well.

-- Buffalo gourd (Curcurbita foetidissima). This wild North American desert gourd, which furnished edible seeds for the American Indians, is a potentially profitable source of protein and edible oil in extremely arid lands. It deserves wider recognition and test planning in all arid regions of the world.

-- Tamarugo (Prosopis tamarugo). A hardy, leguminous tree, native to the forbidding Atacama Desert in Chile, tamarugo grows through a layer of salt sometimes 1 m thick. The nutritional quality of its pods and leaves allows sheep to be stocked at rates approaching those of the best forage areas in the world.

-- Guayule (Parthenium argentatum). A shrub of Mexican deserts, guayule contains large quantities of latex that closely resembles that from the Hevea rubber tree. Technical problems associated with separating the latex from resins and other vegetable matter have prevented its development, but it still holds great promise, and, given research, it could become an important source of rubber for production in arid lands.

Over 21,000 copies of this report have been printed and distributed to appropriate individuals and institutions in both the developed and developing countries. About 25 to 30 requests are received per week, many for multiple copies.

The Winged Bean: A High Protein Crop for the Tropics

The winged bean, Psophocarpus tetragonolobus, a little-known tropical legume, is grown almost exclusively in Papua New Guinea and Southeast Asia.

The plant came to the attention of the National Academy of Sciences during an extensive survey of underexploited tropical plants conducted by an Academy panel in 1974. The seemingly exceptional merits of the winged bean suggested that a separate, in-depth examination of its characteristics and prospects be undertaken promptly and the results brought to the notice of the international development community.

The possibilities of the winged bean as an adjunct to the human diet have not been recognized. It is an exceptional legume: the green pods, leaves, and seeds are rich in oil, protein, and vitamins, and the tuberous roots are--among root crops--uniquely rich in protein. Winged bean plants grow vigorously, appear to have more nitrogen-fixing nodules per plant than other edible legumes, and their extensive root system carries exceptionally large nodules.

To evaluate the available information and assess the potential of this plant, an international panel of specialists on the winged bean, on tropical agriculture, and on nutrition was convened.

The panel was not expected to produce a comprehensive report but to consider such matters as: (1) the state of knowledge concerning the winged bean (2) the bean's promise as a crop plant (3) significant data gaps and research needs, and (4) a strategy for international research and testing to assess the crop's future.

A summary of the recommendations of the panel is as follows:

1. A concerted effort should be undertaken immediately to systematically collect, store, and replicate elite winged bean varieties available in Southeast Asia.

2. Four or five institutions in differing tropical locations should maintain living collections and begin small-plot trials and plant improvement programs. The University of Papua New Guinea; the International Center for Tropical Agriculture in Cali, Colombia; the International Institute of Tropical Agriculture, Ibadan, Nigeria; and the Asian Vegetable Research and Development Center in Taiwan have been suggested as appropriate for this effort.

3. A monograph should be prepared on the genus Psophocarpus. It is basic to all plant improvement programs to know exactly the genetic materials involved and their interrelationships.

4. Agronomic research should be initiated in several areas where present lack of knowledge constitutes a serious barrier to the rational development of the winged bean.

5. Research should be undertaken on the nutritional aspects of winged beans.

6. A research center actively engaged in winged bean research should undertake publication of an informal newsletter that will provide the interested research community with continuous information concerning winged bean research.

7. A step-by-step practical guide to introduce the winged bean to uninitiated researchers in new areas would be valuable.

The initial printing of 3,000 copies was quickly exhausted; two additional printings of 5,000 copies each have been made, and nearly all have been distributed. About 15 to 20 requests per week are received.

The winged bean has received considerable publicity around the world. Requests for reports, seeds, and visits from scientists familiar with various aspects of the plants' culture continue. Several large corporations such as General Foods and C.P.C. have requested kilo quantities of seed for testing. Researchers at the University of Papua New Guinea have distributed over 500 lots of winged bean seeds to readers who saw them listed in the report. University of Florida agronomists have filled a similar number of requests. As a result, the winged bean has now been introduced to scores of countries and literally hundreds of agronomists, farmers, backyard gardeners, and nutritionists, and technical assistance institutions have incorporated the winged bean into their program of diet.

Several acres of winged bean are now being grown near Miami by University of Florida researchers. For the first time this will provide large amounts of seed for comprehensive nutritional and industrial trials.

In addition, 15 winged bean lines are being grown in adaptability trials at different altitudes, climatic zones, and soil types in Florida, Colombia, Nigeria, Australia, Papua New Guinea, and Indonesia. This program, coordinated by an informal international group of winged bean researchers, will produce evidence for the varieties best suited to different environments.

So much research is now underway that a newsletter, the Winged Bean Flyer, is being published. Many of the results in it are observations by non-scientists, but international research institutes such as the International Rice Research Institute, the Asian Vegetable Research and Development Center, and the International Center for Tropical Agriculture, have reported progress as well.

The Asia Foundation sponsored an international winged bean conference January 9-13, 1978 in the Philippines. Over 250 scientists representing 25 nations on six continents attended and gave reports of ongoing research at their organizations.

Products from Jojoba: A Promising New Crop for Arid Lands

A study of jojoba (*Simmondsia chinensis*) by a committee of the National Academy's Office of Chemistry and Chemical Technology seemed so important for developing countries that a BOSTID staff officer provided initial program direction and monitored the study, and AID provided funds to print and disseminate the committee's report to arid developing countries.

In their report, the committee concluded:

-- Jojoba oil and its hydrogenated product have marketable properties.

-- Jojoba's development can reliably rest on its ability to substitute for existing oils and waxes such as sperm oil, carnauba wax, beeswax, and spermaceti.

-- Jojoba oil resembles sperm oil in chemical composition and physical behavior; if a sufficient supply of jojoba oil were available at a competitive price, it would be used as a substitute for sperm oil.

-- Jojoba can increase the productivity of arid lands not suitable for conventional crops.

The report identified crucial research needed to develop jojoba as a crop and gives much technical detail about the chemistry of jojoba products.

BOSTID has distributed 2,000 copies of this report to administrators and researchers in Brazil, Chile, North Africa, the Middle East, Sahelian countries, East Africa, Pakistan, India, Australia, and other countries with arid regions.

Partly as a result of this NAS study, the World Bank and the Government of Israel are embarking on a $1.4 million jojoba development project which will help to make arid areas of the Negev Desert and barren salinified regions near the Dead Sea more productive.

A newsletter, Jojoba Happenings, is now being published six times a year by an informal International Committee for Jojoba Development, based at the University of Arizona.

Energy for Rural Development: Renewable Resources and Alternative Technologies

Some time ago, ACTI initiated a study on low-power sources of electrical energy for developing countries. The original intent was to concentrate on sources that could provide power of the order of 100 watts, for use primarily, but not exclusively, with small communications devices (including village television receivers). At the suggestion of a group of experts, the National Bureau of Standards was asked to conduct, for ACTI's use, a preliminary engineering survey to assess the then current (1973) availability and cost parameters of suitable devices. That survey recognized the potential applications of such things as solar devices and wind-driven generators, but basically assumed the availability of fossil fuels (e.g., kerosene) in most rural areas in the less developed countries, and emphasized the economic and mechanical advantages of small, inexpensive internal combustion engines.

It soon became apparent, however, that the world situation with respect to the evaluation of conventional energy sources was changing considerably. ACTI decided it would be more useful to broaden its original concerns. A panel of experts was appointed to consider alternative sources of energy indigenous to developing countries that can be usefully and economically exploited with a minimum of development. The panel examined energy technologies applicable at a village or rural level and considered power capabilities with a maximum in the range of 10 to 100 kilowatts. Each technology is discussed in terms of current (i.e., short-term) and future (i.e., intermediate-term) availability; the former is defined as availability within five years and the latter as availability within five to 10 years. In addition, the report suggests specific research and development needed to make intermediate-term application a realistic prospect.

The technologies considered by the panel fall within the categories of direct and indirect uses of solar energy. Direct uses of solar energy include:

solar cookers

solar stills for portable water

heating and cooling of buildings

refrigeration

heating water

crop drying

salt production

photovoltaics.

Indirect uses of solar energy include:

photosynthesis

microbial conversion

wind devices

water devices.

Finally, falling in neither of the major divisions are discussions of geothermal energy and the general problems of energy storage. (There were some initial doubts about the usefulness of including geothermal sources in this study because of the magnitude of their power capabilities and the cost of exploration and exploitation. However, the panel felt there may well be special circumstances that would make geothermal wells a practical source of energy for rural areas in developing countries.)

The report is divided into two sections in order to maximize its usefulness to two distinct audiences. The first section is a nontechnical summary in which each technology is described and its potential application outlined. This section is directed to the decision maker and planner who must evaluate technical proposals in this field on the basis of their own country's needs and constraints. The second section is directed to the technologist who may be familiar with the basic principles involved but may not be familiar with specific problems or recent developments in particular technologies. This section is also meant to provide other sources of information to the technologist who may wish to pursue a particular point in more detail. As far as possible, a uniform format has been followed in discussing each technology. There are some instances, however, where forcing a discussion into the general format would have detracted from its usefulness, and so a degree of flexibility has been retained.

The report includes the following recommendations:

1. Rural areas in LDCs must be rendered capable of importing certain fundamental products of technology before they can be expected to exploit alternative energy technologies within any reasonable time frame. To this end, a target rural area should be studied by a small team of technologists and development economists. The purpose of such a study would be to devise a scheme to help match that area's economy to the developed world so that it could import simple, moderately capital-intensive energy systems or components, mostly through its own efforts.

2. Regional international energy research and development centers should be established, along the lines suggested by a previous NAS panel on solar energy, provided that rural economists and cultural anthropologists are included on the staffs of such centers. The panel feels strongly that without this kind of input the pattern of nonacceptance (typical of past attempts to introduce solar devices in developing countries) will simply be repeated for all of the technologies discussed in its report.

3. A series of regional workshops should be held in Asia, Africa, and South America to discuss the problems of implementing the first two recommendations and the technological suggestions contained in the report. The workshops are considered a prerequisite to any serious move toward establishing the recommended regional centers. Furthermore, they should be structured to include, in addition to the international and local planners and government representatives, members of engineering faculties of technical schools, and people who are personally responsible for project implementation in the field.

Approximately 17,500 copies of this report have been printed and distributed worldwide. In addition, the report has been translated into French for distribution to French-speaking developing countries, especially in the Sahel region.

Methane Generation from Human, Animal, and Agricultural Wastes

One of the more important alternative sources of energy available to developing countries--particularly in rural areas--is methane, generated from human, animal, or agricultural wastes. In distinction to the other technologies considered in the study of alternative energy sources for developing countries, methane generation has a very broad acceptance in some regions of the developing world; thousands of small-scale generators have been constructed and most are still in use. However, the technology is still not known--or at least not used--in most developing countries, and for these reasons ACTI undertook a report on this technology separate from its report on other alternative energy sources.

The methane study was conducted by an expert panel, and its report, like the one on alternative energy sources, was aimed at a local audience--decision makers and planners on the one hand, and technologists on the other. The objective of the study was to provide the information needed by the former group to evaluate technical proposals dealing with methane generation on the basis of their own country's needs and constraints. It was also meant to serve as a source of basic information to the technologist and lead to other sources for further detailed technical information.

Sections of the report aimed at a nontechnical audience include a general overview of the methane generation process and its past and present uses, a discussion of economic problems associated with evaluating its usefulness in a given situation (including factors to be considered in estimating costs and benefits), and a section on its limitations and the social, cultural, and political implications associated with implementation of a proposed methane generation scheme. The technical sections include a discussion on the state-of-the-art; engineering considerations in design, construction, and operation of small-scale methane generators; and suggestions for research and development.

Ten thousand copies of the report are being published and will be distributed in May 1978.

Making Aquatic Weeds Useful: Some Perspectives for Developing Countries

The menace of water weeds is reaching alarming proportions in many parts of the world. Water is an important resource, and aquatic weeds affect it adversely by blocking canals and pumps in irrigation projects, interfering with hydroelectricity production, wasting water by evapotranspiration, hindering boat traffic, increasing waterborne disease, interfering with fishing and fish culture, and clogging rivers and canals so that drainage is impossible and floods result.

This is a global problem, but it is particularly severe in tropical nations where warm water and increasing numbers of dams and irrigation projects foster aquatic plant growth. Furthermore, it is worsened by increasing enrichment of natural waters by plant nutrients from human and agricultural wastes.

As aquatic weeds spread, they disperse the water snails that cause schistosomiasis, the insidious, debilitating disease prevalent in many developing nations. These snails live on the dangling roots and ride along as wind and current float the plants around. In addition, aquatic plants foster malaria, encephalitis, and other mosquito-borne diseases, because small, sheltered pools perfect for mosquito-breeding are formed between the floating plants.

Today, the serious implications of the presence of aquatic weeds are becoming more widely recognized; scientists, engineers, and government administrators are beginning to take action. Unfortunately, there is no simple way to reduce the infestations. Herbicides that kill aquatic weeds and mechanical devices are almost the only methods used in advanced countries. Both techniques are expensive and developing countries must spend scarce foreign exchange to import them.

And yet, in a sense, aquatic weeds constitute a free crop of great potential value; a highly productive crop that requires no tillage, fertilizer, seed, or cultivation; a crop that is relatively pest-free. Aquatic plants have potential for exploitation, but the technology for producing, harvesting, and processing them has not been commercialized. Nonetheless, certain aquatic plants have qualities that already make them useful for animal feed, human food, soil additives, fuel production, and waste-water treatment.

Some of the uses described in the report are:

-- The Grass Carp. A quick-growing fish that lives on plants and prefers succulent submersed weeds (which are hard to control by conventional techniques), converting them into highly prized meat.

-- Freshwater Crayfish. Among the least exploited edible freshwater organisms, these close relatives of the lobster bring premium prices as gourmet food. In the state of Louisiana, crayfish are farmed on a large scale in rice paddies where they feed on aquatic weeds, rice stubble left after harvest, and other organisms.

-- Ducks and Geese. If carefully managed, these common herbivorous animals can clear aquatic weeds remarkably well. In doing so, they provide meat and eggs. They are particularly promising for small farmer use in developing countries.

-- Dewatering. High moisture content is the single most important difference between aquatic and terrestrial vegetation. Typically, aquatic weeds contain only 5 to 15 percent solid matter. To transport them, or to mix them in animal feeds or other processes, much of the water must first be removed. Pressing the water out mechanically and removing it by solar drying are methods now under development.

-- Soil Additives. Fertilizer is in critically short supply in many developing countries. Many aquatic weeds contain appreciable quantities of nitrogen, phosphorus, potassium, and other fertilizer ingredients.

-- Energy. In a project in Mississippi, the National Aeronautics and Space Administration (NASA) is fermenting water hyacinth to methane gas.

-- Water Treatment. Nitrogen and phosphorus compounds are common pollutants in waterways; they also happen to be major ingredients in fertilizer. Aquatic weeds extract these materials from water and incorporate them into their own structure. Researchers in a number of laboratories have recently found that these plants can be used to treat sewage effluent so that nutrients dissolved in it are recovered for reuse.

-- Aquatic Plants for Food: Miscellaneous Uses. A few aquatic plants are widely used as food crops--for instance, rice, Chinese water chestnut, and watercress. Some little-known species worth researching are given here.

An initial printing of 7,000 copies was quickly exhausted, and 5,000 additional copies have been printed to fill continuing requests.

Guayule: An Alternative Source of Natural Rubber

Of the 2,000 or so plants known to contain rubber, only two have ever produced it in substantial commercial quantities; these are Hevea brasilinesis, the rubber tree grown principally in Southeast Asia, and guayule Parthenium argentatum Gray, which grows wild in some arid regions of North America. Totally unlike the majestic tropical Hevea tree, guayule is an inconspicuous desert shrub that resembles sagebrush. Nevertheless, during the first half of this century it was a commercial source of rubber.

No guayule rubber has been produced commercially for 30 years, however. The times were against guayule when, in the mid-1940s, it was abandoned. Then it appeared to serve no purpose, there was little need for another rubber source, hevea rubber was in good supply, and it was thought that manmade elastomers would completely dominate all future markets.

But the outlook has changed dramatically. Today, hevea rubber shows no likelihood of being displaced by synthetic rubbers. It has retained its position as one of the world's most important commodities. The increasing price of oil lowers the competitiveness of synthetic rubbers (which are produced from petroleum-based feedstocks), and there is an ever-increasing world capacity to absorb hevea rubber. It is now predicted that by 1980 its production will be about 5 million tons, which will be one-third of the world's total rubber.

Today, a plant that produces hydrocarbons is more worthy of investigation because our major hydrocarbon source, petroleum, is dwindling and is widely predicted to run out within a few decades. Guayule is an alternative source--a renewable source--for petroleum-derived polyisoprene rubbers. It seems likely that in coming decades there will be markets for all the "natural" rubber that can be produced whether it be hevea or guayule.

With today's increasing population growth, we have an increasing need to utilize marginal lands worldwide productively, especially arid wastelands; to find crops adapted to fragile, but harsh, desert environments; and to give jobs and income to desert dwellers living where conventional farming production is risky or impossible. This, too, casts guayule in a new light, for experiments have shown that "guayule could be grown successfully on many lands where the supply of irrigation water was insufficient for the successful production of most agricultural crops." Thus today, the general economic climate is quite different from that when guayule rubber was last produced commercially. But guayule is worth cultivating only if its rubber has the technical quality to meet commercial needs.

To determine this possibility, the NAS appointed an ad hoc panel to collect, collate, and analyze the known information on guayule as a basis on which to make an objective evaluation of the plant's potential in light of contemporary conditions.

The conclusions of the panel were:

-- Deresinated guayule rubber has chemical and physical properties essentially identical to those of rubber from the hevea tree.

-- If guayule rubber can be produced economically, a large market for it exists.

-- Using the old plant varieties, production techniques, and rubber extraction methods, guayule would not be a commercially viable crop today. However, modern technology and research could easily change this. There is a high probability that research could bring guayule to the point of commercial viability in under 10 years.

-- Guayule has potential to become important to the nation's economy and well-being.

-- Guayule growing could eventually help Indians in the southwest develop an economic basis for their now impoverished reservations; also, guayule has potential to become an important crop in several semiarid regions outside its native North America.

A report recommending further applied research and development of guayule was published in March 1977. Features have appeared in major newspapers and trade magazines worldwide. As a result, both the U.S. House and Senate have introduced legislation that includes guayule research and development. A bill has been introduced in the House to strengthen U.S. agricultural research and research education, and for other purposes. Funds totalling over $100 million are included for the next five years "...for the purpose of conducting research, development, and demonstration of new crops, including guayule and jojoba."

Legislation also has been introduced in the Senate and House to begin a national effort to develop an American natural rubber industry. This action followed the release of BOSTID's report that recommends the use of the guayule plant as a source of native latex rubber. This legislation would establish a technology development and transfer effort within the Agricultural Research Service in the Department of Agriculture. Authorization of $60 million during the next five years is also provided under the measure. About 6,500 copies of the report have been distributed.

Tropical Legumes: A Resource for the Future

Of all plants used by man, only the grasses are more important than the legumes. However, while enormous resources have been expended in recent decades on grasses like rice, wheat, corn, sorghum, and barley, among the legumes only soybeans and peanuts (groundnuts) have received much attention. Yet it is the family Leguminosae that shows most promise for the vastly increased supplies of vegetable protein that the world will need in the near future. In developing countries especially, cultivation of legumes is the best and quickest way to augment the production of food proteins.

Leguminous plants are found throughout the world, but the greatest variety grows in the tropics and subtropics. Because tropical botany has been relatively neglected, there are thousands of promising species that await research and study. Of the 18,000 known legumes, less than 20 species are used extensively as food today. The remaining varieties are little used as yet, and many of them are almost unknown to science.

This project, initiated in 1976 at the request of AID's Office of Agriculture and Office of Science and Technology, had as its objective a demomstration of how little-known legumes can contribute to the economies of developing countries. A list of 150 neglected and seemingly promising legumes was mailed to plant scientists throughout the world. Each recipient was asked to "vote" for the species most worthy of inclusion in the report to be produced by an expert panel. More than 130 scientists responded, and, at the same time, nominated an additional 250 species for consideration. In a total of about 400 species, almost 200 received top ranking from at least one reviewer. Furthermore, as the study progressed an additional 200 species with promise came to light. From this wealth of candidates the panel at its August 1976 meeting in Kahului, Maui, Hawaii, selected the species that are included in the final report.

