# U.S. Science and Technology for Development:

## A Contribution to the 1979 U.N. Conference

# U.S. Science and Technology for Development:

## A Contribution to the 1979 U.N. Conference

Background Study on Suggested U.S. Initiatives for the U.N. Conference on Science and Technology for Development, Vienna, 1979

*Prepared by*

NATIONAL RESEARCH COUNCIL
- National Academy of Sciences
- National Academy of Engineering
- Institute of Medicine



*Printed by*
*Department of State*

This report, "U.S. Science and Technology for Development: A Contribution to the 1979 U.N. Conference," was prepared by the National Research Council, a private organization. The Department of State asked the Council to suggest activities that the U.S. government might consider--for increased support within available resources--as means of helping developing countries apply science and technology in support of their own development programs. This report is neither a statement of U.S. government policy nor a recommendation by the National Research Council that the entire range of suggested activities should or could be supported by the U.S. government.

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402

Stock Number 052-003-00546-8

# PREFACE

The United States, no less than the developing countries, should welcome the decision of the Seventh General Assembly to convene a General Conference on Science and Technology for Development in Vienna, Austria, in August 1979. Almost 15 years have passed since the 1963 U.N. Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas, which generated an enormous volume of material on the state of science and technology at that time. Yet 15 years in science and technology represents many generations of research and development, and the "less developed areas" have changed a great deal since then, some of them almost beyond recognition. Furthermore, the world has come to recognize new problems--finite energy supplies, environmental degradation, runaway population growth--which it was hardly conscious of then.

In late October 1977, the National Research Council agreed to conduct a study for the U.S. Department of State which would assist U.S. preparations for the 1979 Conference by providing suggestions for specific initiatives that the United States could take to further the purposes of the Conference.

This report, resulting from that study, identifies ways in which U.S. scientific and technological resources could better contribute to developing country needs. We believe that practical proposals in areas of common interest between the United States and the developing countries will better serve the purpose of the 1979 Conference than dwelling further on such matters as the nature of development problems, the allocation of responsibility for their existence and cure, the general role of science and technology, or ideological or policy differences among countries.

We have recognized, as well, that the Department of State is receiving inputs from many sources as it prepares for the 1979 Conference. In particular, the Department has received a comprehensive review of the

potentially important role of private U.S. corporations which was based on an extensive dialogue with representatives of the business community.

The National Research Council established an Executive Committee to take responsibility for this report. The Committee consists of the chairmen of five panels which covered the various subject areas, the Foreign Secretaries of the National Academy of Sciences and the National Academy of Engineering, the chairman of the Committee on International Health of the Institute of Medicine, and myself as overall chairman. The subject areas covered are:

-- industrialization;
-- health, nutrition, and population;
-- food, climate, soil, and water;
-- energy, natural resources, and environment;
-- urbanization, transportation, and communication.

Chapters 2-6 of this report are based on the panel reports.

The work of our panels was supplemented by views and suggestions received at four public forums, including written materials submitted by attendees or other interested parties during and after these forums. Held in mid-January in New York, Atlanta, St. Louis, and San Francisco, the forums attracted about 400 participants, primarily representing civic, public interest, and business organizations, and the academic community.

This report offers a wide range of possible initiatives, selected from much larger lists initially identified by the panels and other sources. Our purpose is to suggest enough options to permit substantial scope for selectivity.

It is not the purpose of this report to recommend an overall policy on development for the U.S. government or overall organization to handle science and technology in development. Clearly, however, an adequate program of initiatives along the lines suggested in this report will not be fully realized unless a strong mechanism is created within the government to guide U.S. policies and programs for applying science and technology to development, and to help the agencies and departments that are responsible for specific initiatives gain the authorization and funds to carry them out properly. President Carter's recent decision to establish a Foundation for Technological Cooperation within a new U.S. development assistance organization creates an important opportunity to achieve these purposes.

On behalf of the Executive Committee and the National Research Council, I gratefully acknowledge the

extensive help that we received from many sources. The largest contribution came, of course, from the project panels and staff, who are listed separately immediately following this Preface along with consultants who assisted the Executive Committee and the panels.

I am especially grateful for the enthusiastic and helpful response shown by representatives of industry, nongovernmental organizations, the academic community, and others to our four public forums (see Appendix). Their success owes much to the generous efforts of staff at the host institutions, particularly the chairmen and liaison officers for the forums: George Bugliarello and Leopold Felsen, Polytechnic Institute of New York; Joseph M. Pettit and Ross Hammond, Georgia Institute of Technology; Robert P. Morgan, Washington University, and Michael Witunski, United Nations Association, Greater St. Louis Chapter; and Richard Heggie, World Affairs Council of Northern California.

Several elements of the National Research Council (NRC) also contributed ideas to this report: Assembly of Behavioral and Social Sciences, Assembly of Engineering, Board on International Organizations and Programs, the Board on Science and Technology for International Development (BOSTID), Committee on International Scientific and Technical Information Programs, Commission on Sociotechnical Systems, International Environmental Programs Committee, and Ocean Policy Committee. Particularly, credit goes to the project staff, led by Joel Bernstein, Study Director, assisted by Patricia W. Blair, Deputy Study Director, Sabra Bissette, Editor, and the NRC professional staff who worked directly with the panels--Rose A. Bannigan, B.K. Wesley Copeland, Jay J. Davenport, John G. Hurley, and Augustus Nasmith of BOSTID--and Hugh H. Miller, Executive Director, Office of the Foreign Secretary, National Academy of Engineering. Valuable advice and assistance was also provided by Victor Rabinowitch, BOSTID staff director; W. Murray Todd, Executive Director of the Commission on International Relations; and Judith A. Werdel, CISTIP. The report also benefited from the comments and suggestions of the National Research Council's Report Review Committee. And, of course, I would like to express my appreciation to the members of the Executive Committee itself, who generously gave their time for this project.

Our Committee believes that the 1979 Conference, and particularly the international dialogues before and after, can stimulate more international cooperation to

find better solutions to the problems of daily living that affect people everywhere. We hope that our suggestions foster useful action for this purpose.

H. Guyford Stever
Washington, D.C.
April 1978

EXECUTIVE COMMITTEE
STUDY ON U.S. INITIATIVES FOR THE U.N. CONFERENCE
ON SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

H. GUYFORD STEVER, Washington, D.C., CHAIRMAN

JOHN H. BRYANT, M.D., Chairman, Committee on International Health, Institute of Medicine, and Director, School of Public Health, Columbia University, New York, N.Y.

EMERY N. CASTLE, Vice President, Resources for the Future, Inc., Washington, D.C.

JOHN H. GIBBONS, Director, Environment Center, University of Tennessee, Knoxville

GEORGE S. HAMMOND, Foreign Secretary, and Chairman of the Commission on International Relations, National Academy of Sciences, and Professor of Chemistry, Merrill College, University of California at Santa Cruz

N. BRUCE HANNAY, Foreign Secretary, National Academy of Engineering, and Vice President, Research and Patents, Bell Laboratories, Murray Hill, N.J.

WILLIAM A.W. KREBS, Vice President, Arthur D. Little, Inc., Cambridge, Mass.

WILFRED OWEN, Senior Fellow, The Brookings Institution, Washington, D.C.

ALLAN ROSENFIELD, M.D., Director, Center for Population and Family Health, and Professor of Public Health and OB-GYN, Columbia University, New York, N.Y.

RESOURCE PERSONS: Elizabeth F. Colson, Professor of Anthropology, University of California at Berkeley; Franklin A. Long, Henry R. Luce Professor of Science and Society, and David Lewis, Assistant Professor of City and Regional Planning, Cornell University, Ithaca, N.Y. Suggestions on Initiative 4, Chapter 1, from Lowell S. Hardin, Program Officer of Agricultural, Economic and Social Development, International Division, The Ford Foundation, New York, N.Y.; Chester O. McCorkel, Jr., Vice President, University of California at Berkeley; Sylvan Wittwer, Director, Agricultural Experiment Station, Michigan State

University, East Lansing; and Sterling Wortman, Vice President, The Rockefeller Foundation, New York, N.Y. Review of education sections by Charles W. Kidd, Research Professor, George Washington University, Washington, D.C.

STUDY STAFF: Joel Bernstein, Study Director; Patricia W. Blair, Deputy Study Director; Sabra Bissette, Editor; Brenda Buchbinder, Administrative Secretary. Victor Rabinowitch, Staff Director, BOSTID.

STUDY PANELS

INDUSTRIALIZATION

WILLIAM A.W. KREBS, CHAIRMAN
ROBERT B. AMES, Vice President, Allis-Chalmers Corporation, New York, N.Y.
KARL J. BRUNINGS, Program Manager for Technology and World Trade, Office of Technology Assessment, U.S. Congress, Washington, D.C.
W. GILBERT CARTER, Nicholson and Carter, Washington, D.C.
NAZLI CHOUCRI, Associate Professor, Department of Political Science, Massachusetts Institute of Technology, Cambridge
RICHARD ECKAUS, Professor of Economics and Ford International Professor of Economics, Department of Economics, Massachusetts Institute of Technology, Cambridge
ELIZABETH R. JAGER, Economist, Department of Research, AFL-CIO, Washington, D.C.
NARINDER S. KAPANY, President, Kaptron, Inc., Palo Alto, Calif.
THOMAS R. MILLER, Vice President, Union Carbide Corporation, New York, N.Y.
BRUCE S. OLD, Senior Vice President, Arthur D. Little, Inc., Cambridge, Mass.
JOSEPH M. PETTIT, President, Georgia Institute of Technology, Atlanta
SAADIA SCHORR, Vice President, Harbridge House, Inc., Los Angeles, Calif.
GUS TYLER, Assistant Vice President, International Ladies Garment Workers Union, New York, N.Y.

RESOURCE PERSONS: D.H. Andriadis, Manager, International Public Affairs, E.I. duPont de Nemours, Inc., Wilmington, Del.; Jack Baranson, President, Developing World Industry and Technology, Inc., Washington, D.C.; Jack N. Behrman, Professor of International Business, School of Business Administration, University of North Carolina, Chapel Hill; Robert E. Driscoll, Vice President, Fund for Multinational Management Education, New York, N.Y.; Donald Evans, Assistant Director, Institutions and Programs, International Division, Denver Research Institute; Oswald Ganley, Deputy Assistant Secretary for Advanced and Applied Technology Affairs, Bureau of Oceans and International Environmental and Scientific Affairs, Department of State, Washington, D.C.; Frederick T. Moore, Industrial Policy Advisor,

Industrial Development and Finance Department, International Bank for Reconstruction and Development, Washington, D.C.; and Raymond Vernon, Dillon Professor of International Affairs, Harvard University, Cambridge, Mass.

STAFF: Hugh H. Miller, Panel Director, and Executive Director, Office of the Foreign Secretary, National Academy of Engineering, and Jay J. Davenport, Associate Panel Director, BOSTID. Edward M. Graham, Assistant Professor, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, PANEL RAPPORTEUR.

HEALTH, NUTRITION, AND POPULATION

ALLAN ROSENFIELD, M.D., CHAIRMAN
ROY BROWN, M.D., Associate Professor of Community Medicine, Mount Sinai Medical Center, Mount Sinai Hospital, New York, N.Y.
GORDON W. DUNCAN, Director, Population Study Center, Battelle Memorial Institute, Seattle, Wash.
DONALD R. HOPKINS, M.D., Assistant Director for Operations, U.S. Center for Disease Control, Atlanta, Ga.
WILLIAM N. HUBBARD, JR., M.D., President, The Upjohn Company, Kalamazoo, Mich.
STEPHEN JOSEPH, M.D., Director, Office of International Health Programs, Harvard School of Public Health, Boston, Mass.
W. PARKER MAULDIN, Senior Fellow, The Population Council, New York, N.Y.
GEORGE REID, Distinguished Professor, College of Engineering, University of Oklahoma, Norman
PRISCILLA REINING, Program Director, Office of International Studies, American Association for the Advancement of Science, Washington, D.C.
WILLIAM REINKE, M.D., Professor of International Health, School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.
WARREN ROBINSON, Professor of Economics, Pennsylvania State University, University Park
SUSAN SCRIMSHAW, Assistant Professor of Public Health, Department of Public Health, University of California at Los Angeles
C. PETER TIMMER, Professor of Economics of Food and Agriculture, Harvard School of Public Health, Boston, Mass.
JOE D. WRAY, M.D., Visiting Professor and Acting Chairman, Department of Population Sciences, Harvard School of Public Health, Boston, Mass.

RESOURCE PERSONS: Bernard Berelson, President Emeritus, The Population Council, New York, N.Y.; Henry Feffer, M.D., George Washington University Clinic, Washington, D.C.; George I. Lythcott, M.D., Assistant Surgeon General and Administrator, Health Services Administration, U.S. Department of Health, Education, and Welfare, Washington, D.C.; and David Tilson, Institute of Medicine.

STAFF: Rose A. Bannigan, Panel Director, BOSTID. Walter B. Watson, Senior Research Associate, Columbia University, New York, N.Y., WRITER/ANALYST.

FOOD, CLIMATE, SOIL, AND WATER

EMERY N. CASTLE, CHAIRMAN
HAROLD E. CALBERT, Professor of Food Science and Chairman, Department of Food Science, University of Wisconsin, Madison
HAROLD DREGNE, Horn Professor and Director, International Center for Arid and Semi-arid Land Studies, Texas Tech University, Lubbock
KENTON MILLER, Associate Research Scientist in Natural Resources, School of Natural Resources, University of Michigan, Ann Arbor
DONALD L. PLUCKNETT, Professor of Agronomy and Soil Science, Department of Agronomy and Soil Science, University of Hawaii, Honolulu
JAN VAN SCHILFGAARDE, Director, U.S. Salinity Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Riverside, Calif.
STEPHEN C. SMITH, Professor of Resource Economics and Associate Dean, School of Natural Resources, College of Agricultural and Life Sciences, University of Wisconsin, Madison
LOUIS M. THOMPSON, Associate Dean of Agriculture, College of Agriculture, Iowa State University, Ames
D. WYNNE THORNE, Professor Emeritus, Soils and Biometeorology, Utah State University, Logan
IRENE TINKER, Assistant Director, Office of Policy and Planning, ACTION, Washington, D.C.
BURLEIGH C. WEBB, Professor of Agronomy and Dean, School of Agriculture, North Carolina A&T State University, Greensboro
ROBERT M. WHITE, Chairman, Climate Research Board, Assembly of Mathematical and Physical Sciences, National Research Council
HAROLD L. WILCKE, Former Director of Research, Ralston Purina Company, St. Louis, Missouri

RESOURCE PERSONS: Jesse Ausubel, Climate Research Board, Assembly of Mathematical and Physical Sciences, National Research Council; Gilbert L. Corey, Senior Water Management Specialist, Soil and Water Management Division, Office of Agriculture, Development Support Bureau, U.S. Agency for International Development, Washington, D.C.; Roy Lovvorn (retired), U.S. Department of Agriculture; E.R. Pariser, Senior Research Scientist, Department of Nutrition and Food Science, Massachusetts Institute of Technology, Cambridge; Dean F. Peterson, Chief, Soil and Water Management Division, Office of Agriculture, Development Support Bureau, U.S. Agency for International Development, Washington, D.C.; and Hugh Popenoe, Director, Center for Tropical Agriculture and International Programs in Agriculture, University of Florida at Gainesville.

STAFF: B.K. Wesley Copeland, Panel Director, BOSTID. Robert Morris, National Research Council, WRITER/ANALYST.

ENERGY, NATURAL RESOURCES, AND ENVIRONMENT

JOHN H. GIBBONS, CHAIRMAN
LEONARD BERRY, Dean, Graduate Program of Geography, Clark University, Worcester, Mass.
NORMAN L. BROWN, Office of International Affairs, U.S. Department of Energy, Washington, D.C.
JOHN C. CALHOUN, Executive Vice Chancellor for Programs, Texas A&M University System, College Station
JOHN D. COSTLOW, Director, Marine Laboratory, Duke University, Beaufort, N.C.
J. FRANK McCORMICK, Senior Ecologist, Fish & Wildlife Service, U.S. Department of the Interior, Washington, D.C.
CLAIRE NADER, Washington, D.C.
PHILIP F. PALMEDO, Head, Energy Policy Analysis Division, Brookhaven National Laboratory, Upton, N.Y.
ROGER REVELLE, Professor of Science and Public Policy, Department of Science, Technology and Public Affairs, University of California at San Diego
PATRICIA ROSENFIELD, Research Associate, Resources for the Future, Inc., Washington, D.C.
GLENN E. SCHWEITZER, Senior Research Fellow, Cornell University, Ithaca, N.Y., RAPPORTEUR
MACAULEY WHITING, Vice President, Dow Chemical Company, Midland, Mich.
F. KARL WILLENBROCK, Dean, School of Engineering and Applied Science, Southern Methodist University, Dallas, Texas

RESOURCE PERSONS: Paul Craig, Energy and Resources Council, University of California at Berkeley; M.B. Dickerman (formerly U.S. Forest Service), Alexandria, Va.; Paul Donovan, Donovan, Hamester and Rattien, Inc., Washington, D.C.; Jonathan Gibson, Sierra Club, Washington, D.C.; Karim Ahmed, Natural Resources Defense Council, New York, N.Y.; John Knauss, University of Rhode Island, Kingston; J. Liston, University of Washington, Seattle; Bill L. Long, U.S. Department of State, Washington, D.C.; Erven J. Long, U.S. Agency for International Development, Washington, D.C.; Ned Ostenso, Director, National Sea Grant Program, National Oceanic and Atmospheric Administration, U.S. Department of Commerce, Washington, D.C.; John Reinemund, U.S. Geological Survey, Reston, Va.; Maxine Savitz, U.S. Department of Energy, Washington, D.C.; Mason Willrich, Rockefeller Foundation, New York, N.Y.; and Warren Wooster, University of Miami, Coral Gables, Florida.

STAFF: John G. Hurley, Panel Director, BOSTID.

URBANIZATION, TRANSPORTATION, AND COMMUNICATION

WILFRED OWEN, CHAIRMAN
HERRINGTON J. BRYCE, Vice President for Washington Operations, Academy for Contemporary Problems, Washington, D.C.
JOHN EBERHARD, President, American Institute of Architects Research Corporation, Washington, D.C.
WILLIAM J. HARRIS, JR., Vice President, Research and Testing Department, Association of American Railroads, Washington, D.C.
ALBERT L. HORLEY, President, EDUTAL Communications and Development, Inc., Palo Alto, Calif.
GRETCHEN S. KOLSRUD, Assistant to the Director for New and Emerging Technologies, Office of Technology Assessment, U.S. Congress, Washington, D.C.
LEO MOLINARO, President, American City Corporation, Columbia, Md.
HARVEY PERLOFF, Dean, School of Architecture and Urban Planning, University of California at Los Angeles
VLADIMIR SLAMECKA, Professor and Director, School of Information and Computer Sciences, Georgia Institute of Technology, Atlanta
WILLIAM M. SPREITZER, Head, Transportation and Urban Analysis, General Motors Technical Center, Warren, Mich.
ALFRED P. VAN HUYCK, President, PADCO (Planning and Development Collaborative International), Washington, D.C.

MELVIN WEBBER, Professor, Institute of Urban and Regional Development, University of California at Berkeley

GEORGE W. WILSON, Professor of Economics and Business Administration, Graduate School of Business, Indiana University, Bloomington

RESOURCE PERSONS: Henri G. Busignies, Member, R.V. Mrozinski, Staff Director, and Frank M. Snyder, Staff Officer, Committee on Telecommunications, Assembly of Engineering, National Research Council; Clifford Block, Associate Director, Education, Communications and Technology, Office of Education, Development Support Bureau, U.S. Agency for International Development, Washington, D.C.; John Dickey, Urban and Regional Advisor, Office of Urban Development, U.S. Agency for International Development, Washington, D.C.; Laurence F. Gilchrist, Staff Officer, and Clotaire Wood, Executive Director, Space Applications Board, Assembly of Engineering, National Research Council; and Judith Werdel, Professional Associate, Committee on International Scientific and Technical Information Programs, Commission on International Relations, National Research Council.

STAFF: Augustus Nasmith, Panel Director, BOSTID. Col. John R. Fowler, Executive Secretary, Committee on Transportation, Assembly of Engineering.

TABLE OF CONTENTS

# Chapter 1

# OVERVIEW

President Carter has called for a renewed American dedication to helping developing countries meet the needs and aspirations of their people. In this, Americans are motivated by a desire to help build the kind of global environment in which the conditions for liberty and equity can grow and in which U.S. interests can best be protected. Further, they are motivated by a humanitarian sensitivity to the needs of the poorest people.

The United Nations Conference on Science and Technology for Development will ask how science and technology can better serve socioeconomic development. The growth of scientific and technical capabilities in developing countries over the past three decades offers new opportunities to create cooperative international relationships for this purpose. Growing recognition of common global interests and concerns offers a basis for sustaining such relationships.

The United States and other developed countries are increasingly concerned with development collaboration. Nevertheless, multilateral and bilateral assistance continue to play a significant role in helping developing countries strengthen their own institutions. Both development assistance and development collaboration are parts of an overall pattern of mutually beneficial relations which includes trade and other forms of exchange. Certainly, scientific and technological activities are an important part of that pattern. U.S. strengths in these fields are widely admired and sought after by developing countries. The private sector--including universities, nongovernmental organizations, and private industry--will continue to play a particularly useful role.

## AREAS OF CONCERN

One constructive effect of preparations for the 1979 Conference is that the U.S. government has begun a systematic review of what it can do to improve the U.S. scientific and technological contributions to development. This report, designed to assist those preparations, proposes initiatives that could be components of such a program.

These initiatives were selected from a much larger list considered by our panels. Most involve additional actions of types already undertaken or actions that have already been discussed elsewhere. We have sought to provide the U.S. government with a wide range of initiatives, each of which would have a strong positive impact on development. From these, the government can select those it wishes to pursue in the context of the 1979 Conference.

In our search for initiatives, we have kept several factors in mind: (1) the needs and priorities of developing countries, as we understand them; (2) their special concerns, including the desire for self-reliance and greater autonomy in the management of their affairs; (3) potential mechanisms for transferring and adapting foreign technology to conditions found in developing countries; and (4) ways to help developing nations both draw on world science and technology in devising answers to their own problems and contribute to the world experience used by all countries.

Once the U.S. government selects those initiatives it is best able to pursue, and how far, in light of financial and other feasibility factors, it will need to work out the particulars that will make them into operational proposals. Our Committee was not in a position to do this, but we note that the initiatives vary greatly in their cost implications. Many suggestions would call mainly for adjustments in policy and orientation of existing activities. Others would require substantial additional public appropriations, the magnitude of which can be varied. The Administration has expressed its desire to increase substantially the U.S. development assistance program, and we believe that this list of initiatives provides many opportunities to put such funds to good use. However, we note that the total list is very extensive, so that selection to hold within feasible cost limits will be essential.

We note that the phrase "developing country" is inexact. Each country has unique scientific, technological, and development needs. Moreover, developing countries are showing a growing interest in interregional cooperation. Thus the United States must

be prepared to offer and participate in programs that aim at a wide range of needs, appeal to different countries and regions, and are also responsive to the varied interests and capabilities of people and institutions in the United States.

## The Goals of Development

Broadly speaking, development is concerned with two important goals: (1) eradication of extreme poverty by satisfying the most basic needs for food, shelter, health, employment, and education; and (2) modernization and growth of national output both for domestic consumption and to earn income through export.

Scientific knowledge and technology are an indispensable part of the development process. Yet, they are only two elements in a larger setting where political, social, and economic traditions, values, and processes may be more fundamental factors affecting change.

The experience of the past quarter century has shown the limitations of equating growth with development. Many developing countries have successfully raised their gross national products, increased food supplies and educational opportunities, and improved health and living conditions. Yet millions of people remain little affected by these successes, necessitating new and different measures to bring these benefits to the poorest people.

Quality of life and quantity of output are, however, closely related. Low-income countries cannot overcome the worst aspects of poverty without raising average output and income per capita; this fact has led most to drive for industrialization and more substantial access to the world's industrial technology. The thorny issues raised by these desires are discussed in Chapter 2. In developing countries, fear of exploitation by transnational corporations that control much of the science and technology needed for industrialization is matched, in developed countries, by fear that exports of industrial technology will result in loss of jobs and markets. There is no easy resolution of these issues, but the 1979 U.N. Conference can provide an important opportunity for generating greater common understanding of the problems involved.

## Autonomy and Interdependence

Developing countries often identify autonomy and self-reliance in the management of their own affairs as

primary development goals. Implicit is a desire to reduce dependence on outside sources for modern technology. At the same time, there is a demand for greater access to technology held in the developed countries and better terms for its importation.

These are legitimate and important concerns. Continued gross disparity in scientific and technical capabilities between developed and developing countries is not in the long-term interest of either. The spectacular growth in world trade after World War II, thanks in good part to U.S. help in rebuilding war-devastated Europe, testifies to the gains for all sides to be had from self-reliant economies. Strong economies in developing countries could support similar growth worldwide.

The drive for greater autonomy in developing countries involves contradictions, however: self-reliance is not equivalent to self-sufficiency. Fulfillment of aspirations for material progress normally leads to increasing interdependence among countries, since no country is entirely self-sufficient in the resources needed to achieve its goals.

Global problems also foster interdependence among countries. The scarcity of petroleum, minerals, and usable water resources, for example, affects world agricultural and industrial production and distribution. Growing world population is putting new demands on the world's ability to produce food, jobs, and services. Many environmental issues are global in nature. Furthermore, as populations multiply and improvements in communication and transport spread, people everywhere are affected more and more by actions taken beyond their borders. Thus it is important to foster cooperation among countries while at the same time promoting sustainable, more self-reliant growth in developing countries.

## Technology Transfer and the Problem of Proprietary Knowledge

Technology is transferred from the United States to developing countries by many routes, via universities, laboratories, visiting experts, books, journals, technical reports, and the like. Much, especially industrial technology, is transferred through commercial firms in the form of products and processes.

Commercial transfer of technology often involves proprietary knowledge, available only on terms negotiated with the owners of the technology being sought. In the private enterprise system of the United States and most industrial countries, the ability to protect private skill and information is an important

incentive for economic performance and technical advancement. We do not anticipate any basic change in U.S. laws relating to this protection.

A small fraction of U.S. industrial and commercial technology will continue to be withheld for reasons of national security or commercial secrecy. However, most proprietary technology can be purchased, and developing countries are increasingly adept at negotiating better terms for it. In any case, it seems clear that the extent of private technology flows to developing countries will depend on whether conditions in each country (markets, regulations, institutional and business capabilities, and so forth) attract such flows. At the same time, the United States should be alert to opportunities for encouraging U.S. private enterprise to negotiate such exchanges on terms that would facilitate broader participation by developing countries.

One important point is that much U.S. technology is nonproprietary in the sense that fees need not be paid for its use--a fact that the United States may have done too little to make clear. Much technology is published. Other freely available technology includes that embodied in expired patents that have never been brought to large-scale commercialization but that may, because of changing circumstances (e.g., increased energy costs or decreased supplies of raw materials) be newly attractive. The substantial amount of technology developed with U.S. government support is normally in the public domain. Nonproprietary technologies include, for example, a large segment of industrial and communications technology, and most of those used in public services, construction, transportation, health, and agriculture. The latter areas may be the sectors in which actual yield on investment, in terms of improved living standards, will be greatest.

Universities, government laboratories, and industries generally are prepared to cooperate in adapting or transferring this technology, and the United States, by way of the Agency for International Development (AID), has actively supported its transplantation, with particular concern for adaptation to conditions in developing countries.