Criteria for selection included:

-- the plant's potential to help improve the quality of live in developing countries;

-- a lack of recognition of the plant's potential; and

-- a need for greater attention to the plant by researchers and farmers, and for increased investment by organizations that fund research and development projects.

Other considerations were: Does the plant improve the lot of the rural poor? Can the plant yield more than one product useful to a developing country? Can it be grown in habitats where other plants grow poorly (for example, arid areas, swamps, slopelands, toxic soils)? If introduced to a new region, is the plant likely to become a pest? Little consideration was given to how much is known about the plant--if a species showed the requisite promise, it was included in the book even if it had been little studied in the past.

The panel's report provides a brief introduction to the plants selected. It is intended neither as a textbook nor a comprehensive survey of tropical botany. Most of the plants are presented in separate chapters, with each chapter in the following general order:

-- Description of the plant and of its advantages

-- Limitations and special requirements

-- Research needs

-- Selected readings (significant reviews and general articles)

-- Research contacts (individuals or organizations known by the panelists to be involved in relevant research and who have agreed to provide advice and perhaps small amounts of seed to bona fide researchers).

The book is divided into six sections: root crops, pulses, fruits, forages, timber and wood products, and a final section on ornamentals; sunhemp; gums; green manure, soil reclamation, and erosion control.

Legume seeds are second only to cereals as a source of human and animal food. Nutritionally, they are 2-3 times richer in protein than cereal grains. A movement similar to the "Green Revolution" in cereals is needed for legumes to help eliminate the widespread protein malnutrition found in underdeveloped countries today.

Other legumes less widely known are the ornamentals and the timbers. Many of the beautiful tropical flowering plants are legumes, as are several timbers which are valued for cabinet work and carving.

Legumes are crucial to the balance of nature, for many are able to convert nitrogen gas from the air into ammonia and nitrates, forms in which nitrogen is readily utilized by plants. While a few other plant families include species with this ability, legumes produce a great mass of biologically fixed nitrogen. Even today, cultivated legume crops add more nitrogen to the soil worldwide than do fertilizers. Legumes use nitrogen-fixing bacteria to meet their needs for nitrogen without requiring fertilizer. Since energy is no longer cheap nor abundant, and neither is fertilizer, especially nitrogen fertilizer, planting of legumes could increase food production without using large quantities of fertilizer.

Ten thousand copies of this report will be printed in late 1978 for distribution to researchers, governmental organizations, universities, funding agencies, and international organizations.

Leucaena: Promising Forage and Tree Crop for the Tropics

Of all tropical legumes, leucaena probably offers the widest assortment of uses. Through its many varieties, Leucaena can produce nutritious forage, firewood, timber, and rich organic fertilizer. Its diverse uses include revegetating tropical hillslopes and providing windbreaks, firebreaks, shade, and ornamentation. Although individual leucaena trees have yielded extraordinary amounts of wood--indeed, among the highest annual totals ever recorded--and although the plant is responsible for some of the highest weight gains measured in cattle feeding on forage, it remains a neglected crop, its full potential largely unrealized.

Inasmuch as the varieties with exceptional size, vigor, and other desirable qualities have been discovered or developed only during the past two decades, experience is still limited and literature sparse. Moreover, leucaena's reputation has suffered in some areas due to an aggressive variety that has become a weed. Further, leucaena's development has been retarded because its foliage contains an uncommon amino acid, mimosine, which is toxic to nonruminants at levels of about 10 percent in the diet.

Leucaena usually has large and prolific nodules and requires little or no fertilizer nitrogen, because the Rhizobium alone provides nitrogenous compounds in amounts adequate for normal growth. This permits leucaena to thrive in some soils where nitrogen levels are inadequate to sustain the growth of most other crops.

The nodules occur on rootlets in the aerated surface soil layer, but leucaena develops a taproot that penetrates deep soil layers and exploits water and minerals below the root zone of many agricultural crop plants. This, too, helps it to grow where other plants fail.

The report of the study details the plant's values, but experience with leucaena is limited, in most cases, to a few sites. Many tests, trials, and development studies are still needed.

Specific recommendations made are as follows:

- An abundant supply of high quality leucaena seeds should be established.

- In conjunction with the establishment of a seed supply, extensive trials should be initiated, aimed at comparing performance of each of the most promising leucaena varieties.

- Research should be conducted in areas where present uncertainties about leucaena cultivation will hinder its widespread use.

- Pasture-crop specialists and animal nutritionists throughout the tropics should include leucaena trials and research in their programs.

- Throughout the tropics, forestry research programs should include trials with Salvado-type leucaena.

-- Where deforestation and erosion are severe, trials with leucaena should be begun immediately.

-- Pilot-size plantations for production of firewood, fuelwood, and charcoal should be established.

-- Leucaena's value in shifting cultivation and other uses also merits testing and research.

-- Leucaena researchers should undertake to publish four documents about the plant--newsletter, planting guide, annotated bibliography, and a monograph on the genus Leucaena.

Seven thousand copies of the report were printed and distributed worldwide. Interest in the report continues, and a second printing of 5,000 copies has been made.

Firewood Crops: Bush and Tree Species for Energy Production

Recently, the firewood shortages in developing countries have received international attention. However, because few, if any, clear solutions to this problem have yet been advanced, a study was undertaken to identify those plant species with the most promise of becoming fuelwood crops. Some attention was given to species suitable for fueling small industrial factories, electricity generators, and driers for crops like tobacco. Primary emphasis, however, was given to the problems of providing firewood for individual family needs, which possibly can be met by low-growing, dense, woody shrubs rather than forest trees.

As an initial step, botanists and agronomists were canvassed worldwide for suggestions for plant species that have yet unrealized potential to become important firewood crops throughout the developing world. Special emphasis was given to such features as:

-- species adapted to tropical highlands;

-- nitrogen-fixing species;

-- fast-growing species;

-- species with high caloric value;

-- multiple-purpose plants that have uses in addition to firewood (sources of food, raw materials, erosion control, etc.);

-- species that coppice (regrow after cutting);

-- species that require little care and can be grown in village environments;

-- species for difficult environments such as steep hillslopes, low nutrient or toxic soils, arid zones.

The report, which is scheduled to be published in late 1978, will be distributed free to decision makers in government, technical assistance agencies, research institutions, universities, development banks, etc. Data on the species selected will be presented in the following format:

Description

Advantages

Limitations

Research needs

Selected readings

Sources for germ plasm

Underexploited Microbial Processes of Potential Economic Value

In 1977, an AID official recommended that ACTI undertake a study on foods produced by fermentation--foods such as fish sauce, soysauce, soycake, and yogurt. Fermentation techniques are well known in developing countries: they can be scaled for small-scale use in rural areas; they produce palatable, often highly nutritious, foods. Fermentation is an age-old technique that maximizes use of indigenous materials and skills. Often it is a way of preserving foods and reducing food losses without the use of expensive equipment.

Microorganisms can, however, help developing countries in many more areas than in food production. They are crucial for fixing nitrogen from the air, and they can be used to produce fuel, industrial raw materials, and pharmaceuticals. A wealth of microorganisms that can improve the quality of life in developing countries is available. Many of them are little known or little appreciated by persons other than microbiologists; some are used in one part of the developing world but are unknown elsewhere; some that were made obsolete by cheap petroleum may now be competitive once again.

The study has the following objectives:

-- to identify neglected but seemingly useful bacteria, fungi, and algae;

-- to select the ones that show the most promise for wider exploitation throughout the developing world; and

-- to indicate the requirements and avenues for research that would develop the selected microorganisms to their fullest potential.

Practical uses and the latest knowledge of fermentation technology will be emphasized. The topics to be covered in the report are:

- -- Fuel and energy
- -- Foodstuffs (human and animal)
- -- Industrial raw materials
- -- Waste utilization
- -- Bioinsecticides
- -- Antibiotics
- -- Vaccines
- -- Nitrogen fixation
- -- Cellulose degradation
- -- Rhizobia and related organisms.

This report, to be published in late 1978, will be addressed to those government administrators, technical assistance personnel, and researchers who are concerned with helping developing countries achieve a more efficient and balanced exploitation of their biological resources. The report will have a brief introduction to the organisms selected, and each organism will be presented in a separate chapter arranged to describe:

The Organism, its Production, and Use

Limitations and Special Requirements

Research Needs

Selected General and Research Reading

Research Contacts and Germ Plasm Sources.

SPECIAL STUDIES/ADVISORY PANELS

East Pakistan Land and Water Development as Related to Agriculture

In 1970, BOSTID was requested by AID's Near East and South Asia Bureau to undertake a study and evaluation of an $800 million multiyear program, proposed by the International Bank for Reconstruction and Development, to support water resource and agricultural development in (then) East Pakistan. This program was proposed for support by the multinational Aid-to-Pakistan Consortium, of which the United States was a member. The examination of this proposal was undertaken by an ad hoc committee of BOSTID composed of nine agricultural and water resource experts familiar with East Pakistan, under the chairmanship of Dr. Dean Peterson of Utah State University. It was carried out in the broader context of a review of factors inhibiting the economic and social development of East Pakistan. The committee's report, "East Pakistan Land and Water Development as Related to Agriculture," advised AID on ordering of priorities relating to water resource and agricultural development in East Pakistan, and included an assessment of the World Bank's proposal.

Since the objective of the panel's study was a review of the World Bank's proposal to AID, a summary of the recommendations in the absence of a detailed presentation of the World Bank's proposal would not be of value.

Shortly following transmittal of this report to AID, two catastrophes hit East Pakistan--a severe typhoon and the outbreak of civil war. As a result, the implementation of this project was not possible.

International Development Institute

Undertaken in 1970 at the request of the White House Office of Science and Technology (OST) and AID, this study was to parallel a study by an interagency task force under the chairmanship of the OST deputy director. The committee was convened by BOSTID and charged with considering the character, purposes, and functions of the International Development Institute (IDI) proposed by the President of the United States in his September 15, 1970 message to Congress, "to bring U.S. science and technology to bear on the problems of development," as a key element in a reorganized foreign aid program.

The report prepared by this committee endorsed the concept of such an institute, and expressed the hope that it would be established as a landmark institution through which the people of the United States can cooperate with the peoples of the developing countries in devising solutions to critical worldwide human problems. It was felt that this task would require an institution with the capacity to mobilize the resources of U.S. universities, research institutions, industrial and service organizations, and the nation's managerial and technical skills to work with and help improve the institutions and human resources for developing countries. The committee believed that what we do not know about development is far greater than what we do know and that, without greater knowledge and the ability to apply it wisely and effectively, the problems of poverty, illiteracy, disease, malnutrition, and the pressures of rapid population growth may have even more tragic consequences for most of mankind.

The essentials of the panel's recommendations were that the International Development Institute should:

1. Mount intensive attacks on knowledge gaps in a limited number of critical high-priority problems--such as hunger and malnutrition, unemployment, and rapid population growth--whose solution would have a beneficial impact on the developing world as well as on domestic society. In its mission to generate new knowledge, the IDI should (a) identify a small number of key, clearly defined, and potentially attainable goals; (b) formulate a systematic strategy for working with the developing countries to attain those goals, encompassing activities along the entire continuum of research-development-demonstration-diffusion; and (c) mobilize U.S. resources to carry out that strategy. It should collaborate with interested developed and developing countries as well as international bodies.

2. Respond to initiatives from individual countries and to needs for technical assistance in areas outside the IDI's priority concerns. Whereever these additional purposes are to be served, the IDI should condition its assistance on the establishment of a jointly organized and managed foundation-type instrumentality.

3. Have assured continuity of adequate funding by means of a special fund that combines biennial congressional appropriations and repayment of past loans. This fund should be authorized initially at a $1 billion level, with periodic review of the authorization ceiling.

4. Operate essentially as a management and funding agency marshalling intermediate organizations to carry out the bulk of programs as stated above.

5. Have freedom to arrange unique and unconventional modes of operating with intermediate institutions. Institutions receiving IDI grants and contracts might include universities, federal agencies, technical and voluntary service organizations, and private enterprises, both here and abroad.

6. Have a small, top quality staff capable of (a) providing strong policy and program direction; (b) analyzing problems, defining programs, and assembling program elements; (c) supervising and coordinating implementation of these programs; and (d) providing follow-through for evaluation and utilization of results.

7. Have at its command a first-rate multidisciplinary facility for development research and analysis. This should be primarily policy-oriented, but also should be able to include some experimental research capabilities if these are lacking elsewhere.

Unfortunately, shortly following transmittal of the report of this study to AID, interest in the subject at the highest policy levels waned. Nonetheless, the model outlined in the report has wide relevance to efforts to transfer technological capabilities from developed to developing countries; therefore elements of the report have been incorporated in a number of proposals dealing with this subject including those of the Commission on U.S.-Latin American Relations, chaired by Sol Linowitz.

Solar Energy in Developing Countries: Perspectives and Prospects

In response to a request by AID, an ad hoc panel convened by BOSTID considered the present state of development of processes for using solar energy, its present applications, and possible future developments in solar processes, all in the context of energy needs in developing countries. The panel also considered the desirability of establishing an International Solar Energy Research Institute in North Africa.

Based on these considerations and on the experiences of its members, the panel drew several general conclusions: solar energy is widely available in areas with energy needs in developing countries; useful applications of solar energy are now being made; other applications are in various stages of experimental development; knowledge of energy needs in developing countries is inadequate and must be improved; and research and development programs to meet these needs should include, but not be limited to, consideration of solar energy. The panel concluded that solar energy is a resource that has the capability to meet energy needs substantially beyond the applications now being made, and that this potential can be realized only with further research and development.

The panel considered that the essential problems are energy, not solar, problems, and that solutions to these energy problems require consideration of alternative sources of energy. From this the panel evolved, and recommended to AID, the concept of regional energy research and development centers, which would study energy needs and means (including solar) by which these needs might be met. The suggested International Solar Energy Research Institute in North Africa, if expanded in scope to include other energy sources and with functions described below, was envisioned to be one such regional center.

The panel noted that the solar processes now useful, or that could be brought to a stage of development in which they could produce useful results in the shortest time, are evaporation, drying, distillation, and water heating. More extensive development of processes for refrigeration, new methods of solar drying, heating, cooling, and thermal design of buildings should make some of these uses practical within the decade. Applications of solar power will require substantial development of new technology.

The panel recommended systematic approaches to energy resource and utilization programs for developing countries or regions. The following approaches were included:

- -- detailed studies of the energy needs of the given region or country as a basis for selecting the most useful energy processes to be developed;

-- thorough understanding of the objectives to be achieved by the supply of energy;

-- an examination of the possible energy supply alternatives, which would include solar energy but would not be confined to it;

-- a detailed set of criteria for measuring the desirability of actions;

-- studies of the costs and merits of the available options of energy supply to meet known needs;

-- surveys to determine the investment and manufacturing capability required; and

-- the development of strategies to bring about desired action from suppliers and users, such as manufacturing in the appropriate location, suitable distribution, education of users, etc.

If this systematic approach is followed, then the question arises of how the needed information base can best be generated and the research and development proceed.

In the unanimous judgment of the panelists, the establishment of regional energy R&D centers was a valuable concept to consider for performing the above tasks. The panel felt strongly that the tasks could best be performed _in situ_, and that the regional centers should be staffed mainly with people from the region, if possible, and augmented by experts from developed nations. Staff would then deal with the practical energy problems of their regions and, at the same time, exchange information and experiences with other regional centers, in order to avoid wasteful duplication and to maximize the gains to the developing countries from their efforts. They would also be aware of and ready to take advantage of advanced technology from developed countries that could be transferable to their regions.

The regional centers would be responsible for:

-- generating an information base on energy needs in the region;

-- carrying out the needed research and development to meet regional energy needs;

-- field testing and providing feedback from users to the centers in order to improve energy processes and evolve useful solar (or other) processes;

-- acting as information, education, and training centers in cooperation with local universities; and

-- maintaining close contact with scientific and engineering developments and energy applications in other centers and in industrialized countries.

The panel recognized that the concept of regional energy R&D centers deserved further in-depth study. In particular, the relationship between national energy programs and a regional center would have to be considered in detail.

The proposed International Solar Energy Research Institute in North Africa was to constitute one of the regional centers envisioned by the panel. Its mission would be expanded to include consideration of solar and alternative energy resources. Support could include engineering and scientific laboratory equipment, library facilities, training of personnel, and means of cooperation with similar institutions in other regions and developed countries.

The report of this study, published in 1972, was distributed widely in both developing and developed countries. Requests from U.S. agencies and institutions concerned with solar energy research and development and from government agencies and research institutes abroad concerned with technical assistance to developing countries continue to arrive despite the fact that the report has been out of print for several years. There has been a particularly large number of requests for copies of the report and for further information regarding solar energy research from research institutes in the developing countries themselves. The information contained in this report has been superceded with the more recent BOSTID publication, Energy for Rural Development.

Scientific and Technical Information for Developing Countries

In response to a request from AID, an ad hoc advisory panel was convened under BOSTID to study the problem of transfer of scientific and technical information to developing countries and to make recommendations on appropriate activity and programs for technical assistance.

The panel undertook the following tasks in carrying out its study:

1. To identify the capabilities of lesser developed countries that need to be developed or strengthened to enable them to acquire and disseminate scientific and technical information more effectively;

2. To identify the types and sources of scientific and technical information, particularly in the fields of natural resources, industrial technology, and the scientific and technical disciplines, pertinent to the needs of developing countries;

3. To define and assess approaches and mechanisms that should be developed by AID to expand the flow of information to and between developing countries;

4. To develop a rationale for technical assistance in scientific and technical information that will provide AID with policy, programming, and priority guidelines;

5. To recommend specific projects and programs with respect to scientific and technical information that might be undertaken by AID.

The panel of 10 was composed of information specialists and development experts. It met three times and was aided in its deliberations by a number of individuals from institutions in the United States and other aid-donor countries, as well as from regional and international organizations.

The essentials of the recommendations of the panel are as follows:

-- In the overall technical assistance effort of the United States, high priority should be given to assistance programs that improve the transfer of appropriate scientific and technical information to developing countries.

-- This assistance should give primary attention to developing and strengthening appropriate information infrastructures of these countries. Programming should be directed toward developing such functioning infrastructures before major technical assistance programs are phased out.

-- Assistance should serve to stimulate the developing countries to give greater attention to the problem of scientific and technical information, including articulation of national policies in this regard and commitment of indigenous financial and human resources to needed action programs.

-- Assistance activities should not take the form exclusively of specially designed projects for the transfer of scientific and technical information, but should also constitute a significant component, wherever relevant, in other AID sector- or problem-oriented programs. In programming information-type assistance activities, all forms of aid should be utilized: technical assistance loans, U.S. surplus property, research funds, institutional grants, and use of foreign currencies obtained from the sale of U.S. surplus commodities.

-- An organizational entity should be established within AID to implement scientific and technical information assistance activity. It should make use of an external advisory panel for policy and program guidance. AID-sponsored assistance should be coordinated with that of other donor countries as well as regional and international agencies engaged in similar or related efforts.

With the increased worldwide attention being given to scientific and technical information, particularly as it relates to economic development, there has been a great interest both by developed and developing countries in the recommendations in this report. The report has also been requested by organizations in other developed countries concerned with technical assistance to developing countries.

In association with the National Technical Information Service of the U.S. Department of Commerce, AID has undertaken a multi-faceted technical information exchange program that reflects in many respects the recommendations and proposed program activities in the BOSTID report.

Science and Technology in Sao Paulo's Development

In November 1971, officials of the AID mission to Brazil met with staff members of the Office of the Foreign Secretary to discuss a new approach for utilizing science and technology for economic development of the State of São Paulo. Before proceeding further with the project, which was expected to be partially funded by a $25 million soft loan from AID, AID officials sought a critical and objective outside review of the project's concepts and the possible mechanisms of implementation. The NAS was requested to establish an ad hoc committee to perform this function.

The main objectives of the Brazilian project were:

1. to improve the scientific and technological resources in the State of São Paulo, particularly as they relate to key areas on the industrial development of the state;

2. to encourage industry to utilize indigenous manpower capabilities and to develop new, or adopt imported, technologies that would accelerate development of new domestic products and processes or reduce production costs; and

3. to increase the state's capacity to train scientists, engineers, and technicians for pure and applied research.

To reach these objectives, the Brazilian project proposed:

1. to develop an advisory group to plan and evaluate programs in science and technology within the state's Ministry of Planning;

2. to enhance the resources to train scientists, engineers, and technicians in the universities and centers of technology through provision of scholarships, research grants, and the institution of exchange programs; and

3. to provide risk capital for funding research and development projects for industry.

The AID mission in Brazil believes the Sao Paulo project to be the first of its kind in that it utilizes a systems approach to harness science and technology for economic development. The project intends to concentrate on increasing the capacity of centers of research, i.e., universities, institutes of technology, and industrial research organizations, to train competent individuals and to conduct in-house research. These centers will be coupled to industry through the provision of risk loans to support research based on industrial needs. Significant emphasis will be placed on the development and improvement of services such as science information, standards, patent banks and protection laws, and financing institutions to support the research program.

Six major recommendations are quoted below from the report of the NAS panel:

First: The CET (Council of Science and Technology)/BADESP (Banco de Desenvolvimento de Estado de São Paulo) Fund loans should be promoted for and directed to research projects that have a demonstrable commercial importance. Accordingly, most of the loans should go to the projects of firms susceptible to breaking into the EDR (engineering, development, and research) cycle. Correspondingly, we recommend that projects proposed and initiated by government institutes and universities should be financed from the Fund only if 20 - 30 percent of the total cost will be borne by one or more industrial or agricultural enterprises that would ultimately benefit from the work.

Second: The initial projects selected for financing from the Fund for Science and Technology should be used for a relatively few, generally large-scale, demonstration projects, which will have high visibility and thus lend credibility and impetus to the effort to promote the utilization of research and applied technology in São Paulo industry. To ensure this result, extraordinary support--technological, managerial, and financial--for the design and execution of these demonstration projects should be mobilized in Brazil and abroad.

Third: The CET and BADESP should be supported with highly competent staff to perform the key coordinating and policy and program decision making functions in the use of the Fund and in mobilizing resources to

- Encourage projects in export areas of economic and technological significance;

- Assist in policy formulation, and in the review and monitoring of projects from the perspective of the adequacy of the scientific-technological preparations for the projects as well as the possibilities of successful execution;

- Bring to bear on the selection of project proposals--and in the design of project proposals--judgments of a substantial marketing and research competence; and

- Assure that projects have as their objective tangible product and process development, the key purpose of the entire program.

The CET and BADESP also should undertake to assure the establishment in such institutions as the Instituto de Tecnologia de Alimentos (ITAL) and the Instituto de Pesquisas Tecnologicas (IPT), of a strong capability for market research and project evaluation so that these institutions can make a strong contribution to the purposes of the Project.

Fourth: Since the proposed Project is only one part of the state's program in science and technology, it is essential that the state give concomitant and substantial budgetary support to the research institutes and universities. More specifically, the state should strengthen the capacities of these institutions to contribute to the Project by correcting such fundamental problems as low salaries at the institutes and the prohibition on consultation with industry by university faculty and staff.

Technical assistance, to support the roles in the Project envisaged for the research institutes and the universities, should take the following forms:

- For the research institutes: Resources should be provided for sending technical specialists from the United States to work with staff in the São Paulo research institutes to help these institutes develop and strengthen their capabilities in such fields as project evaluation and market research, product and process development, standardization and quality assurance, and information systems. In certain circumstances, it may be advantageous to send institute staff to the United States for training in these fields.

- For the universities: Resources should be provided for sending young educators from U.S. universities to the universities in São Paulo to initiate or strengthen educational programs in, for example, research and engineering fields related to the project, research management, and marketing. U.S. postdoctoral students could be most usefully engaged in this task. Correspondingly, support should be provided for Brazilian students to enroll in U.S. universities for doctoral training in similar fields so they will be able to assume these educational responsibilities in the São Paulo universities in due course.

Fifth: Technical assistance provided by USAID should be deployed so as to have significant impact on the project in two ways: first in the use of funds; and second, in the administration of the use of resources by USAID itself.

Concerning the proposed use of funds, the proposal at present suggests that $10 million be allocated for hardware, and $15 million for other forms of technical assistance. We believe there was insufficient justification for the hardware and that most of the equipment required by the Project can be made available from other existing sources, such as state and federal agencies.

We believe, further, that some of the other forms of technical assistance described in the Project are not fully responsive to certain major needs of industry. Technical assistance should support the marketing, evaluation, and technical-service efforts that are summarized in the third and fourth recommendations, as well as the projects approved by the Council of Science and Technology. This would suggest a major emphasis on technical assistance of a practical type, except in such specialized areas as certain research and engineering fields related to the Project, information systems, standardization, and development of new university education programs. In any case, U.S. advisors in São Paulo should have ready access to institutional support in the United States.

The other major contribution of USAID will be through the activities of the staff it enlists to administer the technical assistance support for the Project. The quality of this administrative effort, especially in mobilizing other high-quality resources for the Project, will be a key factor in the entire process. Since this is an extraordinary role, it requires extraordinary talent.

To offer less than excellence in the management of USAID's contributory role could seriously handicap this promising initiative in economic development; to provide outstanding advice, counsel, and technical help through this Project could tangibly demonstrate the will and ability of the United States to mobilize its best resources to help Brazil achieve its major national objective.

Sixth: The entire Project, as revised, should have an implementation plan and program. Such a plan and program should be the principal responsibility of the CET Project director and staff; it should be coordinated with the Government of Brazil and USAID as the other major participants in the program; and it should encompass activities outside São Paulo, in the United States, and possibly, Europe and Japan which could aid in mobilizing EDR resources, facilitating access to appropriate technologies, and in creating a network of institutional relationships that would backstop the São Paulo engineering, R & D, and information-systems efforts. A deliberate, well-coordinated, and performance-oriented implementation program, possibly involving further assistance from the National Academy of Engineering, could be vital in moving the Project from an original, exciting concept to the realization of a model effort by Brazil to become an "outwardly oriented" industrial country in the shortest possible time.

The opportunity exists; the means are at hand; and Brazil and São Paulo have already demonstrated the national will and regional dynamism that can make this effort succeed.

In submitting its report, the panel chairman emphasized the following points: "first, the importance of having the São Paulo Project focus on those efforts in science and technology that can improve the capacities of Brazilian industries to compete successfully in world markets; second, the potential importance of the São Paulo Project as a model for demonstrating some of the significant ways by which science and technology can contribute to economic development; and third, the need for a plan and program of implementation that can better assure the successful operation of the São Paulo Project as a viable model for Brazil and other developing countries."

The proposal for the São Paulo project, partly as a result of the panel's deliberations, was significantly modified prior to resubmission to AID for subsequent approval.

The São Paulo project, as of 1975, was an ongoing $40 million project having long-term contracts with six major U.S. institutions (MIT, Vanderbilt, Stanford Research Institute, Denver Research Institute, National Bureau of Standards, and CODOT, a consortium of the universities of Washington, California, Wisconsin, Rhode Island, and Michigan State).

Outside Brazil, there appears to be considerable interest in the São Paulo project as a possible means for the effective organization of science and technology for economic development.

Research Management and Technical Entrepreneurship:
A U.S. Role in Improving Skills in Developing Countries

AID requested this study on the recommendation of BOSTID, which was convinced, after several workshops on industrial research, that the absence of properly trained R&D administrators was a serious obstacle to the growth of industry-oriented, applied research in developing countries. The workshops have recommended that training programs in research management be developed.

An ad hoc panel of 15 persons, drawn from U.S. government laboratories, industrial firms, contract research organizations, and graduate management schools, addressed the following directives:

-- To identify elements and characteristics of alternative training programs for research management and senior staff that U.S. organizations might undertake in the host country, or in the United States;

-- To assess the interest and potential contributions of U.S. universities and government and industrial laboratories and research institutions in such programs;

-- To recommend to AID steps for setting up training programs.

The following is a summary of principles the panel felt should guide a U.S. program for improving technical management in LDCs.

1. New ideas permeating development thought--on mobilizing science and technology for solving development problems, on selecting and using technologies that will minimize harm to the environment, on realigning policies to promote employment through better utilization of technology,

on helping the poorest groups in LDC societies--will give rise to programs requiring LDCs to have vastly improved competence in technical management. That the present deficit in technical management is a limiting factor to development should receive explicit recognition within the entire U.S. aid program.

2. Given the still rudimentary experience in organizing comprehensive technical management training programs for LDCs, the approach to be followed in program development should be gradual and selective, giving first emphasis to pilot experimentation.

3. The single most important goal of technical management training should be to institute technological entrepreneurial qualities in the participants, be they from the research institute or from industry.

4. A major objective should be to implant within selected LDCs a cadre of personnel, institutional resources, and other means adequate to sustain an ongoing, indigenous action for the improvement of technical management.

5. Until LDCs achieve this capability, the United States should commit itself to an effort endowed with assured continuity and coherence.

6. Several advanced industrial countries have great competence in areas of technical management and have an important contribution to make in assisting LDCs. The United States should actively encourage their interest and participation in this endeavor, which will meet the critical need only by commitment of resources and coordination of effort on the widest multilateral basis.

7. Several LDCs that have achieved an intermediate level of development and have acquired institutions or established practices of recognized quality should also be encouraged to participate. Their experience and their proximity to other LDCs in the region may help facilitate the organization of training programs on a larger scale and at a lower cost than possible in the United States or other advanced countries.

8. Programs should be designed to take into account, and to adapt to, the profound variations in local and regional conditions.

RECOMMENDATIONS TO THE U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

1. To provide a focus within AID, it is desirable that the Office of Science and Technology establish a position with clear responsibility for promoting and coordinating technical management training programs, filled by a staff officer with experience in industrial technical management and familiarity with industrial conditions in LDCs. The office would monitor projects in technical management training contracted with qualified institutions.

2. The proposed key elements of the program to be undertaken, either within AID or through contracted services, are as follows:

a. An information clearinghouse should be maintained on U.S. and third-country sources of assistance* in management training and development.

b. U.S. efforts in technical management training and development should be coordinated with those of international and bilateral agencies concerned with, or engaged in, similar programs, among other things to identify gaps in present training activities in order to formulate specific training activities to fill them.

c. Clearinghouse data should be based on a systematic canvass of U.S. government laboratories, contract research organizations, and industrial firms.

d. A series of carefully designed specific training projects in the United States and the LDCs for technical management should be developed on a pilot basis.

RECOMMENDATIONS TO LDCS

1. To secure a better balance, the panel urges LDCs to recognize and pay special attention to aspects of technology policies that are distinct from those bearing on scientific and educational development but perhaps sensitive to domestic and international economic stimuli. A sound national technology policy must provide for aggressive development of indigenous technical management capability.

2. No adequate plan for developing technical management can be formulated without an objective assessment of resources in trained manpower and the capabilities of technical institutions, as well as their potential for improved performance, to help to meet national goals. Methodologies for making such surveys have been developed in the United States and elsewhere; assistance would be available from contract-research organizations and universities for collaborative assessments of physical and human resources for technological development.

3. Preferential policies to aid small- and medium-size enterprises, the backbone of the industrial sector in LDC economies, should be adopted.

4. To stimulate the measures just listed, LDC governments should provide fiscal incentives to industry for R&D not only to improve products or processes, but also to upgrade the technical and management competence of staff. Such incentives could be provided through cost-sharing or tax relaxation.

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* See U.S. Department of State; Office of International Training, (1972) Technical Cooperation Training Resources Catalog. Agency for International Development, Washington, D.C.: U.S. Government Printing Office; and Selected Training Opportunities for Industrial Development, a catalog published periodically by the U.N. Industrial Development Organization (Vienna).

5. An important factor in the improvement of U.S. technical management has been the organization of groups for discussion and study of common managerial problems and for arrangements for training of present and prospective managers. Similar groups have been established in Western Europe and Japan. Forming such groups requires local initiative and leadership, and deserves official support. Leadership in the creation of such associations should properly come from LDC technological institutes, but development banks, governments, and industry should contribute to their support.

U.S. International Firms and R, D and E in Developing Countries

Improving the efficiency and effectiveness of industrialization programs has become of increasing concern not only to economic planning authorities in less developed countries, but to political and opinion leaders as well. The reasons for this heightened concern with types and techniques of production include:

-- the desire to save foreign exchange and other scarce resources by developing a more efficient range of industries that produce goods, primarily for sale in the domestic market, that would otherwise be imported;

-- the desire to earn more foreign exchange by efficiently producing goods that can be sold on world markets; and

-- the development of a greater sensitivity than ever before to the need for reducing unemployment and underemployment, upgrading skills, distributing income more equitably, and having available an array of products suitable for purchase by low-income groups as well as the more affluent citizens of the country.

The implications of these developments for U.S. firms interested in selling to, or manufacturing in, LDCs are far reaching. Governments of LDCs want foreign enterprise to assist them in (1) developing indigenous capability to adapt technology to their particular needs, (2) training research and engineering personnel to perform a wide range of adaptive engineering, and (3) enabling enterprises in LDCs to acquire, control, and use more industrial technology.

The role played by U.S. firms in strengthening research, development, and engineering in LDCs has varied greatly, depending on corporate philosophy, the "systems dependence" of the corporation's product or products, and the hospitality of the local environment for research, development, and engineering work. Size of market and stage of industrial development of the host country are also important elements.

At the request of the Agency for International Development, BOSTID convened a panel of experts to examine the past and potential role of U.S. firms in strengthening the R, D, & E capabilities in developing countries, and to identify the principal factors tending to promote or inhibit such a contribution.

The panel approached its task fully aware that the questions before it could not be viewed apart from the increasingly tense relations between the international investor community and the less developed countries. Because these tensions impinge so forcefully on corporate attitudes and plans, both the panel and the consultants gave them careful consideration. In its efforts to respond to the demands and aspirations of developing countries, the panel had to be guided by what collective international experience has shown to be achievable and mutually beneficial to host country and investor companies alike. Its insistence on "workability"--a characteristic of successful industry performance--helped assure realism in assessing the limits of private sector action, and within these limits, the potentials for present and future action.

The panel concluded that U.S. international firms in some cases already have played, and in more cases could play, a major role in the transfer to and improvement of technological capabilities in LDCs. The panel's conclusions and recommendations are presented under three headings: (1) actions by U.S. international firms, (2) actions by host countries, and (3) actions by international agencies and agencies of developed countries. Following are the key points:

1. All parties concerned need to recognize that R, D, & E is a complex, time-consuming, and costly activity that requires a stable, long-term, and open relationship between the host nations and the investor.

2. U.S. firms should relate their affiliates' activities to host countries' development goals, priorities, and strategies.

3. Host countries should encourage this process and establish mechanisms that foster consultation and interaction among the government, the scientific sector, and the productive sector.

4. Governments of LDCs are urged to improve the ties between their local research services, including universities and institutes, and the private productive sector.

5. U.S. firms are urged to explore a range of activities that could be undertaken within the limits of a local, profitmaking enterprise, such as close analysis of local development needs and resources as a guide for selective R, D, & E activities; an active collaboration with local universities and research institutions; strengthening of local affiliates' personnel in R, D, & E; deliberate programs to implant technological capability; and expansion of programs in adaptive technology.

6. The panel recommended further actions that U.S. firms could take, if externally funded, in applying their resources to joint R & D efforts with local governments and with other industries, foreign or domestic; projects for training local research personnel, and for gathering and disseminating technological information useful to the LDCs were also suggested.

7. To facilitate these and other R, D, & E activities, the panel recommended that international organizations and aid agencies of developed countries

provide a range of financial incentives.

The report has been widely distributed to the U.S. industrial community through individual mailings and through institutional channels. Bulk quantities were furnished to the U.S. Chamber of Commerce for dissemination to relevant constituent units, and to the Council of the Americas for its entire membership. The report also served as a basic reading document for the June 1975 Conference on the TransNational Corporation sponsored jointly by the Council on Religion and World Affairs and the Aspen Institute Program in International Affairs, and attended by 70 senior business executives. The AID-State Department Latin America Bureau found the report useful for the formulation of a program position for U.S.-Latin American cooperation in science and technology following Secretary Kissinger's commitments at the 1974 Foreign Ministers' Conference in Mexico.

Meeting the Challenge of Industrialization: A Feasibility Study for an International Industrialization Institute

Industrialization is a critical challenge facing developing and developed countries alike in the decades ahead. Increases in population, food production, and mobility combine to present overwhelming needs for jobs, improved income distribution, and city-regional balance; these can be met only by new and better use of the world's resources, both human and natural. Effective industrialization is vital to efficient resource utilization.

Several seminars, held under the auspices of the U.S. Agency for International Development, considered the prospects and problems of international industrialization and reached the following tentative conclusions:

1. The contribution of industrialization to fulfilling national goals, including employment, is complex; it requires an understanding of individual national factor endowments, such as natural resources, capital, labor, and infrastructure, and of alternative paths for their use and development.

2. Existing knowledge of the industrialization process is too limited, localized, and unsystematic, and its applicability to current and emerging needs too unexplored, to provide an adequate basis for effective industrialization policies or programs.

3. Although several international institutes have been organized to study ways of enhancing agricultural productivity, and another is being considered to study the social and economic effects of agricultural growth, no such institute exists to study industraalization.

4. To assist in evolving improved decisions on industrialization, the formation of a new multinational institute that would examine and illuminate these interacting forces could be of distinct value.

In view of these hypotheses, the Board on Science and Technology for International Development was requested by the Agency for International Development to undertake a study of the need and demand for an International Industrialization Institute. The organizational structure and possible program was also studied. To determine whether the proposed institute would duplicate or significantly add to existing institutional resources, the study was to include a review of current programs of international assistance to industrialization.

It was recognized at the outset that any such study must include large inputs from representatives of both industrial and industrializing nations. Likely users of its studies and other outputs should participate in the evaluation, design, and development of the institute if they are to believe in the utility of the institute and its findings.

The study was conducted in two phases. Phase one, designed to furnish a preliminary assessment, was based on interviews with knowledgeable persons in organizations located in the United States, such as the United Nations, foundations, the World Bank and its affiliated units, and other assistance agencies. This phase culminated in a two-day meeting in April 1972 of a specially appointed NAS-NAE panel composed of U.S. and LDC specialists. The panel recommended an in-depth study, with extensive canvassing of informed opinion, in developing countries and appropriate development-oriented organizations and institutions in other parts of the world. These inquiries were conducted in the summer of 1972, and the results--as well as a draft report--were submitted to the orginal panel, which reconvened in November. Additional interviews were held; drafts of the report were prepared in the following months; and a final report was sent to AID in August 1973.

The panel recommended that the International Industrialization Institute be organized as a research body devoted to enhancing knowledge of the industrialization process. The aim would be to help both developing and developed countries maximize the contribution of industrialization to their economic and social development, and to share equitably in its benefits.

The institute will be constructed to ensure autonomy and perceptive awareness of critical industrialization issues. It will be governed by an independent, self-perpetuating board of trustees drawn equally from developing and developed oountries. The institute will have a core staff of about 40 professionals from various nations who are expert in a variety of disciplines, including industrial economics; physical and social sciences; engineering; international economics and trade; and industry location, marketing, and manpower develomment.

The institute's interdisciplinary work program will not duplicate that of any existing agency. Program activities will be carried out in close collaboration with other research groups at national, local, and international levels and with industrial and financial institutions. Location of the institute for maximum use of human and information resources will be determined by the board of trustees in consultation with prospective host countries.

The program of the institute will emphasize applied research to create new linkages among policy, the market mechanism, and technology, thereby helping to guide industrial decisions more effectively toward development goals. The initial program focus would be directed toward:

- -- selection of industries and technologies by countries of varied circumstances;
- -- identification of policies to promote the growth of the selected industries; and
- -- increasing adjustability in advanced economies to accelerate desirable shifts of industries to new locales.