Of paramount concern, however, are the developing countries' own capabilities to assess, select, develop, adapt, and apply technology and the underlying scientific knowledge. Thus throughout this report, we stress measures that would help build these capabilities.

## OPPORTUNITIES AND PROPOSED INITIATIVES: HIGHLIGHTS

The initiatives identified in this report fall into two categories: (1) those that relate to specific clusters of development activities, and (2) those that help strengthen the general abilities of developing countries to make use of science and technology for national purposes. The first 16 initiatives in this chapter highlight those in the first category that seem to this Committee to have the highest priority among the many discussed in later chapters. They relate to:

-- increasing food supplies,
-- health and related needs,
-- urbanization and industrialization,
-- management of resources.

The remaining initiatives identified in this chapter fall into the second category, that is, they relate to the general abilities of developing countries to use science and technology. This list does not, of course, exhaust the total of potentially useful initiatives. Many more are outlined in subsequent chapters; still others were raised in public forums and elsewhere.

The problems we have identified for concentrated effort share three attributes: (1) successful work on the problem would have a broad impact on development and human welfare, especially on the poorest sectors in developing countries; (2) developing and developed countries have a mutual interest in collaborating on the problem; and (3) the scientific and technical knowledge needed for addressing the problem is available or foreseeable. Any U.S. initiative proposed at the U.N. Conference needs to be judged against all three criteria if it is to be well received at home and abroad. Moreover, the policies and actions of each country set the directions and pace of its development, which normally is affected only marginally by outside initiatives. However, international collaboration, such as the initiatives listed below, can be decisive in dealing with key problems.

### Increasing Food Supplies

Increased crop production to feed the world's growing population can be achieved either by expanding the land area cultivated or by increasing average annual yields per hectare. The latter may be accomplished by applying more labor per hectare, applying more capital per hectare (in the form of fertilizers, equipment, irrigation ditches, etc.), improving the biological factors that affect crop

productivity, or making other technological improvements.

Problems abound in this area. The costs of bringing land into production continue to rise, and the expense and environmental damage associated with production inputs constrain their use. People are beginning to question the wisdom of building ever more irrigation dams and using ever greater amounts of chemical fertilizers to grow crops. However, as the following initiatives suggest, important gains in world food supplies are possible via other routes including the reduction of postharvest food losses, more efficient management of tropical soils and water at the farm level, and better plant and animal protection. Furthermore, there is a good prospect that scientific research may, in the long run, develop crop plants that are inherently more productive than those now available.

## 1. Reducing Postharvest Food Losses

Conservative estimates of the amount of food lost between harvest and consumption as a result of pests, microorganisms, inadequate storage, poor processing techniques, and the like, range upward from 10 percent for grains and legumes and 20 percent for perishables. A campaign to reduce or prevent these losses could thus result in a major increase in world food availability with minimal disruption of familiar production techniques and existing socioeconomic arrangements.

The problem of postharvest food losses is well recognized. In 1975, the Seventh Special Session of the U.N. General Assembly proposed priority efforts to reduce postharvest losses by at least 50 percent by 1985. We believe that the United States should allocate more resources to this goal. In addition, we recommend that the United States encourage the formation of an International Coordinating Council on Postharvest Food Losses to provide a forum in which coordination could be worked out among presently scattered activities in the United States and elsewhere. The council could support or foster development of loss assessment methodologies; strengthen information exchange; encourage scientific and socioeconomic research; promote training programs; identify or develop useful low-cost equipment; and encourage other public and private institutions to contribute funds or expertise to this effort.

Many known techniques for reducing losses can be adapted for use at the farm level if trained personnel and other resources are made available. Thus rapid impact could be expected, contributing to a reduced

incidence of absolute hunger, higher levels of nutrition and health generally, and, with appropriate marketing policies, added income for rural populations. Demands on governments to expend foreign exchange to import food or fertilizer might also be reduced.

## 2. Soil and Water Management at the Farm Level

Both soils and water can be used more efficiently to increase food production. Over half the world's arable land is used sparsely, or not at all, for agriculture. Most of this unused potential is found in the tropics and often has characteristics unfavorable for steady cultivation, e.g., high acidity or high levels of mineral toxicity. At the other extreme, about half of the world's food production, by value, comes from irrigated land. Yet on this land, water is often poorly managed, leaving great room for improvement. Irrigation projects have frequently failed to meet expectations because the delivery, distribution, and drainage of water on farmers' fields are uneven, wasteful, poorly timed, and conducive to waterlogging and salinity.

We recommend that the United states indicate its willingness to respond to requests from developing countries and international organizations in two areas: (1) management systems for sustained crop production on tropical soils, and (2) water management for irrigation. The United States has strong capabilities in both areas. For many years, the U.S. Department of Agriculture (USDA) and other government agencies have worked on similar problems in this country, while AID and others have had extensive experience with these problems abroad.

With respect to management of tropical soils, the United States could offer to increase U.S. participation in joint research, education, and training activities that would develop and demonstrate appropriate management practices; strengthen the capabilities of the AID-supported consortia of universities which have in-depth expertise and worldwide contacts and cooperative activities in this field; support international initiatives to expand and strengthen the evolving informal international network working on problems in soil management; and assist, where requested, in building developing country capabilities in this field.

Similarly, in the area of farm-level water management, the United States could offer to expand bilateral financial and technical collaboration with developing countries; encourage ties between international financing for new irrigation projects and

progress in improving water management at the farm level; support stronger programs by the Food and Agriculture Organization of the U.N. (FAO) in this field; and encourage international collaboration among organizations working on research and technology transfer in this field. In this area, as in many others, judicious use of relatively small assistance funds for communication functions or common services could catalyze much larger programs financed out of the budgets of participating organizations to advance their own program interests.

### 3. Plant and Animal Protection

Fewer than 100 species of plants and animals provide more than 95 percent of the world's food supply. But their productivity, quality, and performance are threatened by more than 25,000 species of bacteria, fungi, viruses, nematodes, insects, rodents, birds, and weeds.

Intensive research in the United States and other countries has identified many of these pests and has led to the development of several types of control technologies, including: breeding of pest-resistant crop cultivars and livestock strains; biological control through parasites or disease organisms that prey on specific pests; safer, more efficient chemical pesticides and application methods; production and harvesting techniques that minimize pest damage; animal inoculations, vaccines, and pesticide dips; and prevention, through better sanitation and more nutritious animal feeds. Integrated pest management combines the most advantageous of these practices for a specific situation.

Possibly no other area of technical assistance has been as favorably received by farmers and herdsmen in developing countries as has protecting crops and livestock from harmful pests. However, excessive use of long-lived or inappropriate pesticides has sometimes resulted in injury to farm workers, evolution of insecticide-resistant pests, reduced yields, and contamination of nearby food crops and animals. Further, in some areas the ecological balance has been upset, so that previously minor insects have become primary pests.

New pest control practices and new chemicals, equipment, and application procedures are continually evolving from agricultural research centers and industrial laboratories. These research results need to be adapted to varying local conditions and used more effectively in practice. Thus <u>we recommend</u> that the United States offer to collaborate with interested

developing countries to train personnel and develop innovative programs for developing and promoting appropriate, location-specific pest management systems for both crops and livestock.

An important complement to this initiative is U.S. technical assistance related to the environmental effects of pesticide use which concern health, agricultural, and environmental officials in many regions. We recommend that the United States enlarge its assistance to departments of entomology in developing country universities, work with government officials on ways to minimize environmental problems associated with pesticide use, and help make available information on the efficacy and effects of alternative pesticides in terms that are easily understandable to governments, formulators, applicators, and farmers.

U.S. pesticide manufacturers should be encouraged to provide on-the-job training for local technical personnel and to supplement AID efforts in other regards. For example, exporters could be required to furnish importers with detailed, easily understood information on toxicology, safe methods for use, and appropriate warnings about the effects of misuse. Also, all development agencies should be encouraged to develop better means of predicting the environmental effects of their programs.

Finally, we recommend that the United States support more complete worldwide collections of (1) germ plasm, especially for crop varieties that have unique resistances to specific pests, and (2) organisms injurious to crops and livestock. U.S. computer capabilities could be used more widely in developing worldwide information banks and diagnostic services in these fields.

## 4. Overcoming Biological Limits to Plant Productivity

Over the long term, sustaining the increases in food production necessitated by a burgeoning world population will depend increasingly on making crop plants themselves more productive. Large, unexploited possibilities still exist for applying available breeding techniques and further identifying the genetic potentials of various crop plants. However, the rate of increase in crop yields by hybridization will decline over time unless some of the fundamental biological limits to plant productivity are overcome.

Accomplishments in identifying further genetic potentials have been quite limited to date. Indeed, evidence suggests that the highest yields of rice and wheat yet obtained may be close to the biological ceilings as perceived by present levels of knowledge.

But there are indications that basic research can substantially reduce some of the fundamental biological limits to plant productivity, which can then be translated into higher yielding varieties.[1]

Recent reports suggest that three interdependent basic research areas are particularly promising for crop plants: (1) increasing biological fixation of nitrogen, (2) increasing photosynthetic efficiency, and (3) developing more powerful tools for genetic manipulation. Since the major impacts of this research are likely to be realized only after 15 to 25 years of effort, this work needs to be sharply accelerated now in order to bring results to farmers' fields before production increases from other means level off. Aside from the long-term payoffs, important benefits are likely in the short and medium term. For example, work on new genetic tools has already produced techniques for screening plant varieties and storing germ plasm more efficiently, which could accelerate advances from conventional plant breeding.

Work to expand the science base for increased global crop production is a strong suit for the United States. Many research leaders in developing countries recognize this and hope for U.S. progress. Thus <u>we recommend</u> that the United States (1) indicate its intent to accelerate basic research in the three areas mentioned above; (2) note the major benefits this is likely to bring for all countries, especially developing ones; and (3) report that U.S. research and international collaboration in this area has already begun to intensify.

## Health and Related Needs

Although health is among the most basic of human needs, it is a need that is frequently unmet in developing countries, except for the small minority of people with access to modern hospitals and well-trained doctors. U.S. investments in improving the health of the poor majority and in the related fields of nutrition and population should thus have high priority.

As the initiatives proposed in this section suggest, more research is needed--for example, on ways to control infectious diseases common in the tropics and on biomedically oriented approaches to the development of new contraceptives. But perhaps the greatest gains can be made from research and development looking toward improving systems for delivering safe, clean water and providing primary care in health, nutrition, and family planning at reasonable costs.

## 5. Delivery of Primary Health Care

The provision of reasonably accessible and economical basic health, nutrition, and family planning services for the world's poor deserves very high priority.

We propose that the United States encourage expanded international support for efforts to demonstrate effective approaches to providing these services widely and at low cost. Such programs, to be carried out in cooperation with countries that make the domestic policy commitments deemed essential to success, would emphasize preventive services (including nutrition, family planning, and environmental sanitation), relatively simple technology, and extensive use of community health workers and other paraprofessionals, along with intensified training for physicians in delivery of primary health services. Many small-scale programs along these lines have worked well, but, with such notable exceptions as those in the People's Republic of China and Cuba, few have been effective on a large scale. Most of the trials have something to teach, but systematic attempts to learn from experience have been too infrequent.

We recommend, therefore, that the United States (1) offer to expand its cooperation in such demonstrations in selected developing countries; (2) establish an experimentally oriented small grant program, channeled through U.S. universities and nongovernmental organizations, to seek needed technological innovations and to promote education, training, and community health programs in developing countries; (3) enlarge its complementary bilateral support of improved health planning and management, including information and evaluation systems; and (4) support international research programs studying the relationships between actual diets and physical growth, mental development, fertility, and other key elements of human performance.

Although the United States has not yet been able to provide adequate health care for all its people, and although many doctors and health officials in developing countries follow the high-technology, hospital-centered, curative approach commonly found in this country, it appears that the United States can usefully contribute more to improved health delivery worldwide. This country has a wide range of the requisite technologies and management skills, and experience working in developing countries. It can also benefit from insights generated in other countries on how primary health care can be provided more effectively to whole populations.

## 6. Pure Water and Waste Treatment

A major hazard to the health and well-being of most people in developing countries is the horde of infectious agents in their environment, most of which reach them, directly or indirectly, via contaminated water or because not enough water is available for household and personal hygiene. More than half the world's population has no reliable and safe water supply; 70 to 80 percent has no sewage disposal. Furthermore, women and children spend hours hauling water from distant sources, using time that might otherwise be spent on more productive activities. An overall problem is the growing competition for scarce water resources among many essential uses.

Despite the availability of engineering capability in developing countries and substantial international interest, relatively little gain has been made in providing adequate supplies of safe water to village households or most metropolitan areas of developing countries. More effective systems are needed for assessing available water supplies, conserving their use, and influencing their distribution and methods of use. The selection of appropriate water system technologies by developing countries--systems that can be maintained and operated effectively with local resources--would stretch scarce capital, allowing more water systems to be constructed and successfully operated.

We recommend that the United States offer to expand its bilateral programs and cooperate in international programs to provide, at acceptable costs, adequate quantities and quality of water for human use in rural and urban areas. This could include: (1) expanded assistance in development of methodologies for identifying appropriate water and waste system technologies and adapting them to local situations, including technologies for industrial waste disposal; and (2) collaboration for improvement of available methodologies for water supply planning and management. The latter could include research on how different types of improvements in water and waste systems affect health and economic development.

Collaboration could also be offered in developing comprehensive, long-range plans for integrated water resource management, including: collecting data on water availability and quality; forecasting demand in different sectors; analyzing the adverse effects of existing uses of water resources; developing techniques for adjusting to variations in water supplies; and evaluating the comparative costs and benefits of using alternative or new technologies, including the techniques of recovery and recycling. In support of

these activities, the United States could encourage the exchange of information on programs, technologies, and personnel in the field of water resource planning and management, and assist with short-course or on-the-job training in this field.