Initially after publication of the report, the International Development Research Center (IDRC) of Canada provided some support to cover follow-up implementation costs. However, in September 1975, Secretary of State Kissinger's speech, delivered through Ambassador Daniel Patrick Moynihan, to the Seventh Special Session of the United Nations General Assembly proposed the establishment of the International Industrialization Institute. Because the speech was sufficiently well received, the State Department and AID have now established an office to proceed with the founding process. As a part of this process, a contract was given to the Foreign Secretary's Office of the National Academy of Engineering to work with the AID office to determine the viability of the proposed institute.

International Development Programs of the Office of the Foreign Secretary

This review covers science cooperation programs undertaken from 1961 to 1971 in 12 African, Asian, and Latin American countries. Primarily a self-evaluation, the study based many program results, favorable and unfavorable, on reports by counterpart organizations, AID missions, and other appropriate sources. The main appendices contain descriptive summaries of programs and projects, project reports and publications, and an extensive list of U.S. and foreign participants who have engaged in the activities covered by the report.

The "analysis" attempts to identify the factors influencing the success of projects. Generally speaking, factors influencing success were: attitudes of AID; leadership of host institutions; availability of funding for workshop development and follow-up; quality of staff and panelists--especially in regard to sensitivity, knowledge, and communication ability; and frequency and quality of communications between the NAS and host institution. Posing questions on the effectiveness of programs points up the difficulty of obtaining accurate program information.

Critical factors for workshop programming evolving from the analysis are:

1. the importance of working with a viable counterpart organization;

2. the need for open, joint discussion of objectives;

3. agreement among participants on the limitations of the exercise, so that the form and content of the program fit the local situation; and

4. avoidance of a pedagogic or a patronizing attitude.

Continuity is extremely important to the success of the bilateral programs and is influenced by several factors, including changes of government, changes in the administration of the host organization, and changes in the political relations between the two countries. Other factors influencing program success include the thinly spread local manpower in science and technology, the local AID mission's indifference toward the program, AID's short institutional memory, and lack of follow-up by NAS staff due largely to lack of funds.

The analysis makes clear that the optimal arrangement for AID-funded efforts is to have AID/Washington provide the basic funding and AID country missions provide the local program costs.

Among its recommendations the report calls for:

1. An in-depth study of the Brazil and Taiwan programs, two of the most successful BOSTID activities, to obtain more insight into factors that influence program quality and success

2. A built-in evaluation of all major projects;

3. More follow-up activity to workshops and studies arranged with counterpart institutions;

4. Evaluation of special studies by an ad hoc committee;

5. A study of factors influencing scientific and technological development in countries where the NAS has not been involved (such as Mexico) in contrast to countries in which NAS science cooperation programs have taken place--to see whether any differences are discernable.

The analysis concludes that the role of the NAS should be to work jointly with developing countries in applying science and technology to their development needs, serving in an advisory capacity and realizing that the implementation of recommendations must be carried out by the host country. The bilateral programs could be improved by finding more private funding (to permit greater flexibility and more follow-up), by careful program selection, (so that BOSTID resources would not be spread too thinly), and by improved identification and selection of panelists and inclusion of more social scientists.

This review involved the issuance of two reports. The first report was more specific and went into considerable detail regarding the evaluation of programs, the results, and the reasons for them. This publication was for limited distribution to AID and within the NAS. The second publication was more general and deleted any negative conclusions, so that it could be made available to the general development community overseas as well as within the United States.

Role of Science and Technology in International Development in the 1970's

One of the activities carried out by NAS staff in the latter part of 1970 was planning and preparation for a study on the role of science and technology in development. The broad objectives of the study included:

- -- identification of development problems most susceptible to scientific and technological solutions;
- -- recommendations on ways of assisting developing countries to create or expand their own capability to develop and use science and technology;
- -- consideration of contributions that the scientific and engineering communities of the industrialized countries are particularly qualified to make to the solutions of development problems;
- -- identification of new developments in science and technology that show promise for economic and social development; and
- -- formulation of guidelines that will assist administrators of technical assistance organizations in using science and technology most effectively to cope with the development problems of the next decade.

MAJOR ACTIVITIES

In the spring of 1971, BOSTID was engaged in planning the initial phase of the study. A steering group met in Washington in January 1971 and in Cambridge, Massachusetts, in March 1971. It was agreed that the first major activity should be an international seminar that would provide a forum for a broad assessment of the major issues concerning science, technology, and development.

The seminar was convened at Woods Hole, Massachusetts, August 15-21, 1971. It was composed of an interdisciplinary group including representatives of the social and natural sciences, and of developing as well as industrialized countries. In addition to the United States, participants came from Argentina, Canada, England, Ghana, Mexico, the Philippines, and Uruguay. International and technical assistance organizations were represented including the World Bank, U.N. Development Program, U.N. Industrial Development Organization, Organization of American States, Agency for International Development, and the International Development Research Center. Universities, research institutes, financial institutions, and international industrial corporations were all sources of participants.

The deliberations of the conference were organized around plenary sessions on the first, second, and sixth days, and meetings of three working groups on the third through fifth days. The topics addressed by the working groups were:

-- the capacity of developing countries to generate science and to generate, adapt, and initiate technologies (Group 1);

-- the capacity of developing countries to use technologies effectively (Group II); and

-- the role of AID, corporations, scientific and technological groups, and private institutions in strengthening science and technology in developing countries (Group III).

One of the conclusions reached at the Woods Hole Conference was that there seemed to be merit in considering a study that would address in greater detail the issues raised at the conference, but in a holistic framework, and that would use specific developing country cases to illustrate the problems associated with science, technology, and development as well as possible solutions and opportunities. Three people were selected from each conference working group to serve as an ad hoc advisory committee to consider the next steps in the proposed study.

The ad hoc advisory committee met in Cambridge, Massachusetts, on November 26, 1971. At that meeting, a number of suggestions were put forward relating to the substantive content of the proposed study. Consideration was also given to the mechanisms and timing appropriate to such a study.

Following the suggestions of the ad hoc advisory committee meeting at the end of 1971, BOSTID staff worked with selected committee members during the early months of 1972 to develop a more detailed conceptual framework for the study. The framework and timetable suggested consisted of drafting of case studies by commissioned authors during the balance of 1972; review of the drafts by members of the formal study committee in early 1973; a second Woods Hole conference to be held in the second half of 1973 to enable the study committee and authors to make an extensive joint critique of all commissioned papers; and final revision and preparation of recommendations during late 1973 and early 1974. It was proposed that the final report of the study should consist of two volumes--one, a summary and presentation of conclusions and recommendations, and the other, the commissioned case studies.

Copies of the papers that reached the stage of a full draft were:

-- "Agricultural Mechanization Technology for Tropical Asia," by Amir U. Khan.

-- "The Modernization of Brazilian Agriculture," by G. Edward Schuh.

-- "A Study of the Role of Science and Technology in Taiwan," by Bruce H. Billings.

-- "The Role of Scientific Research in Agricultural Innovation in Israel," by Shaul Katz and Joseph Ben-David.

During the period in which several papers were being commissioned and drafted, further meetings of members of the ad hoc advisory committee took place: March and May 1972, Cambridge, Massachusetts; July 1972 and January 1973, Washington, D.C. At these meetings, the conceptual framework of the study was discussed further, suggestions for additional commissioned papers were made, and names were considered for a list of possible members of the formal study committee.

As work on the study progressed, it became increasingly apparent that two external developments had substantial implications for the study--the evolution of BOSTID's overall program and the increasing attention by various international institutions to the interaction among science, technology, and development.

As the BOSTID programs with developing countries expanded and diversified, they increasingly addressed aspects of science and technology that were included among the issues to be explored by the study on the role of science and technology in international development. The other BOSTID programs, moreover, were able to address these issues at a level of specificity and detail not possible in a single broad study. The identification of development programs susceptible to scientific and technological solutions and, conversely, the identification of new developments in science and technology that show promise for economic and social development were being addressed by other studies.

When the possibility of an NAS study on science, technology, and development was first discussed in 1969 and 1970, the topic had not yet been given significant attention in the literature of that period. As the Academy study began to move forward, however, interesting new studies began to emerge from organizations such as UNESCO, ECAFE, OECD, UNCTAD, the Committee on Science and Technology for Economic Development (COSTED) of the International Council of Scientific Unions, the U.N. Advisory Committee on the Application of Science and Technology to Development, and the University of Sussex Science Policy Research Unit, among others.

By the middle of 1973, the advisory committee on the NAS study had some doubts that the study was as timely and as likely to be influential as they had originally believed, and felt that its broad scope tended to diminish the prospect of developing actionable recommendations. The formulation of helpful recommendations and programs related to technical assistance seemed more feasible in connection with BOSTID's workshops and studies on particular problems and issues. After committee discussion with the Foreign Secretary, the chairman of the Board on Science and Technology for International Development, and others, this view was communicated to AID, along with the recommendation that the balance of unexpended funds allocated to the study would be more effectively used if spent for other BOSTID projects.

Copies of the working papers as well as the commissioned papers were forwarded to AID for their information.

African Agricultural Research Capabilities

In 1970, following the 1968 Abidjan Conference on Agricultural Research Priorities sponsored by NAS, AID requested a comprehensive study of African research capabilities in the agricultural sciences.

This project was undertaken by the NAS Agricultural Research Board, under the auspices of BOSTID. The committee worked under the following terms of reference:

-- to review, analyze, and establish, if necessary, the priorities in research and education that will enable agriculture to make its maximum contribution to the development goals of Africa as identified in such recent national and international studies as the FAO Indicative World Plan for Africa and the NAS-organized 1968 Abidjan Conference on Agricultural Research Priorities;

-- to specify the institutions and systems of agricultural research and research-related education--international, regional, and national--needed to achieve the goals;

-- to determine the most appropriate roles and modes of operation, and, where advisable, the subject areas and locations for non-African agencies to provide coordinated support for agricultural research and education in Africa, taking into account the developing contributions of African institutions;

-- to suggest appropriate channels of communication and cooperation among nations, institutions--inside and outside Africa--in agricultural research and education;

-- to outline the means by which research and education can be applied most effectively to African agricultural development; and

-- to make a broad assessment of the scientific manpower needs related to the proposed research system(s) and institutions recommended by the committee and assess the African scientific personnel available at the present time, identify scientific manpower gaps and needs, and establish priorities.

The committee met twice in Washington, D.C.; in Addis Ababa in 1971 at the time of the first general conference of the Association for the Advancement of Agricultural Sciences in Africa (AAASA); in Bellagio, Italy; and in Dakar, Senegal for its final meeting. The following general conclusions and recommendations are excerpted from the report:

> This study presumes that, for the foreseeable future, Africa will rely most heavily on the agricultural sector for lifting the standard of living of its peoples in the face of population growth rates ranging from 2.3 to 2.6 percent per annum and of increases in the absolute numbers of people living on farms.
>
> In determining priorities in agricultural development, national decision makers need the help of research to predict the consequences

of alternative courses of action whether at enterprise, whole farm, community, sector, national or regional level.

The Committee recommends that all efforts be made to bring natural and social scientists to work closely together in conducting research that will help national decision makers predict the consequences of alternative courses of action in determining priorities in agricultural development.

The Committee points to three broad problem areas as key ones urgently in need of solution in Africa:

1. improving standards of nutrition and raising the level of food production to satisfy rapidly increasing market demands (i.e., to improve standards of living while providing a constant, more rapid flow of raw materials for national industries, substitutes for agricultural imports and crops for export);

2. helping to alleviate the uneven development that takes place between farm and nonfarm sectors of the rapidly growing economies of African nations; and

3. ensuring that agricultural research contributes properly to a sound national agricultural policy and that agricultural policy itself plays its appropriate role in national and international science policy.

Toward these ends, the Committee recommends that, in technical and related socioeconomic areas, the priorities for strengthening research capabilities be in the areas of farming systems, food crops and livestock improvement in that order.

Agricultural development reinforced by strong agricultural research requires an adaptable infrastructure for policy. Regulatory practices dealing with quarantines and with pesticides will need changing as new pests and diseases cross borders and as information on host-parasite relationships develops. Advisory councils for government; communication networks that interlace scientist, government official and farmer; agricultural experiment stations; and faculties of agriculture--all need constantly to adjust to the kaleidoscopic changes that agricultural development in Africa, or elsewhere, brings.

The Committee recommends that ongoing mutually productive cooperative efforts of forming appropriate scientific councils or other advisory bodies to put agricultural research results to work be intensified, not only for the immediate benefits that will accrue to the nations of Africa but also for the potential advantages that result from a general expansion of knowledge in the area of advisory relationships between science and government.

Detailed recommendations are also grouped under farming systems, commodities, quarantine, pesticides, institutions, manpower, and implementation.

The English version of the report has been distributed widely by AID. A French version was also published and circulated.

The Peace Corps: Perspectives for the Future

At the request of ACTION, NAS-NRC established an Advisory Committee on Development Assistance Opportunities in the Next Decade for the Peace Corps. The Peace Corps was formulating a three- to five-year program strategy for submission in 1974 to the Office of Management and Budget and the Congress. Working groups within the Peace Corps were reviewing Peace Corps policies and operations as background for program strategy, but the agency also wished to have a separate, external group--such as the advisory committee--consider future prospects and opportunities for the Peace Corps.

The 21 individuals who served on the committee represented a wide range of appropriate experience: past services as a volunteer or staff member of the Peace Corps; knowledge of and service in development and technical assistance activities; familiarity with voluntary service in the United States and overseas; and training and distinguished achievement in the natural and social sciences. In addition, six members of the committee were themselves from developing countries.

The terms of reference gave the committee a broad mandate:

-- to reexamine the objectives and programs of the Peace Corps in light of changes in domestic and world affairs;

-- to consider alternative strategies for a U.S. volunteer agency in the context of development assistance opportunities in the next 10 years; and

-- to examine in more detail technical assistance opportunities in selected sectors and areas.

The committee concentrated on the future development of the Peace Corps and did not try to judge or rigorously assess the Peace Corps' record over the past 12 years.

The committee's responsibilities were organized along two parallel lines of activity. The committee as a whole concentrated on a broad assessment of trends and opportunities for the period ahead and the policy, program, and organizational implications of those trends. At the same time, panels were created to examine in greater depth, and primarily from a professional viewpoint, priority needs and special opportunities in agriculture, health and nutrition, and natural resources and environmental quality. These sectors were chosen, by agreement between the Peace Corps and the Academy, as specialized areas in which the experience of the Academy made its advice particularly appropriate.

The main theme of the committee's conclusions was that the Peace Corps idea is still relevant and potentially beneficial for the decade ahead. The following summarized recommendations represent the committee's views on future development assistance opportunities for the Peace Corps and how it can respond to them more effectively.

1. The Peace Corps should adhere to its distinctive character as a volunteer program supplying middle-level manpower to help other countries and to promote international understanding.

2. The Peace Corps should modify its recruitment, training, and placement procedures to enhance the effective use of the generalist volunteer.

3. In geographical scope, the Peace Corps program should continue to focus on the less-developed countries--with special attention to the poorest areas--including, where feasible, those having no formal diplomatic relations with the United States.

4. In operating style, the Peace Corps should strive to remain flexible in its domestic and overseas operation and in the use of volunteers, and should earmark a significant portion of its resources for experimental and prototype programs.

5. In the sectoral areas of agriculture, health and nutrition, and natural resources and environmental quality, the Peace Corps should review and update program objectives, provide more adequate professional and institutional support, and relate more effectively to the career interests of volunteers with specialized training in these areas.

6. The Peace Corps should make continuing use of expert advisory panels for program sectors with a high technical content; broaden its contacts with relevant technical and professional bodies, as well as organizations engaged in development assistance; and monitor its own processes and activities to obtain reliable program data.

7. The concept of binationalism--sharing responsibility for planning and management of the program with host countries--should remain a cornerstone of Peace Corps policy.

8. The Peace Corps program should remain basically bilateral. Some realistic possibilities exist for making particular projects multilateral, but this can usually be done best by the individual host countries.

9. Given the availability of volunteers in the United States and the needs and opportunities for service abroad, the Peace Corps should seek to grow significantly larger in the years ahead.

10. The Peace Corps should remain a governmental or quasi-governmental agency, largely dependent on government financing and capable of devoting a significant portion of its resources to the private voluntary sector,

but it should have a high degree of independence and should be insulated from any utilization as an instrument for the achievement of intelligence, security, or short-term foreign policy objectives.

Advisory Panel on Arid Lands of Sub-Saharan Africa

At the request of AID, the NAS appointed an advisory panel on Arid Lands of sub-Saharan Africa late in 1973 to "advise AID with respect to the critical medium- and long-term natural resource management problems of the drought-stricken region of West Africa, and to provide assistance in the design and implementation of U.S. participation in an international collaborative scientific effort being organized to address the emergency situation."

The panel met formally five times and held special meetings to consider particular topics such as the future climate of the Sahel region. In late October 1974, a group of panelists met with other international scientists and planners familiar with the Sahel at the Rockefeller Foundation Study and Conference Center at Bellagio, Italy, to discuss strategies for the long-term development of the Sahel region. Panel members met individually with a wide range of people knowledgeable about the Sahel, and visited the area during the period covered by the panel's report. The panel provided an overview to AID in reviewing proposals AID received, in responding to questions raised within AID, and in helping AID conceptualize strategies that will assist the Sahel countries in ultimately achieving economic self-sufficiency.

The highlights and conclusions of the panel's work are noted below:

1. A discussion of AID's mid-term (1974-75) program of activities for the Sahel countries took place, which enabled AID officials to reassess the problems associated with some of the large proposals such as tsetse fly clearance and provision of large areas of grazing reserve. In line with the panel's suggestions, AID has now reallocated its resources with respect to these problems.

2. A critique of the draft report of the group at MIT with which AID contracted to produce alternative strategies for the long-term development of the Sahel. Since the decision to undertake the MIT study antedated the establishment of the NAS panel, and since the conclusions and recommendations of the final report by MIT were not available to the NAS panel before it completed its work, a critical review was not possible. Panelists' concerns about the methodology of the study, however, were conveyed to AID and MIT representatives and perhaps contributed to a revised approach to the study. The final MIT report was distributed to panelists for individual comment.

3. A special meeting on the future climate of the Sahel convened by the panel brought together a large group broadly representative of U.S. climatologists. Opinion was divided as to the atmospheric conditions that cause severe drought, and as to man's ability to predict when they

would occur, and whether or not future droughts will be more frequent and severe than those of the past. More information is necessary to improve our ability to predict drought, and attention is being given to this problem. Drought is, unfortunately, an inescapable feature of the Sahel region; planning must take into account and cope with the severe droughts that may be expected to occur periodically.

4. An international meeting of NAS panelists, scientists, and administrators from Africa, Europe, and international agencies was convened to discuss strategies for the long-term development of the Sahel region. This meeting, held in collaboration with the Rockefeller Foundation at the Foundation's Study and Conference Center at Bellagio, Italy, provided a unique opportunity for participants to exchange viewpoints and perceptions of drought-related problems. The panel's report of the Bellagio meeting and a Bellagio Working Paper prepared by the Rockefeller Foundation will be circulated widely to disseminate the conclusions and recommendations on opportunities for long-term Sahelian development. The conclusions and recommendations emphasized: (a) the need for a systems approach to the utilization of available resources, and (b) the need for an institutional mechanism in the region (a "Sahel institute") that would provide systems research and development to support the long-term development effort. Within these contexts efforts should be undertaken to:

   -- upgrade the nomadic-pastoral livestock system;

   -- improve the predictive capacity of meteorological services;

   -- improve the supply of information on soil and water resource development <u>to farmers</u> on a farm scale;

   -- accelerate food production, both crop and livestock, as the basis for food security for the region, which will permit and support long-range economic diversification including such things as small-scale agro-industry;

   -- improve understanding of the economics of marketing at the farm-level, within and between countries;

   -- improve infrastructure, roads, and communications in the area;

   -- ensure that in developing large-scale water resource projects in the great river basins of the area, opportunities for small-scale water resource development (such as described in BOSTID's <u>More Water for Arid Lands</u>) are not neglected; and

   -- above all, improve the level of education of the people of the region, adults as well as children, by all methods (formal and otherwise) as the main basis on which long-term change can be effected in the area and on which all other development activities will depend.

At the panel's final meeting in December 1974, members felt that the original mandate of the panel had been accomplished, and it was agreed that therefore the panel, as then constituted, should be dissolved. However, it was also agreed that the following important tasks, which might require a different panel or other mechanisms, should be undertaken:

1. Collecting, collating, and analyzing the recent drought experience. A great deal of information has been derived from the recent drought, which should be systematically collected (before it is irretrievable) and analyzed for the lessons that should be preserved to reduce the impact of the next drought.

2. Providing a focus for U.S. scientific and technological inputs for problems of long-term self-sufficiency in arid lands around the world, particularly in Africa.

3. Implementing the ideas outlined in the Bellagio report. To do this, it was proposed that AID should consider establishing working groups to address the specific problems areas, e.g., upgrading the nomadic-pastoral livestock system. These working groups should not undertake studies of the problems per se, but rather design products and programs for donor agency financing and implementation to remove the critical constraints towards progress in development. Each working group should, of course, include African participants from the Sahel countries.

Following completion of the report, an informal proposal was circulated to a variety of individuals and agencies in the U.S., Africa, and elsewhere. It suggested the convening of an organizational meeting of representatives of institutions carrying out research into the Sahel drought experience, particularly those institutions in the region itself. This meeting was to discuss the coordination, collation, and collection of information relating to the drought. The particular focus would be to identify gaps in the research and develop a plan for an international conference at which the information could be discussed and recommendations formulated for the governments of the region so they could deal more effectively with drought in the future.

The proposal generated a great deal of favorable support, but funding has not yet been secured. However, it was discussed by an AID-supported meeting of African social scientists on adaptive strategies for the Sahel, sponsored by the Nigerien Institut de Recherche in Sciences Humaines, which took place in late June 1975.

The UNDP has sent a feasibility study group (including one participant in the Bellagio meeting) to visit the Sahelian country governments to discuss the concept of a Sahel Institute. Preliminary reports indicate that the idea of an institute with a very limited core administration, working primarily through existing institutions in the Sahel countries, is being favorably received.

A new contract has been negotiated with the Africa Bureau in AID for a two-year period beginning August 31, 1977. The objective of this project is to assist AID in designing long-term development interventions in the Sahel

Region generally and specifically in cooperation with the Ecology and Forestry and Adaptation of Technology working groups of the Club du Sahel.

Ad Hoc Meeting on the Development of an AID Technical Assistance Strategy in the Field of Energy

In 1974, AID's Office of Science and Technology was asked to prepare position papers on U.S. policy alternatives for technical assistance to LDCs in the areas of energy conservation, improved utilization of indigenous energy resources, and programs of research and technology development relevant to these policies. Because of the complexities of the energy problems in a diverse set of developing countries, coupled with the short time provided for response, AID asked the Academy to convene informally a panel of experts to review the policy and program options available to the United States and to make suggestions for alternatives based on the panelists' experience and expertise, as well as to comment on feasibility, costs and resources, timing, and other factors affecting the selection and implementation of policies and programs.

A panel of approximately 10 persons met. Per agreement, no written report was issued. However, attendance and participation of AID officials allowed them to obtain the panel's thinking and suggestions regarding the various matters discussed.

Role of U.S. Engineering Schools in Technical Assistance

Discussions between AID and the NAS-NAE in 1970 revealed a common desire to see U.S. engineering schools play a more active and relevant role in overseas technical assistance efforts, a role comparable to that of agriculture schools and experiment stations of U.S. land-grant universities. AID subsequently asked the NAS-NAE to undertake a study of the subject.

The panel's terms of reference were as follows:

- -- To identify interests and capabilities of U.S. engineering schools relevant to developing countries' needs, such as curriculum reform, training and orientation of teachers, and development of indigenous institutions.

- -- To recommend needed changes in U.S. engineering school curricula to orient training of engineers more directly to the problems of developing countries.

- -- To examine means of relating research interests of U.S. schools to specific developing country problems and recommend ways in which AID can mobilize U.S. schools for their role.

- -- To assess the interest and capabilities of U.S. engineering schools in acting as intermediate contract organizations in implementing development projects.

An eight-member ad hoc advisory panel, formed under the auspices of BOSTID with the advice of NAE, met in May 1971. The panel met again in September 1971 and produced a draft report of its recommendations. At a third meeting in January 1972, in conjunction with the International Division of the American Society for Engineering Education, the draft recommendations were discussed with the engineering community attending the meeting.

In reviewing the draft, it became apparent that the study should be broadened to address additional questions: the implications of changing concepts and priorities in economic development policy for the engineering education community and its LDC-oriented activities; the concept of the "development technologist" as a new professional category, combining high-level competences in engineering and development economics; and the curriculum implications required for training such professionals. Moreover, other important questions on the potential role of engineering schools had emerged in the meantime, and the NAS proposed to AID that the study be extended into a second phase that would permit, with a change in the composition of the panel, a more extensive consideration of the subject. A report encompassing both phases was published in 1976, which stated that the most important role U.S. universities can play in present and future development is that of facilitation. They should seek innovative ways whereby their faculty and resources can perform this role and expedite the transfer of technology through LDC institutions and industries. To do this, the universities need assistance; therefore, any of the following recommendations were directed toward sponsoring agencies.

RESEARCH

-- AID and other technical assistance agencies should find ways, especially by new funding, to increase applied resaarch on LDC development problems at both U.S. and LDC institutions, and particularly at regional graduate research centers.

-- AID should strengthen institutional capability by such means as its 211(d) program, including extension of this kind of support to additional engineering colleges.

CURRICULUM IMPROVEMENT

-- Funding is needed to improve courses and programs at selected U.S., LDC and regional graduate centers for graduate students interested in economic development.

-- Innovative work-study programs are needed for students at both U.S. and LDC institutions.

-- U.S. colleges of engineering technology, together with funding agencies, should test the potential for this type of technical education in the LDCs.

TECHNOLOGY TRANSFER

-- The concept of establishing engineering/industrial extension services to facilitate the transfer of technology, especially in rural areas of LDCs, should be explored as to feasibility and applicability.

-- U.S. schools should seek to expand their contract services to offer additional special education in development-related subjects to LDC government and industrial managers.

-- Programs should be generated to encourage U.S. faculty members to take short-term assignments abroad in advisory and consulting capacities and to instruct other teachers.

-- To upgrade LDC faculties and to keep LDC faculties and students abreast of new technological developments, U.S. schools should develop short courses, workshops, and seminars.

EVALUATION

-- Past programs involving "sister" schools and consortia of U.S. schools that assist LDC institutions should be evaluated against original objectives and new priorities in order to design better support arrangements in the future.

-- Future programs should specify an evaluation phase, complete with clearly stated objectives.

-- Consideration should be given to providing criteria and means for the evaluation of U.S. faculty performance in development assistance.

Two thousand copies of this report have been printed and distributed worldwide.

Systems Analysis and Operations Research:
A Tool for Policy and Program Planning

Use of systems analysis by the most advanced of the developing countries is expanding as the demands for planning at various levels and in different sectors become more complex and highly trained personnel and facilities such as computers become more available. Although elements of a systems analysis capability are beginning to be present in an increasing number of countries, the effective use of such internal resources remains limited, and local needs continue to be met substantially by foreign consultant services. There is growing interest among many of these countries, however, in building up indigenous analytical capabilities and in applying them to a widening range of problems. International aid agencies are actively fostering this demand by their insistence on receiving well-formulated project proposals that assure effective use of external resources within a framework of sectoral planning.

As a result, in 1974 AID asked BOSTID to study the feasibility and character of a technical assistance program aimed at strengthening the systems analysis capabilities of developing countries. AID and development specialists view systems analysis as an important methodological tool with which developing countries are inadequately proficient. A significant number of these countries are at a point in their development where local competence can be institutionalized and where a high level of self-reliance can be achieved.

This study encompassed the following subject areas with recommendations as appropriate:

-- exposition of systems analysis methodology and its limitations with emphasis on the planning aspects and the practical nature of the results sought;

-- illustrative applications of systems analysis in public and private sector decision making with particular reference to LDC problems and needs;

-- requirements for establishing and operating a systems analysis group and variety of organizational modes suited to LDC conditions;

-- training processes and criteria for producing competent systems analysis personnel; and

-- technical assistance implications and opportunities for AID.

A summary of the panel's findings indicates that:

-- Systems analysis/operational research (SA/OR) is a demonstrated technique for assisting administrators and other decision makers.

-- It is of particular value when limited resources must be used to maximum effectiveness.

-- Its application is within reach of most developing countries.

-- It can be developed and carried on by local scientists and technicians.

-- The industrialized countries can assist LDCs with the training of SA/OR personnel and the development of the SA/OR operation.

-- SA/OR is not a panacea for the problems of the LDCs; its limitations must be taken into account.

The summarized recommendations of the panel for the attention of developed countries are:

-- Set up a prototype SA/OR group that will report to an administrator committed to its success.

-- Exercise caution in selecting specialists as advisors and using competitive sources and the advice of experienced SA/OR practitioners.

-- Encourage university courses in the practice of SA/OR and related subjects.

-- Sponsor conferences to familiarize business and government executives with SA/OR.

-- Sponsor scholarships, at home or abroad, for potential SA/OR practitioners.

Over 7,500 copies of the report of this study were published and distributed to appropriate individuals in both developed and developing countries. From this, two overseas activities resulted, one in Korea and one in Tunisia.

Appropriate Technologies for Developing Countries

This study, initiated in 1971 under the title, "Labor-Intensive Technologies for Developing Countries," was broadened in 1972 to include a wider range of topics in the choice of technologies for agriculture and industry. A treatment of technological choice in the broad context of technology transfer to developing countries must deal with scientific, technical, economic, social, organizational, and political questions. The NAS study included:

1. A general consideration of the interaction between technology and development in terms of a historical overview and the present setting of the problem.

2. The relationship of technological parameters to social and economic choices such as:

   a. availability of technologies through patents and licensing, "tied" transfer of technology, questions of access to information, substitutability of material, quality control standards of the market, etc;

   b. economic factors such as the economies of scale, monopoly power or firms and/or labor, foreign exchange restrictions, local taxes, etc;

   c. administrative constraints such as tariffs, market entry restrictions, balance-of-payments questions; and

   d. social objectives of the country such as capital- vs. labor-intensive processes, employment restrictions, income distribution, regional vs. national growth, urbanization, etc.

3. Comparison of special questions of technology choice in the industrial and agricultural sectors.

4. Consideration of a U.S. role for assisting in the choice of appropriate technologies.

Activities under the NAS-NAE appropriate technologies study have included:

-- Publication by the Overseas Development Council of Washington of a review paper and a selected bibliography entitled, "Economically Appropriate Technologies for Developing Countries - A Survey."

-- Convening three ad hoc panels of economists, engineers, and general development specialists to define parameters and specific terms of reference for technological choices as they affect social and economic development.

-- Establishment of an Academy panel to direct the study and prepare a report for AID and other development assistance agencies.

-- Convening with the American Association for the Advancement of Science a session at its 1974 annual meeting (February, San Francisco) on possible U.S. efforts to enhance the choice of technologies for development.

-- Commissioning background papers, or case studies, to examine in more detail specific problems including (a) appropriate chemical technologies in developing countries, (b) a survey of research trends for appropriate technologies in housing, (c) economic-technological behavior in metalworking industries, (d) appropriate technologies in iron and steelmaking, and (e) technology transfer and research in agriculture.

-- A survey-questionnaire of experience in the acquisition, adaptation, and development of technologies among a sample of decision makers in LDCs.

The experience of the panel and the extensive literature on technology choice have been assembled into a report. The report discusses appropriate technology from the viewpoint and needs of the decision maker in a developing country (both private entrepreneurs and government polic makers). Equally important, it makes recommendations to AID, to other supporting agencies, and to developing countries on steps that can assist in the process of linking technology more effectively to the development process.

The report has been published for sale by NAS and free copies have been distributed to appropriate recipients in developing countries.

Discussion Seminar on Systems Analysis-Operations Research

An informal advisory SA/OR committee was convened on October 29, 1976 to consider means by which NAS might assist LDCs in implementing the recommendations of its publication, <u>Systems Analysis and Operations Research: A Tool</u>

for Policy and Program Planning for Developing Countries. This was intended to provide general guidance to Dr. Philip Morse in his forthcoming talks in Tunisia where support for a program by the local AID mission appeared likely.

The committee concluded that BOSTID should establish a panel under its auspices to:

1. Follow up on requests from LDCs, such as the one from Tunisia.

2. Perform the functions of an SA/OR Fellowship Board, i.e., to prepare a catalog of SA/OR training capabilities in the United States to be sent to all AID missions in LDCs; seek AID (and other) financial support for LDC students to study SA/OR in the United States; advertise the availability of SA/OR fellowships; receive applications from LDC students for referral to appropriate U.S. institutions for their consideration; seek assistance and cooperation from business enterprises that have SA/OR in-house groups with regard to providing on-the-job training for LDC students; and encourage the preparation of specialized SA/OR training programs for LDC students in U.S. universities, as well as in universities in LDCs.

3. Promote and participate in conferences and seminars on SA/OR in LDCs.

4. Build support for SA/OR activities in LDCs from industrialized countries.

Resource Sensing from Space: Prospects for Developing Countries

The primary base for the economic development of most developing nations lies in their natural resources. Yet these nations, on the whole, do not know enough about the nature, quantity, and location of their resources to harvest them effectively for the welfare and progress of their people.

Much of the developing world is still inadequately mapped. Many countries have yet to determine the extent and condition of their arable land, forests, rangeland, and water resources to identify promising areas for mineral exploration. Vitally important, at a time of world food and energy shortages and of spreading environmental deterioration, is the need to monitor the changing condition of their natural domain--to forecast crop yields, to detect land erosion and water pollution, to recognize alterations in land use, and to give early warning and assess damage of natural disasters, and to observe many other aspects of environmental change.

At the request of AID's Office of Science and Technology, the National Academy of Sciences established a committee whose purpose was:

- -- to provide an assessment of the merits and effectiveness, if any, of remotely sensed data for resource management and environmental monitoring in developing countries;

- -- to formulate advice on a possible long-term AID role in fostering its use; and

-- to consider such other issues evoked by the technology of remote sensing that might affect its dissemination and use for developing countries.

The scope of the study was:

1. To assess the state-of-the-art in spaceborne remote sensing (including the complementary role of airborne remote sensing) with particular reference to applications relevant to the development needs of LDCs. Consideration should include the probable character and effects of improved remote sensing systems that might be available within the next 10 years.

2. To identify and evaluate the data requirements of LDCs for resource management, in light of their developmental objectives, with attention to specific information needs that might be met through remote sensing technology. Consideration should include current progress to disseminate knowledge of remote sensing applications technology.

3. To look upon use and dissemination of remote sensing technology for LDC application within the overall context of technical assistance/cooperation activity involving:

   a. AID/OST (Office of Science and Technology, Bureau for Technical Assistance);

   b. AID regional bureaus in the use of remote sensing as a progam element;

   c. Other suppliers of space-derived imagery, and other bilateral and multilateral aid-granting agencies; and

   d. LDC countries either as buyers of the technology or as aid recipients.

4. To focus study on the relevance of remote sensing to the specific needs of the developing world, with case studies of selected LDCs at different levels of development, and considering various institutional means and requirements for the acquisition, processing, distribution, and analysis of remote sensing imagery.

The Committee recommended that the U.S. through AID and through multilateral bodies, where possible, engage in a sustained, long-term, systematic effort over the next decade to transfer to interested developing countries the capability to utilize remote sensing technology from space. An AID program of technical cooperation in resource sensing from space should be increased at least tenfold and should include the following elements:

-- Pilot country programs to help establish in a selected number of countries exemplifying a variety of conditions a broad indigenous capability to analyze and utilize remote sensing data.

- <u>Demonstration projects</u> to show planners and resource managers how the technology works in individual resource sectors, and to translate the accumulating experience into methodological principles.

- <u>Research projects</u> to address problems peculiar to the developing countries owing to tropical conditions, special data needs, and new application opportunities.

- <u>Information and training programs</u> to help developing countries understand the capabilities and limitations of the technology and acquire over time the pool of technically proficient personnel they will need.

- <u>Equipment information and procurement assistance</u> to promote more knowledgeable acquisition practices and, where necessary, to facilitate acquisition of essential major equipment items through loans or grants.

- <u>Remote sensing data in AID-sponsored projects</u> to strengthen the Agency's internal project design and implementation capabilities and concurrently those of the recipient country.

- <u>Assistance to regional centers</u> in cooperation with other bilateral and multilateral development agencies, to help the centers get established and to enable them to perform their data dissemination, training, and technical advisory services effectively.

- <u>Coordination initiative</u> to ensure that the diverse assistance flows in remote sensing are complementary and reinforcing, and endow recipient countries with a permanent, institutionalized capability to apply the technology to their needs.

Over 10,000 copies of this report were printed and distributed worldwide.

World Food and Nutrition Study

The World Food and Nutrition Study Steering Committee was established in response to President Ford's December 1974 request to the Academy to organize "a major effort to lessen the grim prospect that future generations of peoples around the world will be confronted with chronic shortages of food and with the debilitating effects of malnutrition." Specifically, the President asked the Academy to "make an assessment of this problem and develop specific recommendations on how our research and development capabilities can best be applied to meeting this major challenge." The Steering Committee's activities were primarily funded by a consortium of government agencies, through a contract between the National Science Foundation and the National Academy of Sciences.

An interim report was submitted in November 1975 to respond to the government's request for early recommendations on actions that could proceed without waiting for findings from the full study. The focus of the final report is on how the U.S. can best contribute to the limited but extremely important goal of building the research base to avert mass hunger for future decades. It examines all discernible lines of research and development on world food supply and nutrition that could open the way to major improvements.

The Commission on International Relations was responsible for this study. However, the study director, Dr. Joel Bernstein, asked BOSTID to provide staff assistance for the following study teams:

Study Team 8: Information Systems. Study Team 8 considered R&D to strengthen the contribution of information gathering, storing, and disseminating technologies to improve food supply and nutrition. The team considered both formal information systems and less formal means of maintaining effective two-way information flows between the farm level and governmental and commercial program and policy levels, within and between countries. Consideration of formal systems examined ways to develop capabilities for making use of remote sensing, computer technology, and related information and communications systems.

Study Team 9: Nutrition. This study team viewed global, national, and local food systems from a nutritional standpoint (covering the whole sequence from the development of seeds and other inputs through production, marketing, and bodily absorption of nutrients), and identified the most critical intervention points (agricultural and nonagricultural) at which new options opened by R&D could substantially reduce the incidence of serious malnutrition around the world. The team noted the most important R&D areas to improve these intervention possibilities, suggested overall planning and management programs to combat malnutrition, and recommended what might be done to strengthen this R&D.

Study Team 11: "Blue Sky" on Food Supply. This team ranged freely over possibilities for big breakthroughs in the means of supplying world food needs that are not receiving adequate attention, and the R&D needs to realize these possibilities. The team's orientation was primarily long term, i.e., R&D to ease the prospects of tripling world food supply over the next 30 to 40 years (assuming a need for about a 3 to 3 1/2 percent average annual increase to keep pace with population and income rise).

Study Team 12: New Approaches to Alleviation of Hunger. This team's brainstorming focused on what U.S. R&D might to do open up major new approaches outside the food production sphere to reduce world hunger. The search for high priority R&D included social engineering as well as technology, with appropriate mixes of the two: the stress was on socio-political approaches (including selective income augmentation) and therefore on social science inputs. Like Team 11, this group looked for relatively unconventional or neglected means of alleviating hunger with strong long-term potential, such as new approaches to food distribution problems or other ways to achieve better use of food supplies (healthier, less wasteful, lower cost, etc.). This included possibilities for specially prepared nutritious foods for mass, low-cost distribution under public auspices (or private auspices if feasible) to populations chronically undernourished. And it considered R&D to expand national options for the poor countries and those augmented by international involvement.