## 7. Controlling Infectious Diseases of the Tropics

The impact of infectious diseases in developing countries is enormous. For example, up to 25 percent of African children under five years old die of measles or its complications, and many others are left partially blind or otherwise handicapped. Control of endemic malaria has halved infant mortality rates in some countries.

Infectious diseases fall into roughly three categories with respect to the knowledge and resources needed to deal with them. The first category includes diseases such as malaria and schistosomiasis, for which existing control methods have only limited effectiveness. Control of these diseases will require more extensive research at both the laboratory and field levels. In the second category are diseases such as measles and some nutritional deficiencies, where the chief problem is more effective delivery of control methods that have already been developed. Cholera, diarrhea, and typhoid, among others, are a third category of diseases which are exacerbated by malnutrition, large and poorly spaced families, and unsanitary living conditions. Here innovation in medical technology is less important than social change and progress in providing pure water. An important need is for more social science research on involving communities in new forms of health-related activities and developing more effective delivery systems for preventive health information.

To provide a focus for research on these problems, <u>we recommend</u> that the United States create a new, highly visible program to improve understanding, prevention, and treatment of the infectious diseases of the tropics. Such a program could be established either by creating a National Institute for Infectious Diseases of the Tropics, or by providing an appropriate mandate and funding for an intensified program at the National Institute of Allergy and Infectious Diseases, one of the National Institutes of Health (NIH) which already has many of the relevant research capabilities. In either case, the program would deal primarily with the needs of developing countries, although U.S. benefits would include protection of U.S. citizens working or traveling abroad, reduced need to deal with infectious infestations from abroad, and advances in

basic knowledge about immunity factors that play a role in such diseases as cancer.

This program might, for example, support research on long-term immunization against malaria and various parasitic diseases; heat-stable vaccines for diseases such as measles and malaria; simplification of the BCG vaccination procedure for tuberculosis; new products and packaging for oral rehydration, particularly for children with cholera and other severe diarrheas; and delivery mechanisms in areas without electricity for immunizations and medications that presently require refrigeration. Much of this work would be done most effectively in developing countries. Thus U.S. research support should achieve some balance between support of domestic institutions and their subsidiaries abroad and the development and strengthening of institutions in developing countries.

Alleviation of the priority diseases will probably require investment of a decade or more in research and clinical trials before advances can be applied on a wide scale. Therefore, a buildup of trained personnel is needed in the United States as well as in developing countries to form an expanded next generation of laboratory researchers, epidemiologists, and program planners and managers. Investment of fiscal, human, and organizational resources in biomedical research issues should not, however, detract from investment in basic health, nutrition, and family planning delivery systems in developing countries, which are of equal or higher priority.

## 8. Improved Contraceptives

Greater support for basic, biomedically oriented contraceptive research at U.S., international, and developing country institutions would benefit both developed and developing countries. Present methods, although much improved over past ones, are far from satisfactory; all have drawbacks due to inconvenience of use or delivery, medical complications, lack of adaptation to specific country situations, or lack of cultural or moral acceptability.

Improved contraceptive technology was given high priority in the World Population Plan of Action adopted unanimously by 135 nations at the U.N. World Population Conference in 1974. More recently, the reproductive sciences and contraceptive development were systematically reviewed by more than 160 experts from 26 nations. Their report called for a significant increase in research in this field (Greep et al. 1976). A variety of improved methods is needed, since the diversity of the world's culture and peoples, and the

changing needs of men and women during the course of their reproductive lives, guarantee that a single, ideal contraceptive method will never be found. Contraception for the male merits high research priority, along with expanded study of methods aimed at the female. Possibilities include biodegradeable systems for the delivery of injectable hormonal contraception, immunological approaches, and reversible sterilization procedures. Choice among research topics should consider both the effectiveness of such potential systems and their prospects for scientific discovery.

Promising technologies are already in the development stage and promising leads have come from past research, but additional expertise and funding are needed to exploit these possibilities. We recommend that the United States propose international support for a priority international program of biomedically oriented contraceptive research. Many of the basic studies could be conducted in this country, but adaptive work needs to be conducted in local settings in both the United States and developing countries, as does study of the sociocultural factors affecting the use of contraceptives. Support should also be provided for local manufacture, assembly, distribution, and marketing of new contraceptive devices as they are developed.

Although national fertility patterns are controlled by the complex interplay of a number of social and economic forces, better contraceptive procedures would certainly influence family size and spacing, ultimately having a major impact on the rate of world population growth.

## Urbanization and Industrialization

Exciting possibilities exist for applied research in the industrial, urban, transportation, and communication sectors. For example, a concerted international effort could be made to apply a systems approach to building or rebuilding urban communities, with special attention to the needs of the poorest inhabitants. Integrated adjustments in housing, transport, communications, industrial siting, and land use could improve living conditions and balance the relationship between urban and rural development.

Achieving these purposes in developing countries largely depends on the growth of both urban and rural industries. National capabilities for fitting industrial technologies to local conditions are key factors in establishing effective overall development patterns, as is a better understanding of the

industrialization process generally. It should be recognized that U.S. initiatives in the industrialization field are constrained by the fact that most U.S. industrial technology is in the private sector, which limits the extent of direct government influence on its transfer. Policies and institutional capabilities of both the United States and developing countries do, however, influence the incentives and opportunities for technology transfer and adaptation by the private sector.

## 9. Improving Urban Settlements

By the year 2000, about 40 percent of the developing world's population is likely to be living in urban places (variously defined). Improved technical skills in building and managing urban settlements could help avert the negative impacts of haphazard urbanization that affect both cities and rural areas.

Perhaps the greatest potential for building better cities lies in programs for integrated community-building, from self-help site-and-services projects to massive planned urban development. Many programs undertaken to date have been too costly, have ignored the poor, or have created communities that people find unsuited to their needs. Yet they demonstrate the feasibility of building whole communities through urban development corporations that attempt to lay out workable physical plans and employment opportunities consistent with economic and social goals.

We recommend that the United States propose an international undertaking through the new U.N. Habitat Center in Nairobi to help developing countries organize new metropolitan growth and redevelop existing slums and blighted areas. With adequate international support, programs already underway or being planned in several countries might provide important lessons for improving on the concepts and methods tried to date. We also propose that the United States allocate funds for a series of grants in developing countries for projects in smaller cities (which are potential counter-attractions to the metropolis) to demonstrate new applications of science and technology in solar energy, waste management, water recycling, desalination, innovative public transport, advances in telecommunications, and the like.

The United States might also offer to contribute to an international fund, perhaps managed by the World Bank, to provide loans for city-building activities, emphasizing integrated development of whole communities and covering a wide range of techniques. Control of urban land use is crucial. In market economies, where

land can be bought by urban development agencies at prices that do not already reflect development prospects, the substantial increases in value that are subsequently realized can be captured in the lease of properties to industry and commerce. In such cases, international loans could be secured by rising land values and city-building agencies could use part of the returns for financing community facilities.

The United States has had some disappointing experiences in its own community-building efforts and could learn as much as any country from the experiences of others. However, this country does have useful system design capabilities, technological components, and skills that could be of great help in cooperative undertakings with other countries. To meet immediate training needs and to strengthen its own resources for community-building, we recommend that the United States (1) encourage development of domestic institutions that can conduct research and provide courses relevant to developing countries, and (2) support long-term relationships between urban agencies in the United States and developing countries.

## 10. Planning Transportation Systems

Transport services absorb a substantial portion of the capital budgets of all countries. In developing economies, the proportion is often as high as 25 to 35 percent of total public investments. And, since each method of transport is likely to be built and operated independently of the others, bottlenecks, redundancies, and inefficiencies often result.

No U.S. agency is concerned, on an adequate scale, with transportation as a whole in relation to development. Some university centers are moving in that direction, however, and the U.S. Department of Transportation is positioning itself to exploit the relationships between transport and considerations of land use, energy, productivity, employment, and the quality of life.

We recommend that the United States offer broad support for a number of international activities that would improve transportation infrastructure in developing countries and at the same time produce insights into U.S. transport problems. A key to progress in this field could be the establishment of a research and development network, sponsored by the World Bank or other concerned international agency. Research centers within such a network would focus on improving systems for transport planning as well as on innovative, resource-conserving transport solutions for national needs. The possibilities of substituting

modern telecommunications for some transportation functions (transmittal of information, delivery of mail, etc.) also need to be investigated. Training and joint experimental work should be stressed in order to build the capabilities of developing countries for transport planning and design work.

Analysis and dissemination of information and worldwide experience should be an important component of this network. Particularly emphasis should be put on low-cost practices (e.g., auto user charges, staggered work hours, all-bus or bicycle lanes and streets, and relocation of rail and truck terminals) designed to bring about a workable balance between public transit and the automobile in the world's cities and between transportation supply and the traffic implications of urban land use.

If the United States is to address the problem of transportation and development more effectively, U.S. institutions such as the Department of Transportation's Transportation System Center (Cambridge, Mass.) will need to be strengthened and aided in developing reciprocal relations with other countries. AID might provide funds for university centers willing to study the relationship between transportation and development economics and to create curricula relevant to the training of students from developing countries.

## 11. Building Capabilities for Creating and Using Industrial Technology

In all nations, the ability to absorb, devise, and use technology has an especially important influence on the growth of industrial output. However, very little of the world's industrial research and development now occurs in developing countries. While there is no assurance of success, there is little doubt that their prospects for industrialization will be enhanced if developing nations evolve indigenous capabilities in research and development.

Over the past 30 years, many institutions have been established in developing nations for creating, adapting, and disseminating industrial technology, but few have been effective. The United States is relatively well supplied with people whose skills and experience could help strengthen these institutions.

We propose that the United States offer support for developing countries interested in strengthening their capabilities through three types of institutions: (1) industrial research organizations that help the private and public sectors identify, acquire, develop, and apply suitable technology; (2) centers that specialize in research and development, extension, and informal

training services (technology and management) for small industries, particularly in rural areas; and (3) "productivity centers" that provide industrial extension and training services without a rural bias. In this effort, there are important possibilities for using specialized U.S. institutions that could, with appropriate government support, provide temporary staff or advisers, sponsor research and development collaboration, organize conferences, collect and disseminate information, etc. The United States might also consider extending the U.S. International Executive Service Corps to include the broader "technology corps" concept that it advanced at the fourth session of the U.N. Conference on Trade and Development (UNCTAD IV).

In addition, we recommend that the United States offer (1) to assist in the development of engineering and management institutions in developing countries (mainly by strengthening existing institutions); and (2) to stimulate curriculum development, teaching, research, and technical assistance programs in U.S. engineering schools that develop programs oriented to the needs of developing countries. Since about 30,000 students from developing countries are enrolled in U.S. engineering schools, there is substantial scope for programs of the latter type.

## 12. International Research on the Industrialization Process

The determinants of industrial growth in a developing economy, including the role of technology as an input into industrialization, are not well understood. A limited amount of research in this area is now being performed at universities in the United States and elsewhere, in international agencies, in private research institutions, and at the governmental level. However, neither the volume nor the quality is commensurate with the need or the urgency of the questions that policymakers face.

Better understanding is needed on such questions as the likely trends affecting particular industrial sectors and their implications for patterns of technology choice, industrial location, and international divisions of labor; the benefit-costs and time-phasing of different industries and routes to industrialization; alternative policy instruments to guide industry in investment and adjustment decisions; and the socioeconomic, cultural, and equity impacts of alternative modes of industrialization. To seek these and other insights, we recommend a wide-ranging international program of industrial research, including

development of improved research methodologies, collection and dissemination of information, and training of analysts from developing countries.

If research in this sensitive field is to have high credibility for all users, it is important that it not be financed by any single national government. U.S. government support should therefore be merged with that of other nations, the private sector, and foundations. The following options, among others, appear to be available:

-- creation of an international foundation, with a multinational board and diverse international funding, to manage a program of grants and contracts to existing research institutions around the world;
-- creation of a private international research center, with financial support from governments and private sources, governed by a distinguished multinational board of directors and shielded as much as possible from political influences;
-- creation of a research center or expansion of existing research capabilities within an existing international institution such as the World Bank.

Successful activity in this field, whatever the mode of organization, could promote sound decisions affecting industrial development by policymakers in all nations.

## Management of Resources

Many of the initiatives concerning resource management relate to the frontiers of scientific and technical knowledge. They are designed to produce near-term benefits for developing countries in the exploitation of their energy and other natural resources, including forests and marine environments, and, at the same time, to help scientists from developing countries participate more directly in the emerging networks of basic scientific research of global import.

### 13. Development and Use of Energy

Unexploited energy resources exist in every country--nonrenewable fossil fuels such as petroleum, coal, natural gas, and peat; nuclear and geothermal resources; or renewable resources based directly or indirectly on the sun. Energy is of central importance to development, and developing countries have shown

virtually unanimous interest in the subject. Consequently, we recommend that the United States indicate its intent to lend major new support for public and private research and development activities related to energy problems in developing countries. Major expansion in this direction could be made with only a small portion of the funds the United States will be spending on its own energy research and development, and these activities are likely to produce benefits for the United States as well as for others.

Among the actions recommended in addition to advanced education and training are that the United States:

-- Encourage government-sponsored research and development in the United States to be more responsive to opportunities to work on problems of interest to developing countries, especially on technologies for using renewable energy sources.
-- Develop a program to enable sites in the United States and developing countries with similar climate or geologic conditions or common interests in certain technologies to engage in cooperative research and development of small-scale technologies based on renewable energy resources.
-- Support joint teams of specialists from the United States and developing countries in cooperative study of such energy-intensive activities as transportation, industrial processing, agriculture, and housing. The work should have two objectives: conservation through energy-efficient designs and replacement of costly imports with indigenous energy sources.
-- Establish a specialized advisory service to help strengthen developing countries' capabilities to plan for energy development and promote efficient use of energy. The service could draw from U.S. government, business, and university resources in a broad range of relevant disciplines.
-- Sponsor demonstration projects in developing countries jointly with local institutions to test the local viability of innovative technology designed to reduce energy requirements in agricultural and industrial production and in supply of public services.
-- Support a network of regional research and development institutions in developing countries to concentrate on the energy problems of their regions. To the extent possible, these should be existing institutions whose work could be broadened for this purpose. The United States could also sponsor a continuing series of regional seminars, workshops, and symposia for periodic exchange of

information and ideas. Such activities could be valuable learning experiences for U.S. as well as developing country personnel.

-- Create internships, in cooperation with private industry, so that individuals from developing countries can work directly in U.S. companies, especially those engaged in geophysical studies, exploratory drilling, and development of small gas and oil fields.
-- Strengthen personnel training programs in the energy field.
-- Invite developing countries with significant coal resources to collaborate with U.S. government laboratories on research and engineering on techniques for improving coal combustion and converting coal to liquids or gases suitable for use as fuels or chemical feedstocks.

Developing countries must continue to seek and exploit their own reserves of fossil fuels,[2] but the greatest long-term prospects for increased energy supplies lie in exploiting renewable resources. Especially important are decentralized technologies which may provide energy to rural areas without the need to develop far-flung electric power grids such as those on which the United States has come to depend. Much of this work in the United States is in the private sector. Some promising technologies have been developed and others are on the drawing boards based on solar energy used directly (e.g., heating, distillation, photovoltaic conversion) or indirectly (e.g., wind, biomass, hydropower).

Energy costs are high in most developing countries, and highest in their rural areas. Thus widespread use of solar energy is likely to become economically attractive sooner in those countries than in developed countries which are already committed to existing central generation and distribution of electricity. Expansion of markets in developing countries could in turn accelerate price reductions of technologies potentially applicable in the United States. U.S. consumers, as well as companies manufacturing solar-related products, would be direct beneficiaries of such a trend.

## 14. Remote Sensing and Other Applications of Satellite Technology

U.S. space-age technology is proving ever more useful for tasks associated with development here and abroad. For example, the remote sensing resource satellites--ERTS, and now LANDSAT--are already mapping

large parts of the globe and their products are readily available. Coupled with limited ground surveys, this technology can be used for locating and assessing natural resources, assessing weather and crop patterns, and mapping the topography of inaccessible areas.

Although the technology embodied in these systems is extremely complex, useful information can be extracted even with quite simple equipment and interpretation capabilities. The information generated can help developing countries avert costly mistakes, such as overuse or abuse of soil, water, and ground cover; misplacement of roads; and faulty irrigation planning. Indigenous natural resources may be discovered, and resettlement programs in frontier areas may be facilitated. We recommend that the United States offer greatly enhanced use of LANDSAT for these and other development purposes, building on the experimental programs in developing countries already undertaken by the National Aeronautics and Space Administration (NASA) and AID.

Communications satellites and broadcast satellites are also proving their worth. The former might be used to help establish links among research and development institutes and the latter to contribute to education and rural programming.

The marginal costs of U.S. cooperation in the use of satellite technology in developing countries would ordinarily be relatively small on both sides, since the costs of developing the requisite hardware and software have already been largely committed by the United States for its own purposes. Specifically, we recommend that the United States declare its intent (1) to continue the development of remote sensing technology and to support international collaboration in establishing and operating an efficient network of receiving stations and ancillary services; (2) to enlarge access to U.S. remote sensing imagery and related data; and (3) to expand training and research and development programs in developing countries, as requested, to build capabilities for gathering and interpreting satellite-generated data.

We also recommend further experimentation with educational and informational uses of broadcasting satellites in interested developing countries as well as feasibility studies for making greater use of communications satellites for international information exchange. Although some countries have expressed concern that satellites are potentially intrusive, the technology is available to minimize this problem, and we believe that the interest already shown by developing countries indicates that an offer of the kind suggested would be welcomed.

15. Sustained, Multiple Use of Forest Resources

The United States supports about half of the world's forest research, and it has considerable experience in the development of fast-growing species, optimization of seeding and harvesting patterns, utilization of secondary species, and extraction of chemical substrates. It is in the early stages of experimenting with "energy plantations." Remote sensing via satellites offers new opportunities for identifying forest resources, assessing the impact of development activities, and detecting the onset and early spread of forest diseases.

Some of this research has related to developed countries, and much more is known about temperate zone forestry than about the special problems of tropical forests. However, we believe that the United States could make a major contribution to international development by supporting a greatly enlarged research effort in sustained, multiple use of forest resources in developing countries. Central to this effort would be the establishment or designation of two or three first-class regional institutes in developing countries, patterned after the international agricultural research institutes and oriented toward different ecological zones. These institutes could support research in forest ecology, development and testing of improved varieties, reforestation, determination of sustainable yields, resistance to insects and disease, and innovative use of forest products. We also suggest that a strengthened array of research and experiment stations in the developing countries be integrally related to the regional institutes to keep the regional staff attuned to problems in the field and to help train the specialists that are sorely needed. In addition, we recommend that the United States support the newly created International Council for Research on Agroforestry, which is designed to fulfill such functions as information exchange, identification of research gaps, and encouragement of research funding.

This scientific thrust must be accompanied by improved forest planning and policy in developing countries. Forest exploitation is increasing rapidly in many of these countries in response to pressures for export earnings, building materials, fuel, and forage, as well as to make way for habitation and farming. Such exploitation seldom reflects optimal use either in the near term or over the lengthy time cycle needed for truly sustainable forest management. Unsound harvesting practices often degrade the productivity of the land, destroy wildlife habitats, and invite erosion which destroys adjacent farmland and aggravates

problems of sedimentation and flooding. Insects, disease, and fire continue to take a heavy toll. Developing countries have shown an interest in U.S. and FAO expertise on forest planning and policy, and the United States should be prepared to respond to requests for assistance.

## 16. Research on the Marine Environment

Partly as a result of agreements reached at the U.N. Conference on the Law of the Sea, coastal countries will acquire new rights to, and responsibilities toward, living resources and protection of the marine environment within 200 miles of their shores. But the effective exercise of these rights and responsibilities will require more scientific understanding, cooperation, and mutual sharing of information than is now available.

Not enough is known, for example, about the earth's estuarine and coastal resources, especially their management to ensure sustained, multiple use at high levels of productivity. Nor is the background information yet available to understand the rather complex array of water movements from within estuaries to the continental shelves and along the shelves where the ocean meets more shallow water. Such information should add considerably to our understanding of coastal fisheries, distribution of urban and industrial wastes, and the extent to which offshore mining and sewage disposal, marine transport operations, and recreational activities may affect and be affected by the use of biological marine resources in adjacent areas. Planners would then be better able to assess tradeoffs among potential uses of marine resources.

Recent large-scale international oceanographic programs--the International Decade of Ocean Exploration (IDOE) and the Global Atmospheric Research Program--have advanced the state of knowledge concerning coupling between the atmosphere and the oceans. Testable hypotheses and theories now exist, in particular on the connections between ocean and coastal shelf circulation in a number of regions and how these events may affect fluctuations in the productivity of major fisheries. Within the U.S. oceanographic community, there is considerable interest in studying these and related phenomena, but a mutually agreed basis for sharing of information is needed.

Marine research is necessarily international and cooperative, since scientists need access to the waters of other nations to obtain data and samples. Many developing countries are only now beginning to recognize the need for personnel trained in marine

science to provide accurate evaluation, both short and long term, of national resources. Even where trained personnel exist, marine research facilities are often inadequate, even for studies in coastal areas. It is, therefore, in the interest of both developing and developed countries to mount a systematic and adequately financed effort to assist in creating strong marine science institutions in coastal developing countries.

We recommend that the United States declare its readiness to support, through the U.S. Sea Grant Program, long-term training for developing country scientists, extension services to developing country institutions, and cooperative research on the marine environment, especially in estuarine and coastal areas. Such programs would be greatly strengthened by a U.S. offer to help finance, where requested, acquisition of modern facilities and provision of temporary personnel to help build up regional institutes of marine resources.

## General Initiatives

The need for improvement of several general capabilities in both the United States and developing countries becomes apparent when we compare the reports of our various panels. U.S. proposals at the 1979 Conference should speak to these general concerns.

### 17. Strengthening Scientific and Technological Policymaking

We give particularly high priority to assistance in strengthening assessment and planning capabilities. Countries need government planners and decision makers who know how to bring science and technology to bear on national policy and, conversely, how government policy affects national capabilities in science and technology. The impact of newly introduced technology is not uniformly positive. For example, centralized power and telecommunications systems may make countries excessively dependent on grids and relay stations that are expensive and difficult to maintain and incur unnecessary power losses in long-distance transmission. New agricultural practices brought by the Green Revolution, although impressively successful in raising food production, left some small farmers worse off than before because adjustments were not made in complementary agricultural policies. Such impacts on the complex patterns of development cannot be anticipated adequately by casual assessment processes.

Effective policymaking requires the combined talents of planners and natural and social scientists in an institutional setting that permits systematic analysis.

We suggest that the United States might usefully offer (1) to continue and, if demand warrants, expand short-term exchanges of senior scientists, engineers, and managers to discuss with colleagues in developing countries ways to strengthen mechanisms for bringing local scientific and technical expertise to bear on development policies; (2) to support training of U.S. experts who could consult with developing country planners on ways to institutionalize science and technology in national policymaking; and (3) to develop, in collaboration with developing country analysts, a program of research exploring ways to improve linkages among research and development institutes and between them and individual enterprises.

Another possibility might be to consider whether the United States could help universities or private sector institutions in developing countries to complement policy analysis by government agencies. Much constructive review of U.S. policy is done outside the government; organizations like The Brookings Institution, the American Enterprise Institute for Public Policy Research, Resources for the Future, Inc., and others offer useful counterweights to planning and analysis within the U.S. government. The United States might explore potential contributions to encouraging the development of such institutions in developing countries.

An important function of government policymaking and planning is to promote the health of the nation's scientific and technical capabilities. Large dividends can be expected from strengthening working relationships among organizations concerned with science and technology. Still larger returns are possible from linkages between these organizations and users of technology in the public and private sectors. National research and development laboratories in developing countries have often been ineffective in relating their activities directly to the nation's production needs. One reason for this is that many developing countries need skilled managers of science and technology even more than they need highly trained scientists and engineers.

Nevertheless, the long-term progress of technology development in developing countries depends on a gradual strengthening of science education and research in those countries, and the United States should make clear that it supports this goal. Strengthening the institutions in which scientists work would facilitiate channeling scientific resources in support of efforts to overcome specific local barriers to technological

advance. It would also make it possible for these scientists to contribute to the world stream of scientific knowledge without, as so often happens now, having to move to developed countries to find the facilities they need.

## 18. Information Sharing

Systems for effectively gathering, organizing, disseminating, and using data and information are basic tools for conducting research and managing modern economies. Despite evidence that developing countries want both to manage their own information resources more effectively and to achieve better access to the international "knowledge sector," relatively few resources have been devoted to such activities.

Later chapters in this report suggest that the United States help developing countries build specialized systems to provide data on energy supply, land-use planning, and many other subjects, and that it support specialized information centers or services for weather and crops, germ plasm collection, and water treatment, among others. The need to link international data and information with national development programs--through data banks, repository libraries, referral and extension services, clearinghouses, and use of appropriate forms of systems analysis--is cited repeatedly.

Information supply and management is becoming a more specialized field. We believe that the United States, with its strong public and private capabilities, can help developing countries in three ways: (1) by helping to strengthen national capabilities in information management, (2) by developing programs to train information specialists and "consumers," and (3) by promoting greater access to U.S. information resources. Considerable opportunity exists for the private sector to become involved in these programs. The important thing is to tie information services as directly as possible to specific user needs.

In arriving at a national information policy, developing countries are wise to give priority to strengthening information systems in subject areas of greatest importance to them. Nevertheless, certain general services are important to the efficient use of any information resources. These include national bibliographic control, document reproduction and delivery, translation facilities, information processing technologies, training of specialists, and programs to teach "consumers" how to use modern information services. It would be appropriate,

therefore, for the United States to offer to assist developing countries, through its technical assistance programs or through appropriate international or regional programs, in creating or strengthening general national information management capabilities.

In addition, the United States might support development of special training programs at some of the many U.S. institutions offering education in information management.[3] These programs should encompass training for users as well as specialists from developing countries. Users could be exposed to sources of information--including standards, patents, manufacturers' catalogues, technical reports and journals, and searchable data bases--and to techniques for locating and acquiring public and proprietary technologies.

U.S. public and private information resources range from comprehensive mission-oriented and discipline-based systems to very specialized services.[4] Collectively, they provide bibliographic information and abstracts of published literature; information about research in progress; numeric data and analysis; information on patents and products, including technology available for licensing; and document delivery services. Some resources are maintained by federal and state governments or nonprofit institutions; others are available commercially.

As a first step in making these systems and services more accessible to developing countries, the United States could support international or regional programs to improve document availability and delivery. Bibliographic references and alerting services are of limited use if the underlying documents cannot be obtained. The United States could also survey U.S.-based systems, services, and programs in key problem areas to be considered by the 1979 Conference. Such an overview, in combination with the United Nations' own continuing survey, would help clarify the gaps in present information systems and identify ways of filling them.

At last count, at least 100 specialized information systems, services, and programs were sponsored by U.N. regional commissions and specialized agencies.[5] International bodies often suggest creating new comprehensive systems along the lines of the International Atomic Energy Agency's International Nuclear Information Service (INIS) and the Agricultural Research Information Service (AGRIS), sponsored by FAO. Such comprehensive systems may or may not be justified on the basis of costs, user needs, and overlap with existing services.

An alternative approach is to provide U.S. support for strengthening information systems tied to

international research and development networks that themselves generate and use specialized data. These delimited information systems tend to have a certain built-in selectivity and quality control, relatively low costs, and strong user demand for their products. The United States could also support U.S.-based technical inquiry services in selected fields. Successful examples that use networks of volunteers, thus minimizing costs, already exist in the areas of nutrition, fertilizers, and small-scale technology.