Discussion Seminar on Tropical Meteorology

In the past, BOSTID has organized several informal seminars on new program areas or issues of interest to AID as an experiment in providing AID with informed viewpoints while avoiding the considerable length of time frequently required to prepare and review formal Academy reports. Thus no formal reports are prepared in order to maintain lively discussion and to permit AID staff members the opportunity to question the participating specialists as points are made.

In December 1976, the director of AID's Office of Science and Technology, Mr. Henry Arnold, asked BOSTID to organize a seminar on tropical meteorology. As described by Mr. Arnold, the seminar would:

1. Review the state-of-the-art of applied tropical meteorology and climatology and reasonable prospects for near-term advances, including applications to weather prediction, disaster prediction, and agro-meteorology and agro-climatology.

2. Examine the problems of the users of meteorology and climatology information in developing countries, including needs related to agriculture, hydrology, natural disasters, and other areas.

3. Analyze ways to strengthen the capability of developing countries to apply tropical meteorology and climatology, including needs in training and education, data collection and analysis, and institutions and facilities.

4. Discuss needs for further research that would increase the practical application of meteorology and climatology in developing countries.

5. Exchange views on nontechnological constraints bearing on the application of meteorology and climatology in tropical countries.

The seminar was held at the National Academy of Sciences on May 5-6, 1977. Ten participants, representing a variety of appropriate disciplines and experience, were invited to take part in the discussion and were joined by staff members from AID and the World Bank (which also had expressed an interest in the seminar).

During the seminar, a number of ways in which AID might assist developing countries in activities related to tropical meteorology and climatology were suggested:

1. Explore programs that would help developing countries make better use of existing meteorological and climatological data. Such programs might include activities ranging from provision of training to provision of facilities.

2. Develop programs related to the use of satellite receiving stations. These programs might involve providing new readout stations and using existing satellite data to improve weather prediction.

3. Strengthen AID's internal capabilities to use meteorological and climatological data. Upgrading these capabilities could require hiring appropriate staff or consultants and giving short training courses for exising staff in the related disciplines of agriculture, hydrology, etc.

4. Monitor the world food situation with the help of meteorological information.

5. Perform applied site-specific research on micro-agricultural relationships to weather, including the use of windbreaks, reflectants, surfactants, intercropping, etc.

6. Support a World Climatic Data Center at the National Weather Records Center, Asheville, N.C. Such a center could help create a world historical base of climatic data which can be very important.

7. Establish a program to use existing satellite data accumulated over the past one or two decades to improve rainfall prediction. AID could support such a project, which should be done in the developing countries themselves and would involve relatively small professional staffs.

8. Finally, implement the ideas raised in this seminar by surveying what the developing countries themselves envisage as their needs in meteorology and climatology.

U.S. Science and Technology for Development:
A Contribution to the 1979 U.N. Conference

In late October 1977, the National Research Council agreed to conduct a study for the Department of State which would assist U.S. preparations for the U.N. Conference on Science and Technology for Development, to be held in August 1979 in Vienna, Austria. This study was to provide specific suggestions for initiatives that the United States could propose to better mobilize U.S. and worldwide science and technology in support of development.

Summarized below are 22 initiatives--both unilateral and collaborative--which were given the most emphasis among the many initiatives suggested in this report. The first 16 initiatives relate to specific clusters of development activities, and the remaining would help strengthen the general abilities of developing countries to make use of science and technology for national purposes.

INCREASING FOOD SUPPLIES

1. Reducing Postharvest Food Losses. U.S. expand own activities and encourage formation of an International Coordinating Council on Postharvest Food Losses to foster coordination of activities presently scattered worldwide (illustrative types of Council activities are suggested).

2. Soil and Water Management at the Farm Level. U.S. indicate willingness to make fuller use of its strong capabilities to help developing countries improve management systems for sustained crop production on tropical soils, and develop suitable technologies for farm-level management of irrigation and other aspects of water management.

3. Plant and Animal Protection. Intensify work with developing countries on individual technologies and integrated pest management systems (research, training, and extension), paying special attention to reducing environmental effects of pesticide use. Support this by building worldwide collections of germ plasm for crop varieties that possess unique resistances to specific pests, and of organisms injurious to crops and livestock.

4. Overcoming Biological Limits to Plant Productivity. Expand work on increasing biological fixation of nitrogen for major world crops, increasing the photosynthetic efficiency of crop plants, and developing more powerful tools for genetic manipulation of plants.

HEALTH AND RELATED NEEDS

5. Delivery of Primary Health Care. Encourage and support expanded programs--bilateral and international collaboration--to test and determine large-scale systems for low-cost delivery of primary health, nutrition, and family planning services to whole populations, and to do backup research. Emphasis would be on preventive services, relatively simple technology, and extensive use of paraprofessionals.

6. Pure Water and Waste Treatment. Offer to expand work with individual developing countries and international programs to provide adequate quantities and quality of water for human use in rural and urban areas, at acceptable costs. Emphasis on methodological and planning assistance for water system design, technology selection, and operational management, including waste disposal.

7. Controlling Infectious Diseases in the Tropics. Create new, highly visible U.S. program to focus government, industry, and academic research. Could be lodged either in a New National Institute for Infectious Diseases at NIH, with suitable arrangements for balance between work in developing countries and in U.S.

8. Improved Contraceptives. Support expanded international collaboration on high priority research to improve available methods of contraception, at roughly the levels recommended by the 1976 Committee on Reproduction and Human Welfare sponsored by the Ford Foundation.

URBANIZATION AND INDUSTRIALIZATION

9. Improving Urban Settlements. Propose and support series of activities to improve access of people in urban settlements of all sizes and locations to jobs, shelter, land, water, sanitation, health services, and education. Includes promotion of and participation in international support for integrated community-building programs through new U.N. Habitat Center in Nairobi; special international loan fund for this purpose; U.S. grants program to demonstrate new applications of science and technology in smaller cities to meet basic human needs; and an international research, information, and training network led by the U.N.

Research and Training Programme in Regional Development. Strengthen the capabilities of relevant U.S. institutions for international participation.

10. Planning Transportation Systems. Offer broad U.S. support for international activities that would improve transportation infrastructure in developing countries, while at the same time producing insights into U.S. transport problems. Propose R&D network, sponsored by the World Bank or other concerned international agency, to focus on improving planning of transport systems, resource-conserving transport solutions, training and joint experimental work to build developing country capabilities for transport planning and design, and analysis and dissemination of information and experience worldwide. Strengthen the capabilities of relevant U.S. institutions for international participation.

11. Building Capabilities for Creating and Using Industrial Technology. Offer support for developing country initiatives to strengthen: their industrial research organizations; centers conducing R&D, extension, and training for small industries, particularly in rural areas; "productivity centers"; and engineering and management institutions. Could draw on specialized parallel U.S. institutions, and possibly on extended IESC program (the "technology corps" concept). Complement this by stimulating curriculum development, teaching, research, and technical assistance programs, in some U.S. engineering schools, that are oriented to developing country needs.

12. International Research on the Industrialization Process. Propose support by national and international sources (private and governmental) for a high quality, apolitical program of research and research training on the relationships among industrial growth and technology choice, national development, and world production and trade patterns. Three organizational options are: an international foundation, with a multinational board and diverse international funding, to manage a program of grants and contracts to existing research institutions worldwide; a private international research center, financed by governments and private sources and governed by a board of directors representing themselves (i.e., on a nonpolitical basis); or a new research center or program within an existing international institutions such as the World Bank.

MANAGEMENT OF RESOURCES

13. Development and Use of Energy. State U.S. intent to lend major new support for R&D related to developing country energy problems. Nine types of action are proposed, with emphasis on use of renewable energy soucees and decentralized technologies that can be used effectively in rural areas not served by central generating systems.

14. Remote Sensing and Other Applications of Satellite Technology. Declare U.S. intent to continue development of remote sensing technologies useful

to developing countries and offer increased access to U.S. data, facilities, training, and joint experimentation through a variety of collaborative schemes. This includes using satellites for locating and assessing natural resources, assessing weather and crop patterns, mapping generally, and educational and informational purposes.

15. Sustained, Multiple Use of Forest Resources. Foster a much expanded research effort on sustained, multiple use of forest resources in developing countries through support for: establishing or designating two of three first-class regional institutes in developing countries, patterned after the international agricultural research institutes and oriented toward different ecological zones; strengthening developing country research and experiment stations and integrating their programs with those of the regional institutes, which would help train specialists for national programs; supporting the related service functions of the newly created International Council for Research on Agroforestry. In addition, U.S. should respond to developing country requests for technical assistance on forest planning and policy.

16. Research on the Marine Environment. Declare U.S. readiness to support, through the U.S. Sea Grant Program, training for developing country scientists, extension services to developing country institutions, and cooperative research on the marine environment, especially estuarine and coastal areas. Latter would concern management of these areas to achieve the most productive, sustained use. (Involves interactions of coastal fisheries, distribution or urban and industrial wastes, offshore mining, marine transport operations, recreational activities, and the enhancement of marine biological resources, taking account of interactions between ocean and coastal shelf circulation.)

GENERAL INITIATIVES*

17. Strengthening Scientific and Technological Policymaking. U.S. offer to: expand short-term exchanges of groups of senior scientists, engineers, and managers to discuss ways to bring local scientific and technological expertise to bear on development policies; train and maintain a cadre of U.S. experts for consultations in this field; collaborate with developing countries on exploring ways that governments can improve linkages among R&D organizations and between them and individual enterprises and other users.

18. Information Sharing. Offer assistance (particulars specified) for helping developing countries build their own capabilities to gather, organize, disseminate, and use data and information to support development, and for promoting greater access to U.S. information resources. Various types of specialized training are featured. Support appropriate expansions of specialized information systems in major development sectors (agriculture, energy, etc.) and strengthening of information systems tied to R&D networks on priority problems.

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*These affect all sectors. Specific proposals in each category below appear throughout the recommendations for particular subject areas.

19. Education in the United States. Announce series of U.S. initiatives to improve relevance of U.S. education (undergraduate and graduate) of students from developing countries to tasks and situations that they face when they go home: induce greater proporation of scholarship, fellowship, and research grants in shortage fields; expand courses or components geared to developing country situations; expand opportunities for graduate students to do thesis programs and research on problems that are important in their own countries, and to do research in developing countries.

20. Short-term, Nondegree Training. Announce broadening of U.S. government training grants (AID and other) to include more scientific and technical training, and as much as possible in developing countries, with a complementary expansion of support for developing country training in vocational and technical support skills. Mobilize international corporations, professional associations, and other U.S. governmental and nongovernmental organizations to help organize and conduct more short-term training programs and to sustain professional contact between developing country professionals trained in the U.S. and their U.S. colleagues.

21. Continuing University Interchange. Announce strengthening of U.S. support for working collaboration and exchanges between U.S. universities and other research organizations, and their counterparts in developing countries. Possible devices include acceleration of activities under Title XII of the Foreign Assistance Act and extension of the same concept to other fields, and establishment of modest funding to catalyze collaboration and exchange by helping to cover some overheads or other special costs.

22. Incentives for Development-Related Research in the United States. Announce U.S. plans to increase the incentives of domestic research managers, in fields that overlap major developing country problems, to strengthen the international dimensions of their work through collaboration and exchanges with counterpart organizations and scientists in developing countries. Incentives could include new legislative mandates, such as Sec. 1458 of the Food and Agriculture Act of 1977; administrative decisions to allocate more research, fellowship, and scholarship funds for cooperative international activities; and even special prizes and honors for distinguished achievement in science and technology for development (preferably from international sources).

Postharvest Food Losses in Developing Countries

In connection with the World Food and Nutrition Study, BOSTID organized an ad hoc group in mid-1975 to consider the problem of food losses and their impact on world food supply. This group concluded that the situation was serious enough to warrant a comprehensive four-stage study. Following discussions with AID's Office of Agriculture, BOSTID was asked to undertake the first stage of this study, an identification of research priorities for critically needed quantitative information on food losses and methodologies for obtaining the information. AID also requested suggestions for practical interventions that could be undertaken to reduce losses while the critically needed information was being gathered.

A second ad hoc meeting on May 23-24, 1976 was held to discuss definitions of loss and identify points in the food system where losses occur. This group recommended a broad-gauged study of methodologies to estimate food losses, and to evaluate the efficacy of methods of reducing food losses, with particular reference to their economic value, which should lead to recommendations for appropriate actions by governments and technical assistance agencies in developing countries. In addition, a survey of published and unpublished information on the extent of food losses should be conducted.

With funding from AID's Office of Agriculture, BOSTID established a Steering Committee for a Study on Postharvest Food Losses in Developing Countries. The Committee, whose members had experience with both the technical aspects of postharvest food conservation in developing countries and the broader scientific, social, and economic context, met June 8-9, 1977 in Philadelphia to outline the study and identify key issues. With these guidelines established, compilation of a bibliography was begun and information solicited from large numbers of experts.

The objectives of the study were:

1. to summarize existing work and information on food losses;

2. to discuss some of the important social and economic factors involved in food loss and food conservation; and

3. to identify needs for food loss assessment and food conservation, and to suggest alternatives for food conservation policy and programs for developing countries and development assistance agencies.

On October 31 - November 3, 1977, an international working group of experts was convened to examine the key issues and the roughly assembled study material. On the basis of these discussions, a final draft was prepared by the BOSTID staff for discussion at the third Steering Committee meeting, held February 14-15, 1978.

The final study report emphasizes the need to ensure an adequate food supply for the world's growing population, and details the contribution that reduction of food losses between harvest and consumption can make to this effort. Programs for reducing these losses must be based on reasonable estimates of the losses, as must evaluations of program effectiveness. Yet it is very difficult to estimate postharvest food losses with precision due to their inherent variability, and due to cultural and economic factors that frustrate the smooth, efficient flow of food through the postharvest system from producer to consumer.

The study summarizes existing work about losses of the major food crops, discusses some of the economic and social factors involved, and identifies needs and suggests alternative policies and programs for developing countries and technical assistance agencies.

The study does not prescribe conservation projects or practices applicable to all developing countries, since remedies must depend on each country's particular circumstances and priorities. Rather, it reviews alternative possibilities for reducing losses, presenting them in a way that may help decision makers to understand more fully the possible consequences of various courses of action.

The report is aimed primarily at the decision maker who is responsible for resources that might be allocated to food conservation and who seeks a comprehensive overview of the postharvest system in developing countries. It includes background and basic technical, socioeconomic, and cultural information. The report also serves as a basic introduction for the technical person not familiar with the field, and includes references and suggested reading to indicate further sources of information.

In developing countries enormous postharvest losses of food result from spillage, contamination, attack by insects, birds and rodents, and deterioration in storage. Conservative estimates indicate that a minimum of 107 million tonnes of food were lost in 1976; the losses in cereal grains and legumes alone are an amount that would provide more than the annual minimum caloric requirements of 168 million people.

Billions of dollars have been invested to help developing countries produce food, but this has not been matched by investment--or by an awareness in developing countries of the need for it--either to determine what could be done to reduce losses, or to initiate measures to reduce loss.

Increased food production causes strain on present methods of handling, storing, and processing crops, and increased food losses will result unless developing countries and donors of economic assistance (a) establish and maintain adequate harvesting, storage, and handling practices, particularly in rural areas, and (b) create efficient policy and administrative infrastructures.

The conclusions above lead to the committee's specific recommendations for implementing food conservation programs throughout developing countries.

Institutional Arrangements, Policies, and Mechanisms

The Committee recommends that the following essential institutional arrangements and mechanisms be established in developing countries to deal with postharvest food losses:

-- a national policy body;

-- a national implementing agency or postharvest food conservation unit; and

-- a mechanism to facilitate communication among planning agencies, decision makers, and villagers.

Collectively, the policy and operating bodies would be responsible for assessing the national food loss situation and developing a national plan of action; undertaking rapid assessment of potential points of severe loss; examining national policies with respect to pricing and the role of marketing boards and other financial agencies; provide effective quality control in government commodity purchasing; supporting priority research in both technical and socioeconomic areas; and, ultimately, recommending policy options on food conservation to the decision makers.

Postharvest Loss Estimation

The committee recommends more systematic approaches to loss estimation in developing countries by:

-- adoption of standard loss estimation methodology;

-- development of guidelines for loss estimation of perishables;

-- consideration of socioeconomic sspects of food loss; and

-- integration of loss estimation conservation activities.

International Cooperation Mechanisms

An organization should be created to give international focus to the neglected area of loss in perishable staples.

The Committee, which includes several members of organizations that belong to GASGA, believes that this organization has made an excellent beginning in international cooperation and coordination of efforts to reduce postharvest grain losses. Similar efforts are necessary in areas not covered by GASGA, particularly for the perishable staples. An organization created to deal with problems of perishable staples should receive support additional to that currently provided to GASGA and grain loss reduction generally, and staples should not be part of an expanded GASGA.

Information on Postharvest Food Losses

In view of the importance of improving the quality and availability of published information on postharvest food losses, the international technical assistance agencies should cooperate to strengthen and expand postharvest food loss documentation services.

Specifically, the following steps should be taken:

-- FAO should be supported with funds to ensure that the AGRIS bibliographic reference service section on postharvest technology is adequately strengthened and continually updated.

-- Support should be provided for a microfiche service of the AGRIS publications (through FAO or other agency) to national or regional institutions engaged in postharvest food conservation research, education, or extension.

-- Developed-country institutions should be supported in cooperating with FAO to provide assistance in selecting postharvest entries for the reference service (GASGA members, their equivalents for the perishable staples, and national agricultural library systems).

Education, Training, and Extension

Priority attention should be given to training programs to remedy acute personnel shortages at all levels of the postharvest food system.

Specifically, training efforts are recommended at the following levels:

-- Training programs in postharvest technology for agricultural colleges and similar institutions for extension workers, farm men and women, and others working in agriculture and fisheries.

-- Courses and in-country training programs for other personnel in the postharvest food system, including:

1. lower cadres of marketing agencies involved in procurement, quality control and pest control, warehouse management, and drying, handling, and processing of foods;

2. managers of both government and quasi-government marketing, storage, and processing organizations who should be given sufficient technical knowledge to increase their awareness of the problems involved in their decisions; and

3. country representatives of technical assistance agencies who should be familiar with postharvest loss problems.

-- Teaching skills and materials developed at universities, colleges and research institutions for instructing fishermen and farmers. There is also need for graduate-level training in technical areas to increase the professional staff for teaching and research programs; technical assistance agencies and governments should assist this training both in-country and by providing scholarships to overseas institutions. The establishment of programs to deliver postharvest conservation information to rural people should be given an educational priority co-equal with manpower training.

Research and Development

The committee recommends, as basic to formulation of national-level food loss reduction policies, intensive research on socioeconomic factors, general postharvest technologies, and crop-specific technologies. The bulk of this research should be developed by the national postharvest universities, the research institutes of ministries, and the private sector. These research needs, which should be concentrated at the rural level, are:

1. Socioeconomic Research. Substantial refinement of knowledge about economic cost-benefit factors in postharvest food loss reduction is needed. Plans for food conservation should be supported, meanwhile, by knowledge of the effects of social and cultural factors on the introduction of technological change.

2. General Research and Development Needs.

   -- Development of low-cost cooling systems for food preservation in developing countries.

   -- Research on insecticides, fungicides, and rodenticides, with particular reference to their safety for use in foodstuffs, their environmental consequences, and their use in integrated systems of pest management.

   -- Fundamental research on tropical food crop deterioration and its relationship to environmental conditions.

   -- Research on storage characteristics, or other qualities of crops that affect their postharvest fate, as one aspect of breeding and selection programs.

   -- Socioeconomic studies of the problems of introducing centralized storage in rural areas, with implications for technology design, costs, responsibility and management essential fo facilitate this process.

   -- Adaptive research on small-scale storage technologies, including developing of cheap rodent- and insect-resistant containers that are properly ventilated or sealed as well as resistant to moisture and rainfall.

   -- Rodent surveys and greater emphasis on rodent control in both agricultural and health extension services.

Commodity-Specific Research Priorities

The following research areas illustrate the kind of work that needs to be done with individual commodities and do not comprise a full list of priorities.

1. Rice.

   -- Economic drying of wet-season rice, including particularly natural ventilation methods, and use of preservatives for short-term preservation.

-- Improved design of threshing, parboiling and milling equipment.

2. Maize.

   -- Improved low-cost drying and storage cribs.

   -- Improved village-level processing equipment.

3. Millets and Sorghums

   -- Improved traditional storage and fumigation methods.

   -- Improved village-level processing equipment.

4. Legumes.

   -- Improved milling equipment.

   -- Ways to avoid loss of cooking quality during storage.

5. Roots and Tubers.

   -- Determination of optimum storage temperature, humidity, and ventilation for different varieties.

   -- Better box and clamp design.

   -- Storage of cassava chips, flour, and pellets.

   -- Use of sprouting and rot inhibitors.

6. Fruits and Vegetables.

   -- Low-cost controlled-environment storage, including waxing, storage under plastic sheeting, gas absorbents, rot retardants, etc.

   -- Better low-cost packaging.

   -- Damage control during storage and movement, and in the market.

7. Fish.

   -- Better drying, smoking, and salting methods.

   -- Improved on-board storage and use of by-catch.

III. BOARD SUPPORT, EVALUATION, PROGRAM DEVELOPMENT AND FOLLOW-UP, AND BOARD-RELATED ACTIVITIES

BOARD SUPPORT

All the programs described earlier have been developed under the guidance and approval of the NAS/NRC Board on Science and Technology for International Development. This Board, currently composed of 16 members (see Section V) representing a broad range of scientific and technical disciplines and development experience, meets formally two or three times a year to set program guidelines, review current activities, and approave annual program plans. In addition, panels of the Board meet as required to consider specific opportunities and program possibilities in the areas of biomedicine and public health, natural resources, industrialization, and technical education.

In addition to their regular meetings, individual Board and panel members participate in specific programs; provide advice to the staff; review, on behalf of the NAS/NRC, all reports of Board activities; and respond to informal requests on science, technology, and development from AID and other public and private agencies. At the request of AID, Board representatives and staff members have participated in advisory activities to AID/Washington and to AID missions in the field, including the following:

-- Board members and staff have provided advice and information, on an informal basis, to OST staff and OST contractors--such as FORGE, Southwest Research Institute, Denver Research Institute--as well as to other parts of AID.

-- A BOSTID staff member spent 6 weeks in Dacca in 1971 at the request of OST and the AID mission to advise on (a) the feasibility of using ferrocement to rebuild East Pakistan's devastated fishing fleet, and (b) possible solutions to the water hyacinth problem.

-- A BOSTID member and a staff person visited Chad in 1974 to advise the Lake Chad Basin Commission on water resources.

The professional staff of the Board comes from a broad background of natural and social sciences and engineering. All have had considerable experience with development matters abroad and with private and public institutions concerned with science, technology, and development. Under the guidance of the Board, the staff has responsibility for program development and implementation of the entire range of activities described earlier. An administrative and clerical staff provides essential support functions for the Board programs.

So that the Board and its staff have access to the reference materials necessary to conduct its programs, a small reference collection is maintained with a part-time research librarian. This service has proved invaluable not only to the Board and staff, but also to representatives of AID and other institutions.

As discussed earlier, the work of the NAS/NRC is carried out almost entirely by volunteers from the scientific and technical community at large.

Identifying appropriate and highly qualified participants for the extremely broad range of international development activities is a complex and time-consuming task. In an effort to widen the network of volunteers and to make the search process more efficient, a roster (Kardex) of individuals identified by scientific and technical expertise, international knowledge and experience, previous participation in NAS/NRC activities, foreign language capability, and general biographical background is maintained. This resource has been essential for the successful selection of program participants and also for responding to AID requests for information.

EVALUATION

In June 1975, BOSTID's program was reviewed through an in-depth AID evaluation. The evaluation concluded that BOSTID program was a valuable contribution to AID's program objectives, providing a unique source of scientific and technical advice not only to AID but the developing countries themselves. It recommended a continuation of the AID/NAS relationship with some modifications, particularly as related to cooperative programs in the developing countries. The evaluation felt that closer consultation with AID and LDC counterparts in project definition and design should be attempted.

In this regard, three program development trips were arranged in 1976 to Asia, Africa, and Central America to develop inputs into BOSTID's future program, not only from the point of view of defining concrete programs, but also from the point of view of considering possible new mechanisms for program implementation, follow-up, and evaluation. A similar program development trip to Latin America is being planned in 1978.

In order to have a continuous in-house assessment of programs, BOSTID plans to establish an Advisory Committee on Evaluation to recommend specific policies and procedures for the evaluation of all studies and bilateral activities. A BOSTID staff member will be assigned responsibility for coordinating the evaluation effort.

PROGRAM DEVELOPMENT AND FOLLOW-UP

Both the Board and its professional staff play an essential role in the follow-up to specific program activities. Although follow-up takes different forms, the Board and staff maintain continuing contact with their counterparts and government officials both in the United States and abroad, reviewing progress with respect to specific recommendations emerging from the activity, considering mechanisms for implementation, identifying related new activities, and suggesting possible relationships to activities of other national or international organizations. These follow-up efforts have assumed an increasing part of the BOSTID activity.

Frequent contact with counterparts in developing countries is essential to the development of clear objectives and methodologies for BOSTID programs, and enhances the likelihood that relevant and practical results will occur. Although travel occasionally is undertaken exclusively for program development purposes, program development visits generally are made in connection with other overseas activities.

BOARD-RELATED ACTIVITIES

In direct response to requests from the Department of State and Agency for International Development, the Board has convened several informal meetings to discuss with U.S. officials specific matters relating to science, technology, and development activities. These meetings, frequently dealing with urgent matters, have been convened on such subjects as the U.S. role in environmental implications of development or in science and technology in the United Nations system. In 1972, the NAS organized a seminar to critique the draft U.N. World Plan of Action for the Application of Science and Technology to Development. In 1974, the State Department, through OST, requested NAS advice on the U.S. role at the second meeting of the U.N. Committee on Science and Technology for Development, and ways in which the United States might enhance its capability for dealing with science and technology issues in the U.N. system.

In the International Council of Scientific Unions (ICSU), BOSTID has served as part of the U.S. national committee for the Committee for Science and Technology in Developing Countries, and has played a substantial role in activating other groups within ICSU to interact with developing countries.

In view of their extensive experience, BOSTID staff members often are asked to participate in seminars, conferences, special commissions, and advisory bodies convened by both government and private institutions. Examples include the following:

-- In 1974, the Department of State, responding to initiatives by Dr. Henry Kissinger and the foreign ministers of the Latin American states, created an interagency working group to explore questions of science and the transfer of technologies to Latin America. BOSTID was asked to assign a staff person as a liaison member to each subgroup--U.S. resources for technology transfer, mobilization of interregional transfers in Latin America, and creation of new institutional mechanisms for technology transfer. Considerable time and effort were given to working with the TA/OST staff coordinator (Robert Goeckermann) on the project. Background papers were prepared and strategies discussed whereby the United States might meet requests of the Latin countries more efficiently and more completely. Because of an abrupt interruption of U.S.-Latin American discussions due to political considerations, the project was indefinitely postponed in December 1974.

-- BOSTID staff have informally assisted in the development of scientific and technical aspects of bilateral agreements with Latin American countries and with binational commission activities in the Middle East. Staff members have served as information resource persons at U.S.-Brazil, U.S.-Mexico, U.S.-Egypt, and U.S.-Iran meetings in Washington. Materials have been assembled and presentations made detailing activities and services available under BOSTID programs with AID.

-- At the request of AID, BOSTID staff attended the ACAST regional meeting in Africa in 1971, the "Niamey Dialoque" on the Sahel in 1974, and the first and second general conference of the Association for the Advancement of Agricultural Sciences in Africa.

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CHILE

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COLOMBIA

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Vol. 2. Contributed Papers.

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Vol. 2. Papers Presented.

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Seminario Sobre Administracion de la Investigacion Cientifica, Sede: Universidad de Atioquia, Medellin, 4 al 14 de agosto de 1969. Medellin: Instituto de Integracion Cultural & COLCIENCIAS, 1970.

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Report of a COLCIENCIAS-NAS Panel Study of Graduate Education and Research in Chemistry in Colombia; (NAS Staff) Summary Report. Held in Bogota, Colombia, February 22-27, 1971.

Programa de Impulso a la Investigacion y a los Estudios de Posgrado en las Universidades Colombianas - Informe de la Mision de Matematicas, Bogota, Colombia, 15-20 Marzo 1971.

Report of a COLCIENCIAS-NAS Panel Study of Graduate Education and Research in Mathematics in Colombia: (NAS) Staff Summary. Held in Bogota, Colombia, March 15-20, 1971.

Programa de Impulso a la Investigacion y a los Estudios de Posgrado en las Universidades Colombianas - Informe a la Mision de Ingenieria, Bogota, Colombia, 14-25 Febrero de 1972.

(NAS Staff) Summary Report of the Colombia-U.S. Study Panel on the Potential for Graduate Education and Research in Engineering, Physics, and Applied Geology in Colombia. Held in Bogota, Colombia, February 14-25, 1972.

Programa de Impulso a la investigacion y a los Estudios de Posgrado en las Universidades Colombianas - Informe de la Mision de Biologia, Bogota, Colombia, 30 Mayo - 13 Junio de 1972.

General Report of the Colombia-U.S. Study Group on the Potential for Graduate Education and Research in the Biological Sciences in Colombian Universities. Held in Bogota, Colombia, May 29 - June 13, 1972.

Program for the Improvement of Graduate Education and Research in Colombian Universities in the Sciences and Engineering, February 1971 - October 1972: Final (NAS Staff) Summary Report.

DOMINICAN REPUBLIC

Staff Summary Report: Workshop on Agro-Industrial Development in the Dominican Republic, held in Santo Domingo, Dominican Republic, October 18-22, 1976.

Sponsored by Dominican Institute of Technological Research (INDOTEC), Dominican Republic, and NAS.

GUYANA

Aquatic Plants: Management and Utilization. (NAS Staff) Summary Report of a Workshop held in Georgetown, Guyana, March 15-17, 1973. Sponsored by the National Science Research Council of Guyana and NAS.

Some Prospects for Aquatic Weed Management in Guyana. Workshop on Aquatic Weed Management and Utilization, Georgetown, Guyana, March 15-17, 1973. Sponsored by National Science Research Council of Guyana and NAS.

An International Centre for Manatee Research. Report of a Workshop held in Georgetown, Guyana, February 7-13, 1974. Sponsored by the National Science Research Council, Guyana; the International Development Research Centre, Canada; and NAS.

(NAS Staff) Summary Report: An International Centre for Manatee Research Workshop. Held in Georgetown, Guyana, February 7-13, 1974. Sponsored by the National Science Research Council, Guyana; the International Development Research Centre, Canada; and NAS.

PERU

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Report of a Workshop on the Role of Sciences and Technology in Peruvian Economic Development. Held in Paracas, Peru, April 17-22, 1966, by NAS and ad hoc Peruvian group.

Organizacion de la Investigacion Cientifica, Lima: Comite del Grupo de Paracas, September 1966.

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Vol. 1. Report.
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(NAS Staff) Summary Report on Workshop on Industrial Research Programming and Management. Held in La Granje Azul, near Lima, Peru, January 25-29, 1975.

Jointly sponsored by Institute for Technological Research and Standards (ITINTEC), Peru and NAS.

VENEZUELA

Ciencia y Tecnologia para Los Barrios Urbanos (Un Taller de Trabajo). Report of a workshop held in Caracas, Venezuela, March 6-12, 1977. Jointly sponsored by Fundacion Habitat de Venezuela, Fundacomun, Venezuela and NAS.

Middle East and North Africa

EGYPT

Preliminary staff report of Egypt-U.S. workshop on Science and Technology Policy, Planning and Management in the Arab Republic of Egypt. Jointly sponsored by Egyptian Academy of Scientific Research and Technology and National Academy of Sciences/National Science Foundation. Held in Cairo, May 3-8, 1975.

Science and Technology Policy, Research Management and Planning in the Arab Republic of Egypt. Report of a Symposium on Science Policy Planning held in Cairo, April 30 - May 1, 1975, and a Workshop on the Management and Planning of Research held in Cairo, May 3-8, 1975. Sponsored by Academy of Scientific Research and Technology, Arab Republic of Egypt, and the National Academy of Sciences and the National Science Foundation, U.S.A.

TUNISIA

Staff Summary Report: Workshop on Systems Analysis and Operations Research. Held in Tunis, Tunisia, May 23-26, 1977. Sponsored by Secretariat General of the Government, Office of the Prime Minister, Republic of Tunisia, and NAS.

ADVISORY COMMITTEE ON TECHNOLOGY INNOVATIONS (ACTI) STUDIES

Ferrocement: Applications in Developing Countries. A report of an ad hoc panel of ACTI, BOSTID. Washington, D.C.: NAS, February 1973.

Mosquito Control: Some Perspectives for Developing Countries. Report of an ad hoc panel of ACTI, BOSTID. Washington, D.C.: NAS, March 1973.

Food Science in Developing Countries: A Selection of Unsolved Problems. Compiled by the ACTI, BOSTID. Washington, D.C.: NAS, 1974.

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Expansion des ressources en eau dans les zones arides: Techniques prometteuses et possibilités de recherches. (French version of More Water for Arid Lands: Promising Technologies and Research Opportunities) Washington, D.C.: NAS, 1977.

Underexploited Tropical Plants with Promising Economic Value. Report of an ad hoc panel of ACTI, BOSTID. Washington, D.C.: NAS, 1975.

Winged Bean: A High-Protein Crop for the Tropics. Report of an ad hoc panel of ACTI, BOSTID. Washington, D.C.: NAS, 1975.

Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries. Report of an ad hoc panel of ACTI, BOSTID, Washington, D.C.: NAS, 1976.

L'energie et le développement rural: Ressources renouvelables et options techniques pour les pays en développement. (French version of Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries) Washington, D.C. NAS, 1977.

Methane Generation from Human, Animal, and Agricultural Wastes. Report of an ad hoc panel of ACTI, BOSTID, Washington, D.C. NAS, 1977.

Making Aquatic Weeds Useful: Some Perspectives for Developing Countries. Report of an ad hoc panel of ACTI, BOSTID. Washington, D.C.: NAS 1976.

Guayule: An Alternative Source of Natural Rubber. Report of an ad hoc panel of the Board on Agriculture and Renewable Resources, Commission on Natural Resources, and ACTI, BOSTID, Commission on International Relations. Washington, D.C.: NAS, 1977.

Tropical Legumes: A Resource for the Future (in draft)

Leucaena: Promising Forage and Tree Crop for the Tropics. Report of a study conducted jointly by the Philippine Council for Agriculture and Resources Research, Republic of the Philippines, and NAS. Washington, D.C.: NAS, 1977.

International Consultation on Ipel-Ipel Research, Papers and Proceedings. Jointly sponsored by Philippine Council for Agriculture and Resources Research, Republic of the Philippines, and NAS. Manila, Philippines: Philippine Council for Agriculture and Resources Research, 1977.

Firewood Crops: Bush and Tree Species for Energy Production (in draft)

Underexploited Microbial Processes of Potential Economic Value (in draft)

SPECIAL STUDIES/ADVISORY PANELS

East Pakistan Land and Water Development as Related to Agriculture. Report of an ad hoc panel of BOSTID. Washington, D.C.: NAS, 1970.

International Aspects of Man's Effect Upon the Environment. Ad hoc advisory panel report, Washington, D.C.: NAS, 1970.

The International Development Institute. A report of an ad hoc committee of BOSTID, Washington, D.C.: NAS, July 1971.

Solar Energy in Developing Countries: Perspectives and Prospects. Report of an ad hoc panel of BOSTID. Washington, D.C.: NAS, March 1972.

Scientific and Technical Information for Developing Countries. A report of an ad hoc advisory panel of BOSTID, Washington, D.C. : NAS, 1972.

Science and Technology in São Paulo's Development: A Review and Critique of a Proposed Program to Utilize Science and Technology for the Economic Development of the State of São Paulo, Brazil. By an ad hoc panel of BOSTID in cooperation with Council of Science and Technology for the State of São Paulo. Washington, D.C.: NAS for the AID Brazil Mission, July 1972.

Research Management and Technical Entrepreneurship: A U.S. Role in Improving Skills in Developing Countries. A report of an ad hoc advisory panel of BOSTID. Washington, D.C.: NAS, September 1973.

U.S. International Firms and R, D & E in Developing Countries. A report of an ad hoc panel of BOSTID. Washington, D.C.: NAS, May 1973.

Meeting the Challenge of Industrialization: A Feasibility Study for an International Industrialization Institute. Report of a special international panel of BOSTID. Washington, D.C.: NAS, August 1973.

International Development Programs of the Office of the Foreign Secretary. Staff Study by Harrison Brown and Theresa Tellez. Washington, D.C.: NAS, 1973.

Staff Summary of Role of Science and Technology in International Development in the 1970's. Working papers of Woods Hole Meeting, 1971, plus commissioned papers. (Study terminated.)

African Agricultural Research Capabilities. Report of the Committee on African Agricultural Research Capabilities, Board on Agriculture and Renewable Resources, Commission on Natural Resources, and BOSTID, Commission on International Relations, Washington, D.C.: NAS, 1974.

Perspectives de la Recherche Agronomique en Afrique. (French version of African Agricultural Research Capabilities) Washington, D. C.: NAS 1976.

V. PARTICIPANTS: BOARD MEMBERS, STAFF AND PANELISTS.

The list that follows contains the names of Board members, staff, and panelists who have participated in the activities described in section II. Foreign participants are also included. Care has been taken to ensure that participants' names and affiliations are correct as of the time of their actual participation. (A few listings are incomplete because primary sources were not available and further verification was impractical.)

Advisory Committee on Development Assistance Opportunities in the Next Decade for Peace Corps: Interim Letter Report. Prepared by Waldemar Nielsen, Chairman. Washington, D.C.: NAS, 1 March 1974.

The Peace Corps: Perspectives for the Future. Report of the Ad Hoc Committee on Development Assistance Opportunities in the Next Decade for the Peace Corps, BOSTID. Washington, D.C.: NAS, August 1974.

Arid Lands of Sub-Saharan Africa. (NAS Staff) Progress Report on an Advisory Panel to the BOSTID. September 1973 - June 1974.

Arid Lands of Sub-Saharan Africa. (NAS Staff) Final Report on an Advisory Panel to the BOSTID. July 1974 - March 1975.

The Role of U.S. Engineering Schools in Development Assistance. Report of Panel on the Role of U.S. Engineering Schools in Development Assistance, NAS-NAE. Washington, D.C.: NAS, 1976.

Systems Analysis and Operations Research: A Tool for Policy and Program Planning for Developing Countries. Report of an ad hoc panel of BOSTID.

Appropriate Technologies for Developing Countries. A report prepared by Richard S. Eckaus, Massachusetts Institute of Technology, for the Panel on Appropriate Technologies for Developing Countries, BOSTID. Washington, D.C.: NAS, 1977.

Resource Sensing from Space: Prospects for Developing Countries. Report of Committee on Remote Sensing for Development. Washington, D.C.: NAS, 1977.

World Food and Nutrition Study: The Potential Contributions of Research. Report of the Steering Committee, NRC Study on World Food and Nutrition, Commission on International Relations, NRC (with staff assistance from BOSTID). Washington, D.C.: NAS, 1977.

U.S. Science and Technology for Development: A Contribution to the 1979 U.N. Conference. Prepared for U.S. Coordinator, 1979 United Nations Conference on Science and Technology for Development as an input to the U.S. national paper for the Conference.

Study on Postharvest Food Loss, Minutes, Steering Committee Meeting, June 8-9, 1977, Philadelphia, Pennsylvania.

Postharvest Food Losses in Developing Countries: Staff Summary Report of an International Working Group Meeting, October 31-November 3, 1977, Washington, D.C.

Study on Postharvest Food Loss, Minutes, Steering Committee Meeting, February 14-15, 1978, Washington, D.C.

Postharvest Food Losses in Developing Countries. Final Report, Study on Postharvest Food Losses (in press).