## 19. Education in the United States

Developing country leaders have often said that the U.S. role in education and training has been this country's largest contribution to development. Hundreds of thousands of students from developing countries have studied in the United States, representing a resource of incalculable value to their home countries. In 1974-75, for example, at least 125,000 undergraduate and graduate students from developing countries were studying in U.S. universities, and their numbers are growing rapidly. The great majority of these students come to this country privately or on scholarships from their own governments.

We believe that U.S. institutions can do more to make the education of these students relevant to the needs of their nations, particularly in such fields as engineering, agriculture, and medicine. For example, scholarships, fellowships, and research grants can be used more effectively as incentives to draw students into shortage areas and away from fields that are popular or appropriate to U.S. needs but not necessarily of high priority in developing countries. An educational approach is needed that emphasizes flexible application of modern science to the great variety of forms in which development problems actually arise. This is not easily done, since research equipment and the interests of research preceptors are partly determined by current research styles in the Western world, which rely heavily on sophisticated methodology and elaborate facilities that may not be available when students return home. Such institutions as the Institute for International Education (IIE) or the newly formed Council for International Cooperation on Higher Education might become effective agents in this effort to reorient some aspects of higher education at American institutions.

The United States could support development of special courses or special units of general courses oriented to developing countries in order to encourage

foreign students to relate their training to problems and conditions in their own countries. A good number of universities, departments, or regions have concentrations of students from developing countries which would justify a special effort in this direction. As many as 25 percent of the graduate students in some American engineering schools come from foreign countries (NRC 1976). In 1974-75, 67 colleges and universities had more than 500 foreign students on their campuses, of whom 85 percent overall were from developing countries (IIE 1975). The foreign student population in cities like Boston, New York, Washington, Los Angeles, and many smaller centers could easily support courses offered jointly by several universities. Such courses are also good training grounds for American students interested in international development problems.

The United States could also provide incentive programs to encourage graduate students from developing countries to do their theses on problems of importance in their own countries. Ideally, more graduate research will take place in students' home countries. A number of U.S. institutions have begun to experiment with a variety of arrangements for sharing teaching, research, and accreditation responsibilities with national and international institutions in developing countries. U.S. government funding could play a catalytic role by helping to defray special costs resulting from the international character of such research activities.

## 20. Short-term, Nondegree Training

As valuable as U.S. formal education has been and is, we believe that it needs to be extensively supplemented by less orthodox types of educational activities.

Short training courses of a few weeks or a few months can be particularly effective both in teaching highly specialized techniques and in introducing planners and policymakers to the potentials of scientific and technical advances. Under U.S. bilateral aid programs, individual training grants have gone to over 180,000 persons for study in the United States and other countries. This aspect of development assistance should be broadened to include a heavier component of scientific and technical training, with as much of the training as possible done in developing countries. Professional associations and engineering societies could be used more to help organize appropriate training, workshops, and symposia and to maintain professional contact with U.S.-trained

scientists and engineers who have returned to their home countries.

At another level, training within developing countries in vocational subjects and technical support skills needs to be greatly expanded. Typically, developing countries are still short of people with crucial supporting skills such as equipment repair and maintenance, bookkeeping, welding, data processing, materials inventorying, paramedical techniques, and the like. The problem is not only to strengthen specific technical training but also to spread technical awareness more widely through the population. Younger generations in developing countries are increasingly literate, and aptitudes for scientific and technical work need to be encouraged in early education. The Peace Corps is a useful vehicle for supporting local efforts in this direction.

The United States has in the past provided personnel and funds for building technical training schools in developing countries and will continue to do so. In the future, greater use might be made of the capabilities of U.S. community colleges in this effort. Beyond the educational establishments, however, transnational corporations operating abroad are increasingly perceived as important sources for technical and managerial training. If U.S. experience is applicable, some of the individuals trained through such programs will eventually start new entrepreneurial enterprises, thus building long-range capability for business expansion in developing countries besides providing the skills and local service industries necessary to attract investment.

A great deal of both professional and technical training is already being done by private companies either in the United States or through their affiliates in developing countries. It is a measure of the decentralized, pluralistic character of U.S. society that there does not appear to be any comprehensive inventory of this training, though it is known to be large. We suggest that the United States, as part of its preparations for the 1979 Conference, attempt to survey development-related training presently carried on by U.S. private industry, with a view to considering its present potential and how it might appropriately be enlarged or improved. We believe that U.S. companies would generally be receptive to feasible proposals for strengthening their training activities.

## 21. Continuing University Interchange

Hundreds of our scientific and technical institutions maintain exchange relationships with developing countries which contribute to building functional capabilities in those countries and to maintaining professional skills and knowledge; many would like to strengthen these relationships if more support were available.

One device for supporting long-term university involvement in research collaboration and institution-building in developing countries is Title XII of the Foreign Assistance Act of 1977, presently restricted to the food and nutrition fields. This legislation has evoked very favorable response from U.S. universities, but implementation has been slow. We recommend that programming under Title XII be speeded up; in light of further experience, consideration might be given to extending it to other fields.

The United States also needs to develop mechanisms for continuing involvement with developing country institutions once the development aid period has passed. Scientists and technicians in developing countries seek continuing contact. As their institutions gain strength, they become increasingly viable partners for mutually beneficial research programs and long-term, self-sustaining institutional relationships. The lack of mechanisms to provide even marginal assistance at just this crucial point risks losing some of the greatest potential returns on the U.S. aid investment. We recommend that the United States support a modest program to enable U.S. universities and other research institutions to cover some of the special overhead costs of international collaboration in research and development and to continue to exchange scholars, subscribe to each other's journals, mount joint workshops, and the like, in order to cement continuing, productive relationships.

## 22. Incentives for Development-Related Research in the United States

The U.S. research and development community commands powerful capabilities that can support development if the policy environment is supportive. In the case of government-sponsored research, facilitative legislation may be needed. In the health field, for example, legislative restrictions sometimes limit the types of involvement federal agencies can have; it has been suggested that the charters of the Department of Health, Education, and Welfare (HEW) and,

particularly, the Public Health Service, be revised to include special authority to engage in health activities that have global dimensions. Section 1458 of the Food and Agriculture Act of 1977 is an example of the kind of action that is needed. This section explicitly authorizes the Department of Agriculture to "expand [its] coordination...with institutions and other persons throughout the world" by exchanging research materials and conducting joint research and extension. We believe that legislation of this sort is needed more widely at federal and state levels.

A further need is to increase incentives for work on development-related problems within the U.S. scientific and technical communities. Adjustments of topical priorities in government and university allocations of research, fellowship, and scholarship funds may be the most important line of action the United States could take in order to raise the status of research in development fields.

International prizes and honors for distinguished achievement in science and technology for development might also be incentives. Such awards, toward which the United States might offer to contribute, could be patterned after those given by the Magsaysay Foundation in the Philippines, where an international committee awards five $10,000 prizes to individuals resident in Asia who have performed outstanding service to their community.

## MODES OF INTERNATIONAL COLLABORATION

A question faced throughout this report is how best to reconcile several organizational objectives: strengthening capabilities in developing countries for finding and applying suitable technology; enabling them to make fuller use of worldwide scientific and technical capabilities; invigorating worldwide processes for solving major development problems and establishing the critical mass of technical resources needed to overcome these problems; keeping the costs of all this within feasible bounds; and attracting high quality technical participation from developed countries on a continuing basis. To meet these difficult requirements, our panels have sought modes of strengthening continuing, systematic collaboration among organizations in all countries that are addressing a common problem. Such collaborative systems are frequently referred to in the development literature and in this report as research or research and development or problem-solving "networks." Experience has shown that research networks can be effective under suitable circumstances, for example,

when they are focused on quite explicit problems, with minimal political and bureaucratic interference and strong demand for the product.

Ideally, collaboration on research and development, technology testing, policy analysis, or other problem-solving work can produce a net result greater than the sum of its individual parts. Participants can share specialized research equipment, skills, and findings. Experimental sites located in different environments speed results, and, when common research protocols and evaluation processes are used, offer possibilities for comparative evaluations. Costs can be cut by means of divisions of labor, pooling data, and sharing such services as the collection of information, specialized training, and storage of research materials, including software designs. Participants from developing countries can gain training, advice, and access to worldwide scientific and technical capabilities beyond anything they could mobilize on their own, even with large-scale assistance.

These advantages must be balanced, however, against the possible disadvantages of maintaining a central organization for the collaborative system. Costs include increased overhead expenditures, use of scarce professional time to oversee coordinated activities, and some loss of individual flexibility by the collaborators. Where the central organization conducts part of the problem-solving work, there may well be added costs and difficulties in interacting effectively over great distances with those who would use the results.

Scientists have long pursued opportunities for ad hoc collaboration or exchanges of information with foreign colleagues on problems of common interest. International work on development problems over the past decade or so, particularly in agriculture but also in other fields, has brought out the practical values mentioned earlier of more systematic, continuing collaboration in a format of voluntary participation and mutual determination of common activities among all participants. There are many possible variations in organization, ranging from programming committees to quite elaborate administrative structures. Each has advantages and disadvantages in specific circumstances. Regional intergovernmental institutions, for example, enable developing countries to pool their efforts on a scale large enough to work effectively on tough problems, but many such institutions have been unable to sustain adequate financing, linkages with national operating organizations, and freedom from intergovernmental politics. The private autonomous international research institutes, which are nerve centers for worldwide networks that collaborate on

improving major crops and farming systems, are expensive and difficult to replicate, but when proper circumstances exist, including assured financial support, they have been highly successful.[6] Programming committees that represent research organizations and/or the organizations that finance them are the simplest type of institutional collaboration. Although such committees may get a modest budget for staff or "start-up" activities, the participating organizations do most of the work and may even provide limited common services. These kinds of international networks, operating independently of the U.N. system but maintaining cooperative linkages with it, can be a useful complement to the U.N. agency programs.

This report recommends many new initiatives to increase international research and development, often with preliminary judgments as to the appropriate type of organization. If increased collaboration in a particular field is accepted as a priority initiative, however, further exploration will be needed of specific institutional mechanisms that seem to fit the situation best.

## CONCLUSION

The United States appears to have an important new opportunity to work with other nations in applying science and technology to development problems, to the benefit of all participants. This new opportunity arises from the juxtaposition of several factors:

-- The U.S. research and development community, which commands powerful scientific and technological capabilities relevant to development, is showing greater interest in international collaboration.
-- The United States is reexamining its development assistance programs, opening new prospects for using science and technology more effectively.
-- Properly managed, international collaboration and exchange can enhance U.S. efforts to sustain the internal dynamism and innovative drive of its economy, even in the face of serious U.S. employment problems, growing resource scarcities, and environmental deterioration.
-- To meet their requirements for technology, developing countries appear to be seeking a two-part strategy of (1) building their own capabilities for research and development, and (2) expanding collaboration among themselves and with the developed countries.

We believe that U.S. initiatives of the types described throughout this report can help to realize this opportunity and that the U.S. research and development community stands ready to respond.

## NOTES

1. Several recent studies of agricultural research priorities have emphasized this prospect and need. See, in particular, three studies by the National Research Council (1975b, 1976, 1977), Brown et al. (1975), and a report by the Office of Technology Assessment (1976).

   Eventually, progress in this area could lead to increased food production, reduced need for huge expenditures to supply chemical and other capital inputs for agriculture, and reduced pressure on scarce petroleum, natural gas, and other petrochemical supplies; lower food production costs, permitting both higher farm profits and lower consumer prices in the United States and developing countries; and reduced environmental contamination.

2. Although we focus on renewable sources and coal in this report, this is not to imply that other fossil fuels should be ignored. On the contrary, these resources, especially gas and oil, must be exploited to the fullest since they are usually the least expensive. They are not addressed in the initiatives here, however, since commercial channels for acquiring relevant technology are reasonably clear and established. For similar reasons, nuclear energy has not been considered here.

3. Academic programs and specialized training courses are listed in publications by the American Society for Information Science (1972) and the American Library Association (1977), and in the Directory of Continuing Educational Opportunities (in the United States) for Library, Information and Media Personnel - 1978 (Continuing Library Education Network and Exchange, Washington, D.C., in press).

4. Such systems and services are listed in publications by the National Science Foundation (1977), American Society for Information Science (1976), and Information Industry Association (1978).

5. These are listed in The Directory of United Nations Information Systems and Services (United Nations 1977).

6. Several international agricultural research institutes have been relatively successful in structuring quite elaborate forms of international collaboration. They take leadership in organizing and providing logistical support for collaborative research projects and other programs involving dozens of nationally-based institutions; they sponsor workshops and symposia on common problems and provide training; and they provide management services for research information and materials. The Consultative Group on International Agricultural Research, established to finance and help coordinate the work of these institutes, now directs the use of almost $90 million annually by 11 organizations; funds are contributed by the United States (20 to 25 percent) and 28 other governments, international agencies, and private foundations.

   See Appendix C of the World Food and Nutrition Study (NRC 1977) for a detailed description of the international rice research network and of the role of the international research centers in this network.

## CITATIONS

American Library Association (1977) Graduate Library School Programs Accredited by the American Library Association. Chicago: ALA.

American Society for Information Science (1972) Directory of Educational Programs in Information Science in the U.S. and Canada. Washington, D.C.: ASIS.

American Society for Information Science (1976) Computer-Readable Bibliographic Data Bases: A Directory and Data Sourcebook. Washington, D.C.: ASIS.

Brown, A.W.A., et al. (1975) Crop Productivity--Research Imperatives. East Lansing: Michigan-Kettering.

Greep, R.O., et al. (1976) Reproduction and Human Welfare: A Challenge to Research. Cambridge: Massachusetts Institute of Technology Press.

Information Industry Association (1978) Information Sources: IIA. 1978 Membership Directory. Bethesda, Md.: IIA.

Institute of International Education (1975) Open Doors, 1973/74. New York: IIE.

National Research Council (1975a) Agricultural Production Efficiency. Washington, D.C.: National Academy of Sciences.

National Research Council (1975b) Enhancement of Food Production for the United States. Washington, D.C.: National Academy of Sciences.

National Research Council (1976) The Role of U.S. Engineering Schools in Development Assistance. Washington, D.C.: National Academy of Sciences/National Academy of Engineering.

National Research Council (1977) World Food and Nutrition Study: The Potential Contributions of Research. Washington, D.C.: National Academy of Sciences.

National Science Foundation (1977) Federal Scientific and Technical Communication Activities--1976. Washington, D.C.: U.S. Government Printing Office.

Office of Technology Assessment, U.S. Congress (1976) Assessment of Alternatives for Supporting High Priority Basic Research to Enhance Food Production. Washington, D.C.: U.S. Government Printing Office.

United Nations (1977) The Directory of United Nations Information Systems and Services. Inter-Organization Board for Information Systems and Related Activities. Geneva: U.N.

# Chapter 2

# INDUSTRIALIZATION

## INTRODUCTION

### The Role of Technology

Since the early 1970s, leaders of developing nations have been emphasizing the key role played by technology in industrial development and in related programs for generating employment and expanding trade. Previously, they had put greater stress on increasing stocks of capital and physical infrastructure. This new emphasis on technology has substantial basis. Technology--definable as the application of useful knowledge to felt needs--is an important determinant of economic growth in all major industrialized nations.

Growing interest in technology for industrialization coincides with the firmly held belief among many policymakers in developing nations that industrialization is a precondition of national economic well-being, adequate employment, and national autonomy. While it is possible to question the validity of such a generalization on analytical grounds (for example, in a developing country with strong comparative advantage in world markets for mineral or agricultural products), the belief itself is sufficiently rooted in the economic history of the presently industrialized countries as to stand beyond challenge. Hence the logic that technology will foster industrialization, increase employment, and stimulate trade, thus leading to improved economic well-being, has become a dominant theme.

Coincident with this opinion is a strong dissatisfaction in many developing countries with the small proportion of total industrial production that takes place in the Third World. Although the industrial sector has grown rapidly over the past two decades in a significant number of developing nations,

these nations as a whole accounted for only about 8 percent of the world's output of manufactured goods in 1976, according to World Bank estimates. And yet, developing nations constitute over half the world's population.

The stated goal of the Group of 77,[1] as expressed in the Declaration of Lima of UNIDO II (U.N. Industrial Development Organization) and reiterated at UNCTAD IV, is to increase this share to at least 25 percent by the year 2000. Even if this difficult goal is reached, industrial output per capita for the Group of 77 as a whole would still be less than half of the per capita output of the industrialized nations. While developing country spokesmen recognize that there are many reasons for this state of affairs, they are virtually unanimous in believing that a greater ability to acquire, devise, and utilize modern technology in industry is crucial to changing the balance. Thus U.S. initiatives that are harmonious with this perception will have strong appeal.

## Mutuality of Interest

U.S. initiatives must, however, meet other tests. The most critical is to ensure that both the United States and developing countries have a real mutuality of interest in the effects of an initiative. Initiatives that will lead to increased manufacturing capacity abroad raise sensitive questions about the U.S. interest.

In the broadest sense, the United States has usually maintained that its own long-range interests are best served by foreign assistance policies that strengthen the economies of all friendly nations. By means of the Marshall Plan, the postwar reconstruction in Germany and Japan, President Truman's Point IV program, and successor foreign aid programs, the United States has sought to foster economic and social development abroad. As the world becomes more interdependent, the wisdom of these policies becomes more apparent.

With respect to developing countries, a generally accepted proposition is that, quite apart from considerations of basic equity and philanthropy, improved economic welfare will increase the probability that these nations will recognize that their interests are largely parallel to those of the United States. Alternatively, it is perceived that, if the developing nations were to remain hopelessly impoverished while the developed nations continued to prosper, resentments would build, and the economic, security, and other results would be inimical to the interests of all.

While these propositions are impossible to verify empirically, they are widely held and provide a basis in self-interest for U.S. foreign assistance in general as well as specifically with respect to industrialization. A special basis in self-interest is provided by the fact that the developing countries, containing two-thirds of the world's population, represent an enormous potential market for U.S. exports as well as a critical source of raw materials and other imports of benefit to the United States.

## Concerns of U.S. Labor

A more difficult question of mutual interest is posed when the very success of technology transfer from the United States leads to increased competition, both at home and abroad, with the products of U.S. industry. The history of first, Japanese, and more recently Taiwanese, Korean, and some Latin American transitions from nascent to competitive industrial production in some sectors dramatizes the issue.

The U.S. labor movement, once a leading supporter of free trade and generous in its advocacy of technology transfer, today expresses the view that American jobs can be threatened when certain types of industrial technology are transferred overseas. Therefore, labor is pressing both industry and government to take actions that will prevent a loss of U.S. industrial employment. Whether or not this concern is well founded is a matter on which most economists and labor leaders have real differences of opinion. Nevertheless, the perception that American jobs can be threatened as a result of technology transfers raises issues for which no satisfactory resolutions are at hand.

The predominant U.S. policy to date has been to rely on the validity of the economic theory of comparative advantage and, in foreign assistance as in trade policy, to opt for measures that seek the greatest mutual gains from economic interdependence. Thus U.S. policy has generally recognized that trade is a two-way street: that a large country such as the United States cannot increase restraints on imports without eventually inducing counter restraints on its exports and triggering a decline in the rate of world economic growth (as well as hurting U.S. consumers). In this context, it is significant that U.S. exports to developing countries grew rapidly between 1965 and 1975, and that the United States has been selling those countries more manufactured goods than it has been purchasing (Table 1). As incomes in those nations continue to rise, the United States can expect to

increase exports of manufactured goods, and it can also expect to buy more such goods from them.

Against this background, mutuality of interest in stimulating industrial activity in developing countries should probably be seen as subject to limits similar to those continually being worked out and applied in international trade. Countries and industries offering little present or near-term competitive challenges to U.S. exports can rationally be treated generously in the provision of technical assistance for industrial development. But as a country or industrial sector develops the capability to become fully competitive with U.S. industry, internal pressures are likely to mount and call for less liberal, more selective policies with respect to some types of foreign assistance. Under no conditions, however, should concern for growing competition, however genuine, be allowed to spawn self-imposed restrictions, such as export controls, on the existing system of free international exchange of technological information and know-how, whether through licensing, joint ventures, consulting, product sales, or other channels. As in our relations with fully competitive member countries of the Organization for Economic Cooperation and Development (OECD), the United States stands to gain in the long run by maintaining and expanding (subject only

Table 1. U.S. manufactured goods exports to and imports from developing nations excluding food production, 1972 and 1976 ($ billions)

| Year | U.S. exports to developing nations | U.S. imports from developing nations | Net U.S. exports to developing nations |
|---|---|---|---|
| 1972 | 9.57 | 6.18 | 3.39 |
| 1976 | 28.42 | 14.96 | 13.46 |
| Oil-exporting developing nations | 9.95 | 0.14 | 9.81 |
| Non-oil-exporting developing nations | 18.47 | 14.82 | 3.65 |

Adapted from a table that appeared in "Industries in trouble," The Economist, December 31, 1977, p. 76.

to requirements of national security) the technological interdependence of nations.

## Concerns of U.S. Business Management

Many U.S. industrial managers support a relatively open policy in technology transfer as in foreign trade, probably on the ground that opportunities for exports and for earning income from manufacturing abroad through subsidiaries, joint ventures, or licensing of know-how offset the competitive threat. Indeed, some U.S. companies can only remain competitive at home and abroad by conducting certain activities abroad to keep costs down.

On one basic issue of technology transfer, U.S. business management seems united. It emphasizes that legally established private rights to intellectual property should be respected, and that the U.S. government should seek increased understanding and recognition that this concept has value for all nations. A 1976 report by a task force of the Chamber of Commerce of the United States, "Technology Transfer and the Developing Countries," is illustrative of the U.S. business position:

> Positions currently being put forward by the Group of 77 will impede, rather than encourage, the transfer of technology by raising serious questions of legality, ethics and equity to the extent that we call upon all responsible governments to revise these positions in accordance with the following criteria:
>
> 1) The ownership of technology, whether acquired for value or developed under costly and uncertain conditions, constitutes a property interest. When shared, it is entitled to recognition and protection along with any other property interest.
>
> 2) The sharing of technology normally takes place through voluntary contractual agreements between owners and prospective users.
>
> 3) Agreements to share technology should take place within a framework of due recognition and protection by countries where the technology is to

be used of the rights of owners of technology. These should include the right to adequate payment and the right to protection against unauthorized use.

4) The price and value of technology, as with any form of property, should be determined by its usefulness in the market and not by predetermined concepts of cost or incremental value to the supplier.

5) Suppliers will normally accept responsibility for the effective use of technology only to the extent they are able to participate directly in the use of that technology in the receiving environment.

6) The development of an international and jointly respected vehicle for arbitration of contract agreements might be an important aspect of a more stable and fruitful technology transfer environment.

The U.S. position at the Conference should recognize the importance of these views. It should also recognize that access on commercial terms to proprietary technology available in the U.S. private sector (through foreign subsidiaries of U.S. firms, joint ventures, licensing, consulting, or other means) is of critical significance for industrialization in developing countries.

## Concerns of the Developing Countries

On the other side of the test of mutual interest lies the desire of the developing countries--some of them would call it their right--to have access to industrial technology on more favorable terms than in the past. Such access is seen as a necessary step toward breaking what has been termed the "dependency relationship" between the developing and the developed nations. This dependence, developing countries assert, results in an inability to make key decisions affecting their own destinies because these destinies are so overwhelmingly affected by decisions made in industrialized nations. Developing nations see better

access to technology and increased industrialization a means of reducing dependency and thus improving their economic and political status. While the validity of this sentiment is frequently debated, it is a premise upon which many developing countries are acting.

In such a debate it is worth remembering that, despite the commonality of certain positions, the Group of 77 is made up of heterogeneous nations, each having its own unique problems and opportunities. Even the rapidly industrializing nations in the group are not particularly homogeneous, ranging from small Asian nations such as South Korea, Taiwan, and Singapore to large, resource-rich nations such as Mexico, Brazil, India, Algeria, Iran, and Venezuela. The policies and positions of these nations on industrialization have been and will be different, reflecting different national problems and priorities. Those who formulate U.S. policies need to be cognizant of these differences.

## The Question of "Appropriate Technology"

The 1979 Conference is certain to address the question of whether sound industrialization in the developing countries requires the availability of special technology. This question arises because economic conditions in developing nations differ in a number of respects from those of the industrialized nations. Typically, developing nations have rather large ratios of unskilled to skilled labor relative to those of developed nations. Likewise, the mix of skills within the skilled labor force of developing nations often differs, some developing nations typically having larger proportions of general skill craftsmen and relatively fewer persons with highly specialized technical skills. Most developing nations also have a low rate of capital formation, so that they are characteristically capital-poor when compared with industrialized nations. Thus unit labor costs in these nations are generally lower than those in the industrialized nations, both in absolute terms and relative to capital costs.

These conditions have led many to espouse the need to develop and use labor-intensive and/or capital-saving technologies in developing countries. Such technologies are sometimes referred to as "appropriate" technologies,[2] but this usage can be misleading.

"Appropriate technology," as used in this chapter, means technology that is optimal for a particular situation in a particular developing nation, given that nation's economic and social conditions and goals. For example, if a nation's overriding goal is to maximize

national income, the technologies used should be those that are most efficient, given relative factor costs within the nation. If, on the other hand, national goals stress creating jobs over maximizing national income, more labor-intensive technologies might be chosen. Indeed, for many nations this would imply technologies that are capital saving and/or labor-intensive compared to corresponding technologies used by industrialized nations. It would also imply technologies that are relatively easily learned by workers with no prior industrial training or experience, and technologies to produce goods that are less specialized, simpler to use, and more versatile than similar products made in the industrialized nations. The manufacturing processes implied by these "appropriate technologies" do not necessarily have to be small in scale; hence "appropriate technology," as used here, should not be considered synonymous with cottage industries or with the E. F. Schumacher concept, "small is beautiful."

It is not at all clear that highly labor-intensive technologies are appropriate for all industrial sectors even in developing countries. For example, it is hard to imagine a simplified, labor-intensive process to manufacture petrochemicals. In the textile industry, where numerous variations on basic spinning and weaving technology exist, it has been shown that the most efficient technology for even the least developed nations is one that is capital-intensive relative to many known techniques, but labor-intensive relative to the spinning and weaving techniques that would be optimally employed in a highly industrialized nation. Moreover, in some basic industries capital-intensive investments may be the most effective way to promote more rapid growth of small and medium-sized industry and establish the conditions for maximum overall employment in the economy.

There is a tendency to blame unemployment on the use of "inappropriate" technologies, in the sense that they use too little labor and too much capital for any particular level of output. The argument is that technologies are available or could be found that would employ more labor and produce the same levels of output at the same or lower cost. Undoubtedly, there are examples of mistaken choices of technology in developing (and developed) countries. However, technology assessment is a very inexact art, and circumstances change. Prior analysis would probably not prevent some mistaken choices, even if development goals and the criteria for selecting technologies are clearly established. In any case, there is little, if any, evidence indicating that the employment problems

of the developing countries are primarily due to mistakes in the choice of technology.

Nevertheless, there are examples that indicate that a greater sensitivity is needed to the effects of technological choices. Even when the technological change substantially increases output, it may have negative effects on employment and other aspects of the economic and social structure (for example, when tractors are introduced into grain production systems in areas with a surplus supply of labor).

It should also be recognized that the choice of technology in developing countries can be affected by policies adopted to protect labor or to provide incentives for investment. Minimum wage laws, social insurance programs, and unions all have important justifications, but their impact can increase the effective cost of labor and thus create incentives to substitute capital for labor. Investment incentives that lower the price of capital have a similar effect.