Bibliography, Postharvest Food Losses in Developing Countries. (in preparation)

BOARD ON SCIENCE AND TECHNOLOGY FOR INTERNATIONAL DEVELOPMENT

Members

ROGER REVELLE[1], Chairman, 1969 - 72, Director, Center for Population Studies Harvard University, Member 1969 - 74.

CARL DJERASSI[1,3] Chairman, 1972 - 75, Chemistry, Stanford University; Member, 1969 - 75.

DAVID PIMENTEL, Chairman, 1975 - , Entomology, Cornell University; Member, 1975 -

HARRISON BROWN[1], ex officio, Foreign Secretary, National Academy of Sciences, 1969 - 74.

*GEORGE S. HAMMOND[1], ex officio, Foreign Secretary, National Academy of Sciences, 1974 -

THOMAS F. MALONE[1], ex officio, Foreign Secretary, National Academy of Sciences, 1969 - 74; Foreign Secretary, 1978 -

BRUCE S. OLD[2], ex officio, Foreign Secretary, National Academy of Engineering, 1969 - 74.

RUTH ADAMS, Acting Editor, The Bulletin of the Atomic Scientists, 1973 - 77.

C. ARNOLD ANDERSON, Anthropology, University of Chicago, 1971 - 72.

*EDWARD S. AYENSU, Director, Endangered Species Program, Smithsonian Institution, 1976 -

JOHN D. BALDESCHWIELER[1], Chemistry, California Institute of Technology, 1974 - 76.

*PEDRO BARBOSA, Entomology, University of Massachusetts, 1977 -

JACK N. BEHRMAN, International Business, University of North Carolina, 1973 - 75.

IVAN L. BENNETT, JR.[3], Medicine, New York University, 1971 - 76.

NYLE C. BRADY, College of Agriculture, Cornell University, 1970 - 71.

*DWIGHT S. BROTHERS, Consultant, Concord, Massachusetts, 1976 -

LESTER R. BROWN, President, Worldwatch Institute, 1974 - 75.

*JOHN H. BRYANT[3], Director, School of Public Health, Columbia University, 1976 -

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1 - Member, NAS 2 - Member, NAE 3 - Member, IOM

* Current Board Member

*GEORGE BUGLIARELLO, President, Polytechnic Institute of New York, 1972 -

*ELIZABETH COLSON, Anthropology, University of California, Berkeley, 1977 -

CHARLES DENNISON, Consultant, New York City, 1972 - 77.

*BREWSTER C. DENNY, Dean, Graduate School of Public Affairs, University of Washington, 1976.

*HERBERT I. FUSFELD, Director of Research, Kennecott Copper Corporation, 1977 -

*MARTIN GOLAND[2], President, Southwest Research Institute, 1977 -

*JAMES P. GRANT, President, Overseas Development Council, 1977 -

D. MARK HEGSTED[1], Nutrition, Harvard University, 1970 - 72.

GEORGE R. HERBERT, President, Research Triangle Institute, 1978 -

WILLIAM R. HEWLETT[2], President, Hewlett-Packard Company, 1974 - 75.

WILLIAM N. HUBBARD, JR., President, Upjohn Company, 1978 -

LADY BARBARA WARD JACKSON, Economics, Columbia University, 1971 - 72.

WILLIAM A. W. KREBS, Arthur D. Little, Inc., 1969 - 77.

ROBERT N. KREIDLER, Executive Vice President, Alfred P. Sloan Foundation, 1969 - 74.

FRANKLIN A. LONG[1], Program on Science, Technology and Society, Cornell University, 1974 - 76.

ROY L. LOVVORN, State Research Service, Department of Agriculture, 1969 - 72.

JOHN J. McKELVEY, JR., Agricultural Sciences, The Rockefeller Foundation, 1969 - 72.

*FREDERICK T. MOORE, International Bank for Reconstruction and Development, 1976 -

*W. HENRY MOSLEY, Director, Cholera Research Laboratory, Dacca, Bangladesh, 1977 -

EDWIN MUNGER, Geography, California Institute of Technology, 1969 - 71.

*RODNEY W. NICHOLS, Vice President, Rockefeller University, 1977 -

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1 - Member, NAS   2 - Member, NAE   3 - Member, IOM

* Current Board Member

DANIEL A. OKUN[2], Sanitary Engineering, University of North Carolina, 1978 -

JOSEPH PETTIT[2], President, Georgia Institute of Technology, 1972 - 77.

JOSEPH B. PLATT, President, Harvey Mudd College, 1969 - 77.

JAMES B. QUINN, Amostuck School of Business Administration, Dartmouth College, 1977 -

HELEN RANNEY[1,3], Medicine, University of California at San Diego Hospital, 1974 - 77.

*PRISCILLA C. REINING, International Science, American Association for the Advancement of Science, 1978 -

*RALPH W. RICHARDSON, JR., Natural Environmental Sciences, The Rockefeller Foundation, 1977 -

H. F. ROBINSON, Provost, Purdue University, 1969 - 72.

STEFAN H. ROBOCK, Graduate School of Business, Columbia University, 1969 - 72.

*FREDERICK SEITZ[1], President, Rockefeller University, 1978 -

H. BURR STEINBACH, Oceanic Foundation, 1969 - 72.

*H. GUYFORD STEVER[1,2], Consultant, Washington, D.C., 1978 -

ROBERT M. WALKER[1], Physics, Washington University, 1974 - 77.

CLIFTON WHARTON, President, Michigan State University, 1969 - 1970.

GILBERT F. WHITE[1], Geography, University of Colorado, 1972 - 75.

CARROLL L. WILSON, Management, Massachusetts Institute of Technology, 1969 - 72.

STERLING WORTMAN, Vice President, The Rockefeller Foundation, 1972 - 76.

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1 - Member, NAS 2 - Member, NAE 3 - Member, IOM

* Current Board Member

BOSTID Sub-Panels

Advisory Committee on International Health	-- John H. Bryant, Chairman
Advisory Committee on Technology Innovation	-- George Bugliarello, Chairman
Korea-U.S. Joint Continuing Committee for Scientific Cooperation	-- Brewster C. Denny, Chairman
Advisory Committee on Evaluation	-- Rodney W. Nichols, Chairman
Continuing Committee for Sino-American Science Cooperation	-- Frederick Seitz, Chairman
Joint Consultative Committee NAS-ASRT (Egypt) Applied Science and Technology Research Program	-- H. Guyford Stever, Chairman

BOARD ON SCIENCE AND TECHNOLOGY FOR INTERNATIONAL DEVELOPMENT

Professional Staff

WILLIAM L. EILERS, Staff Director, 1969-70; Head of Bilateral Programs, 1970-71
*VICTOR RABINOWITCH, Staff Director, 1969; (February 1969 - March 1970, State University of New York); Staff Director, 1970 -
*ROSE AMESER BANNIGAN, Professional Assistant, 1969-70; (November 1970 - July 1971, overseas travel); Assistant to the Director, 1971 -
*TRESA A. BASS, Staff Assistant, 1975 -
ROBERT BRAINARD, Professional Associate, 1970-71
NORMAN L. BROWN, Professional Associate, 1970-75
B. K. WESLEY COPELAND, Professional Associate, 1969-78
*JAY J. DAVENPORT, Professional Associate, 1969 -
*DIOSDADA DeLEVA, Librarian, 1971 -
*M. G. C. McDONALD DOW, (December 1968 - September 1972, Haile Selassie I University), Deputy Director for Overseas Programs, September 1972-77; Deputy Director, 1977 -
*JULIEN ENGEL, Deputy Director, 1969-72; Deputy Director for Special Studies, 1970-77; on secondment to Organization of Economic Cooperation and Development (OECD), Paris, 1977-78
*MARY JANE ENGQUIST, Staff Assistant, 1975 -
*JOHN G. HURLEY, Professional Associate, 1970 -
JANE LECHT, Editor, 1971-74
*AUGUSTUS NASMITH, JR., Professional Associate, 1977 -
LORETTA POTTS, Librarian, 1970-71
*F. R. RUSKIN, Editor, 1974 -
THERESA TELLEZ, Head, Latin American Affairs, 1967-70; Professional Associate, 1970-75
*NOEL D. VIETMEYER, Professional Associate, 1970 -
JUDY WERDEL, Professional Assistant, 1970-74
ADOLPH WILBURN, Professional Associate, 1970-71
EARL YOUNG, Professional Associate, 1970-71
JAMES ZAVISTOSKI, Professional Associate, 1970-72

Part-Time Borrowed Staff

WINFRED E. BERG, Executive Secretary, Committee on Remote Sensing for Earth Resource Surveys, Commission on Natural Resources, National Research Council, 1976-77

---

*Current Staff

JOHN R. FOWLER, Executive Secretary, Committee on Transportation and BART Impact Program Advisory Committee, Assembly of Engineering, National Research Council, 1977-78

HUGH MILLER, Executive Secretary, Office of the Foreign Secretary, National Academy of Engineering, 1971-75; 1977-78

DONNA W. SHIPLEY, Assistant Editor, Commission on Natural Resources, National Research Council, 1976

BETSY S. TURVENE, Editor, Academy Forum, National Academy of Sciences, 1976-77

Temporary Appointments

ROBERT E. ASHER, Professional Associate, 1972 (Study on the Role of U.S. Firms in Strengthening R, D, & E Capabilities in Developing Countries)

JOEL BERNSTEIN, Study Director, 1977-78 (Study for 1979 U.N. Conference on Science and Technology in Development)

SABRA BISSETTE, Professional Assistant, 1977-78 (Study for 1979 U.N. Conference on Science and Technology in Development)

PATRICIA W. BLAIR, Professional Associate, 1970-71 (Study on International Development Institute) and Deputy Study Director, 1977-78 (Study for 1979 U.N. Conference on Science and Technology in Development)

JENNIFER S. BOND, Staff Associate, 1975 (Study on Remote Sensing for Development)

MARCIA A. DUNCAN, Research Assistant, 1977 (Study on Lesser-Known Micro-organisms)

JOHN McCONNAUGHEY, JR., Research Assistant, 1972 (Study on Appropriate Technologies for Developing Countries)

ROBERT F. MORRIS, Research Associate, 1977 (Study on Postharvest Food Losses in Developing Countries) and Research Associate, 1977-78; (Study for 1979 U.N. Conference on Science and Technology in Development)

RICHARD MORSE, Professional Associate, 1972 (Study on International Industrialization Institute)

RUSSELL SCARATO, Professional Associate, 1972 (Study on International Industrialization Institute)

JOSE VILLAVICENCIO, Research Assistant, 1972-73 (Study on Appropriate Technologies for Developing Countries)

OVERSEAS PROGRAMS

Africa

GHANA

Workshop on Research Priorities and Problems in the Execution of Research in Ghana, Accra, Janurary 18-22, 1971

U.S. PARTICIPANTS

JOHN J. McKELVEY, JR., Chairman, Agriculture, Rockefeller Foundation
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W.K. AGBLE, Director, Crops Research Institute
YAW ASANTE, Building and Road Research Institute
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M.A. MENSAH, Fishery Research Unit
G.T. ODDOYE, National Council on Higher Education
TWUM-BARIMA, Chairman, Cocoa Marketing Board

Joint U.S.-Ghana Committee on Agricultural Extension and Research, 1971

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E.J.A. ASOMANING, Cocoa Research Institute, CSIR, New Tafo
E. BORTEI-DOKU, Agricultural Economics and Farm Management, University of Ghana
J.S. KANKAM, Crop Production, University of Science and Technology, Kumasi

Joint U.S.-Ghana Committee on the Role of the Council for Scientific and Industrial Research in Determining Science Policy and Research Priorities

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NAS-CSIR Ad Hoc Committee, Washington, D.C., July 1-3, 1974

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NIGERIA

Workshop on Science and Nigeria Development
Bellagio, Italy, August 19-25, 1965

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Regional Workshop on Aquatic Weed Management and Utilization in the Nile Basin, Khartoum, November 24-29, 1975

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Workshop on Solar Energy for the
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Dar es Salaam, August 11 - 19, 1977

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ZAIRE (FORMER DEMOCRATIC REPUBLIC OF THE CONGO)

Role of Science and Technology in the Economic Development of the Congo During the 1970's
Kinshasa, June 7-11, 1971

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Second Joint Meeting, Sino-American Science Cooperation Program, Washington, D.C., February 23-27, 1965

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Fourth Joint Sino-American Science Cooperation Program
(Workshop on the Industrial Development of Taiwan:
Science, Technology and Management), Taipei,
August 26-30, 1968

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Sixth Joint Meeting, Sino-American Science Cooperation Program (Colloquium on Ocean Resources), Taipei, April 28 - May 6, 1971

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Seventh Joint Meeting, Sino-American Science Cooperation Program (Sino-U.S. Workshop on Scientific and Technical Information Needs and Resources in the Republic of China (Taiwan)), Washington, D.C.
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PAKISTAN

Workshop on Science and Technology Policy in Pakistan--
Planning and Implementation, Peshawar, Pakistan,
October 19-27, 1976

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PHILIPPINES

Philippines-U.S. Workshop on Scientific and Technological Cooperation and Development, Manila, November 22-26, 1965

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Second U.S.-Philippines Workshop on Cooperation in Science and Technology, Asilomar, California, November 6-10, 1966

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Philippines-U.S. Workshop on Fisheries and Oceanography
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Philippines-U.S. Workshop on Industrial Research
Baguio City, January 26 - February 1, 1969

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Philippines - U.S. Workshop on Education and Training Needs for Philippine Environmental Programs, Manila, May 27-31, 1974

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SINGAPORE

Regional Workshop on Water Resources, Environment, and National Development, Singapore, March 13-17, 1972

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SRI LANKA

NAS-Sri Lanka Workshop on Natural Products Development,
Colombo, June 2-6, 1975

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THAILAND

Thailand Seminar on Protein Food Promotion, Bangkok, November 22 - December 1, 1970

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Workshop on Science Planning and Policy in Thailand Bangkok, July 3-6, 1972

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AIT-NAS Seminar on Ferrocement Technology
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ARGENTINA

Argentine-U.S. Workshop on Science and Technology in Economic Development
Mar del Plata, July 28 - August 1, 1969

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Argentine-U.S. Study Group on Groundwater Hydrology, 1970

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Joint Argentine-U.S. Study Group
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Joint Argentine-U.S. Study Group
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BRAZIL

First Brazil-U.S. Workshop on Contribution of Science and Technology to Development, Itatiaia, April 11 - 16, 1966

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Fourth Brazil-U.S. Workshop on Contribution of Science and Technology to Development, Washington, November 1 - 5, 1971

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Joint Study Group on Application of Steroid Chemistry to Industry, 1966

CARL DJERASSI, Chemistry, Stanford University
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Joint Study Group on Industrial Research, 1968

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Joint Study Group on Norms, Measurements and Testing, 1968

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Computer Sciences Feasibility Study, 1968

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Joint Study Group on Computer Science, 1971

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Joint Study Group on Agricultural Economics, 1968

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Joint Study Group on Transportation, 1970

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Workshop Planning Committee--Workshop on Science and Technology and the Use of Semi-Arid Land in Brazil, Brazil, March 4 - 9, 1974

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Workshop on Science and Technology for the
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BRAZILIAN PARTICIPANTS -- No listing available

NAS Members of International Steering Committee
on Nitrogen Fixation, 1974 -

ROBERT H. BURRIS, Biochemistry, University of Wisconsin, 1975 -
HAROLD J. EVANS, Plant Nutrition, Biochemistry, Oregon State University, 1974 -
STANLEY SCHANK, Cytogenetics, Plant Breeding, University of Florida, 1974 - 1977.
SHERLIE WEST, Plant Physiology, Agronomy, University of Florida, 1974 - 1977.

Participants at an International Steering Committee
Meeting on Nitrogen Fixation,
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Joint Ad Hoc Committee on Brazil Flora Project, 1976

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Joint Study Group on the Campo Cerrado, 1975 - 1976

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NAS-CNPq Scientific Advisory Committee:
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HELYDE ALBUQUERQUE
MARIA NILDE RIBEIRO
WILLIAM RODRIGUES
MARLENE FREITAS

International Seminar on Climatology of the Southern Hemisphere:
1. Drought and Frost Research in Brazil;
2. Studies and Recommendations of Technical Groups.
Campinas, Brazil, September 5 - 10, 1977

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CENTRAL AMERICA

Central American Workshop on the Environment and Development Antigua, July 25 - 30, 1971

U.S. PARTICIPANTS

EDWARD ACKERMAN, Executive Officer, Carnegie Institution of Washington
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NORTON GINSBURG, Geography, University of Chicago
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NAS-ICAITI Joint Continuing Committee, 1972

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NAS-ICAITI Executive Advisory Committee for the Environmental Systems Study of Pesticides Use in Central American Cotton Production, 1973

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CHILE

Chile-U.S. Workshop on the Contribution of Science and Technology to Development Santiago, January 11 - 15, 1971

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Copper Technology

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COLOMBIA

Colombia-U.S. Workshop on Science and Technology in Development
Fusagasuga, February 26 - March 1, 1968

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Graduate Study Planning Group, 1970

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Joint Study Group on Chemistry, 1971

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Joint Study Group on Mathematics, 1971

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Joint Study Group on Engineering Physics, and Earth Science, 1972

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Joint Study Group on Biological Sciences, 1972

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Joint Evaluation Group on
Graduate Study Review, 1972

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DOMINICAN REPUBLIC

Workshop on Agro-Industrial Development
in the Dominican Republic,
Santo Domingo, Dominican Republic, October 18 - 22, 1976

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T. NAKAYAMA, Food Science and Technology, University of Hawaii at Manoa
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THOMAS S. WEAVER, Resource Economics, University of Rhode Island
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GUYANA

Guyuna-U.S. Workshop on Aquatic Weed Management and Utilization, Georgetown, March 15 - 17, 1973

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Workshop on an International Center for
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PERU

First Peru-U.S. Workshop on Science, Technology and Development, Paracas, April 18 - 22, 1966

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Second Peru-U.S. Workshop on Science and Technology in Development, Lima, Peru, November 20 - 24, 1967

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Joint Study Group on Proposed NRC, 1966

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NAS-ITINTEC Workshop on Industrial Research Management and Programming, Lima, Peru, January 25 - 29, 1975

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VENEZUELA

Workshop on Science and Technology for Urban Poor,
Caracas, Venezuela, March 6 - 11, 1977

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Subpanel on Foodstuffs (Human and Animal)

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Subpanel on Industrial Raw Material

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Subpanel on Bioinsecticides

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DEAN WEBER, Cell Culture and Nitrogen Fixation Labs., USDA
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Subpanel on Plant Nutrition

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DAVID PRAMER, Associate Vice President for Research, Rutgers University
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Subpanel on Microorganism Culture--Availability and Problems

RICHARD DONOVICK, Chairman, American Type Culture Collection

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ROBERT ACKER, American Society for Microbiology

S P E C I A L S T U D I E S / A D V I S O R Y P A N E L S

INTERNATIONAL ASPECTS OF MAN'S EFFECT UPON THE ENVIRONMENT

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EAST PAKISTAN LAND AND WATER DEVELOPMENT AS RELATED TO AGRICULTURE

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SOLAR ENERGY FOR DEVELOPING COUNTRIES: PERSPECTIVES AND PROSPECTS

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MEETING THE CHALLENGE OF INDUSTRIALIZATION: A FEASIBILITY STUDY FOR AN INTERNATIONAL INDUSTRIALIZATION INSTITUTE

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ROLE OF SCIENCE AND TECHNOLOGY IN
INTERNATIONAL DEVELOPMENT IN THE 1970's

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SYSTEMS ANALYSIS AND OPERATIONS RESEARCH: A TOOL FOR POLICY AND PROGRAM PLANNING

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October 29, 1976

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DISCUSSION SEMINAR ON TROPICAL METEOROLOGY
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STUDY FOR U.N. CONFERENCE ON SCIENCE
AND TECHNOLOGY FOR DEVELOPMENT

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Panel No. 2: Energy, Natural Resources and Environment

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Panel No. 3: Food, Climate, Soil and Water

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Panel No. 4: Employment, Trade and Industrialization

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SAADIA SCHORR, Industrial Planning in LDCs, Harbridge House, Inc.
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Panel No. 5: Urbanization, Transportation and Communication

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POSTHARVEST FOOD LOSSES
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