How to develop technologies that are "appropriate" to the goals of developing nations is the subject of wide controversy. It is unlikely that enterprises in developed nations will voluntarily invest substantial resources in the creation of new technologies designed primarily for use in small foreign markets. For this reason, new technologies suited to developing nations are most likely to be created by local business firms which would then have a stake in the outcome. Thus most of the initiatives presented in this chapter, which are primarily designed to enhance the capabilities of developing nations to create and use their own technologies, would also serve indirectly to stimulate the creation of "appropriate technology."

However, local firms in developing nations, both publicly and privately owned, must have incentives to develop the capabilities to create their own technologies. For numerous reasons, present incentives are inadequate. Investment in new technology is risky, and the magnitude of investment required to meet a specified goal is uncertain. Often the domestic market is too small for a firm to obtain a return that would justify substantial investments in the creation of new technologies. Both of these problems could be reduced if effective regional markets are created among developing nations. However, only the developing nations themselves can create the incentives necessary to induce local enterprises to invest in new (and "appropriate") technology.

## OPPORTUNITIES AND PROPOSED INITIATIVES

Taking into account the interests and issues just outlined, this panel has identified two areas of opportunity for possible U.S. initiatives:

1. Building capabilities for creating and using industrial technology
2. Improving access to technologies of industrialized countries

These areas and the initiatives related to them are summarized in Table 2.

### Building Capabilities for Creating and Using Industrial Technology

The initiatives presented here are aimed primarily at strengthening the capability of developing nations to generate and apply their own industrial technology as a way of reducing dependence on imported technology and tailoring technology more fully to local conditions. While many developing nations are actively pursuing programs toward this end, typically through research and development, there is no question that the greatest proportion of investment in industrial research and development still takes place in the developed countries. According to U.N. estimates, no more than about 5 percent of industrial research and development occurs in developing nations. The fact that so much is concentrated in the developed world leads to the possibility that much new technology is not economically or technologically well suited for use in developing nations.

Any serious proposal to strengthen industrial research and development in the developing nations must consider a caveat. The modern world economy is highly interdependent, especially in the domain of industrial technology, and no one nation is self-sufficient in the creation and use of technology. Indeed, developing nations do not seek self-sufficiency. Rather, they seek the ability to perform a more significant amount of industrial research and development, so that they can create technologies uniquely suited to their own environments and become better able to adopt and adapt technologies from external sources.

Two basic requirements must be met if a nation is to create industrial technology that will foster the growth of the industrial sector: (1) a supply of trained practitioners of industrial technology, including scientists, engineers, managers, technicians, and a skilled labor force; and (2) a demand for their

Table 2. Areas of opportunity and proposed initiatives

| Area of opportunity | Initiative |
|---|---|
| Building capabilities for creating and using industrial technology | 1. Expand U.S. assistance for creating and developing engineering and management training institutions in developing nations |
| | 2. Stimulate curriculum development, teaching, research, and technical assistance programs in U.S. engineering schools oriented to developing nation students |
| | 3. Revitalize productivity centers in developing nations |
| | 4. Support establishment of centers for small industry and rural development in developing countries |
| | 5. Expand assistance to improve capabilities of developing countries to conduct industrial research |
| | 6. Promote interchanges of personnel and programs among industrial research institutes in developing nations |
| | 7. Develop a "technology corps" |
| | 8. Support continuing research into the process of industrialization |
| Improving access to the technologies of industrialized countries | 9. Create expertise on the search for and selection of technology |
| | 10. Provide training in the art of negotiation on technology imports |

services. For such a demand to exist, institutions must exist to use the talents of such individuals profitably, and there must be a flow of resources into those institutions. In private market economies, these institutions are largely business firms, and the marketplace provides a flow of resources to those performing a desired function in the society. In socialist economies, these institutions are often state-owned enterprises, and the flow of resources comes from a central allocation process.

In developing countries, the necessary demand is sometimes weak, and, even when latent demand exists, the relationship between industrial research institutions and potential users is not well developed. The contribution of technological advances to economic growth is measurably large. Yet, even in advanced industrialized countries, some corporations do little or no in-house research and development, while others perform a great deal. Indeed, entire industrial sectors can be characterized by low or high rates of investment in research and development. While a correlation is observable between high rates of growth within an industrial sector and high rates of research and development performed by firms operating within that sector, the direction of causality is not entirely clear. All countries, developed and developing, need to learn more about relationships between the extent, form, and manner of technology development and the character of socioeconomic progress. Initiative 8 addresses this need.

Most of the initiatives presented here address the supply side of the requirements outlined above. These initiatives cannot by themselves fully create the capability that developing nations need for providing suitable industrial technology. This depends heavily on the extent to which overall economic policy and institutional development foster industrialization and a demand for better technology. Yet each of these initiatives could help developing nations move a step or two closer to having the needed industrial technology capabilities.

### Initiative 1. Expand U.S. Assistance for Creating and Developing Engineering and Management Training Institutions in Developing Nations

Despite a number of successes, a need still exists in developing countries for additional engineering and management training schools and for upgrading the quality of existing institutions.

Both the U.S. government and private U.S. foundations have played significant roles in this field in the past. Successful efforts include the Asian Institute of Technology at Bangkok, Thailand; the Indian Institute of Technology at Kanpur, India; the Central American Institute for Business Administration in Managua, Nicaragua; the Asian Institute of Management in the Philippines; and others. All of these institutions were originally staffed with both American and national personnel, with the former now largely phased out.

The magnitude and scope of U.S. assistance for the development of educational institutions in developing nations reached a peak during the 1960s and tapered off steadily during the 1970s. In this initiative, we recommend following up on earlier efforts. The bulk of the renewed effort would be directed to working with foreign counterparts to further the development of existing institutions through exchanges of faculty, joint research programs, visiting appointments of U.S. faculty, and other forms of medium to long-term cooperation. However, where the need for new institutions can be clearly identified, new institutions could be created.

Many of the smaller and poorer developing nations do not have viable engineering or management education institutions or a realistic possibility of supporting them in the future. For all practical purposes, therefore, this initiative would apply primarily to nations capable of supporting such institutions--i.e., those with a developed or prospective industrial base or with important present or prospective raw material or agricultural exports. Nonetheless, other countries in a region could expect to benefit from the opportunity to send students and research personnel to the strengthened institutions.

### Initiative 2. Stimulate Curriculum Development, Teaching, Research, and Technical Assistance Programs in U.S. Engineering Schools Oriented to Developing Nation Students

One of the greatest resources for meeting the needs of developing countries for a stronger domestic technological capability lies in the U.S. engineering educational system. Yet from the developing country point of view, this system is frequently not utilized as effectively as it might be. Over 31,000 engineering students from developing nations studied in U.S. engineering colleges and universities in 1974 (IIE 1975), but U.S. engineering schools do not generally offer curricula well oriented to the special skills

needed for conditions found in developing countries. Rather, most students from these nations learn techniques best suited for the industrial environment of the United States and their interest in their own countries' problems is not quickened. Partly for these reasons, engineering graduates often seek employment in the United States or in other industrialized nations, adding to the "brain drain" from developing countries. Moreover, those who do return may find themselves poorly equipped to help solve national problems.

U.S. engineering schools do not in general offer curricula specifically oriented to developing nations for a number of reasons. Although the absolute number of developing nation students in U.S. engineering schools is large, the proportion of students interested in such coursework at any one campus is usually small. Naturally, constrained by resources, engineering schools seek curricula that best meet the educational requirements of the majority of students, who are U.S. citizens. Moreover, resources to support curriculum development and finance student research often come from high priority federal programs such as those of NASA and the Department of Energy. Even if an engineering school sets out to create a "developing country curriculum," it may not have the knowledge base. Most engineers, including those who teach, are relatively uninformed about conditions characteristic of developing nations.

Notwithstanding these constraints, a few U.S. engineering schools have developed courses and research programs oriented toward developing nations, and more of this work should be encouraged. A summary of present and future opportunities is presented in Table 3. Such programs might be undertaken unilaterally or in conjunction with other engineering schools, particularly schools located in developing nations. Discussions of "appropriate technology" in such courses might help sensitize future practitioners to these issues.

Desirable research activities would include projects for modifying existing technologies or developing new technologies better suited to conditions found in developing nations and projects for solving specific problems brought to the engineering school by developing nation governments or firms. This kind of research, if successful, might eventually be sponsored financially by developing country governments or firms, particularly "post-AID" nations or those already having viable industrial sectors.

Sponsored research could bring teams of engineering school faculty into developing countries to perform research and to act in advisory roles. Such research, although primarily conducted to solve real and

immediate problems, would familiarize researchers with the problems of developing countries. The spin-off benefits to the United States from this research could become significant as greater attention is given in this country to energy conservation, resource recycling, and the like.

The establishment of such curricula and related research programs would require a modest shifting of the resources available to U.S. engineering schools and creating a cadre of engineering faculty having the relevant interests, training, and experience. In both instances, initiatives by the U.S. government could be catalytic. Existing and past programs undertaken by national and international agencies to stimulate the training of engineers in developing countries provide useful examples of what can be done.

Specifically, we propose the revival and extension of an AID program first activated in the early 1970s. Under this program, AID awarded funds--called 211(d) grants--to U.S. engineering schools to create centers of development expertise. This program drew on faculty and student interest in development and usually included a combination of courses and field work. As actually carried out, this program was not judged an overwhelming success; its goals were often unclear and the resources devoted to it too meager. However, some 211(d) programs successfully met the primary goal of creating a body of expertise in the university. We recommend that programs of this type be reactivated with better defined goals, a longer grant period than the original five years, and sufficient resources to meet the specified goals.

We also suggest that U.S. engineering schools become more actively involved in field research in developing nations. Engineering faculty would not only participate but would stimulate the interest of their graduate students. U.S. government grants for faculty research and fellowships for graduate student participation are potential means of carrying out such a proposal.

A useful complement would be the establishment of a U.S. government traveling fellowship program in engineering similar to the highly successful Fulbright fellowship program. U.S. engineering faculty and graduate students would be sent to developing nations to teach, study, and do research. Likewise, engineering faculty from developing nations would spend time in U.S. engineering schools. Both exchanges would enable U.S. engineering faculty to become familiar with conditions in developing nations.

U.S. corporations that maintain operations in developing nations are a storehouse of knowledge about the technological needs of these nations. This year,

Table 3. Summary of present and future opportunities for U.S. engineering schools to render development assistance

This chart summarizes major program areas where U.S. schools of engineering can act now and in the future to broaden and improve development-related education and research in this country and developing nations.

| | Conducted in: | |
|---|---|---|
| Program | United States | Developing nations |
| 1. Undergraduate engineering | Basically sound; continue to offer broad, balanced flexible programs; suitable for students interested in development | Continue to upgrade quality |
| 2. Engineering technology | Well established; suitable for students interested in development | Promising applicability; need to establish in developing countries |
| 3. Graduate engineering | Continuing influx of developing country students; good, long-term impact | Create more regional graduate centers of high quality |
| 4. Developing country-oriented graduate education | New courses, more experimentation to match specific developing country needs; cooperative efforts with developing country universities | United States provide assistance in developing advanced programs; develop applied research; provide faculty training at regional centers |
| 5. Industrial extension service | Develop additional models | Develop new university-based centers for transfer of technology |

| | | | |
|---|---|---|---|
| 6. | Contract special training | Potential for expansion, both for schools of engineering and engineering technology | Potential activity at regional centers |
| 7. | Developing country faculty upgrading | Workshops and courses at appropriate U.S. universities | Short courses at regional centers and developing country universities |
| 8. | Seminars on special subjects | Provide professors, experts | Conduct for students/faculty at developing country universities and regional centers |
| 9. | Short courses for developing country engineers | Develop courses; provide visiting professors | Conduct at developing country schools and regional centers |
| 10. | Continuing education | Technical assistance in developing courses for use in the developing countries | Facilitate development and application. Need permanent activity in continuing education |
| 11. | Research (wherever possible cooperative between developing country and U.S. universities) | Development methodology and processes; development-oriented technical research; management techniques; energy; natural resources, etc. | Developing country faculty work on products and processes; marketing; technology applications; housing; energy; natural resources |

Source: National Research Council (1976) The Role of Engineering Schools in Development Assistance. Washington, D.C.: National Academy of Sciences.

for the first time, Cornell University has received permission from the U.S. Immigration and Naturalization Service to place foreign engineering students in work-study programs involving a one-year industrial experience for pay. U.S. companies are interested in students from those developing countries in which their subsidiaries are located. While the absorptive capacity of U.S. industry is limited, a few carefully structured programs similar to the Cornell effort could be useful. Another possibility for tapping this source would be funding of adjunct professorships at engineering schools to be filled on a temporary basis by persons with industrial experience in developing countries who would take short leaves of absence. Other forms of industrial-academic liaison can be envisaged.

A number of technology-based U.S. companies have developed sophisticated short courses for maintaining the high skills of their managers. Courses in the management of research and development projects are considered valuable in the development of executives, and some companies have indicated a willingness to work with U.S. universities to adapt their short courses to make them more useful to students from developing countries. We suggest that a series of short courses be developed for use in this country and abroad by means of a cooperative effort between interested U.S. companies and universities. Clearly, this initiative would most benefit developing nations that send large numbers of students to the United States (mostly "post-AID" nations).

### Initiative 3. Revitalize Productivity Centers in Developing Nations

A problem common to developing nations is low productivity of labor which implies low wage rates and low per capita income. If overall labor productivity could be increased in developing nations, wage rates would also likely increase.

In the 1950s, the United States supported establishment of productivity centers in developing countries, which provided a wide range of extension and other productivity-oriented services to local industries, especially small and medium-sized firms. The International Labour Organisation also supported this effort. However, with the decline in support for industrialization within the U.S. foreign aid program since the 1960s, productivity centers and related activities no longer receive sufficient assistance, even though they are regarded as one of AID's more successful technology transfer programs.

These centers were modeled on the successful productivity centers established in Europe during the Marshall Plan years and were designed to help developing countries increase productivity by applying well-known technologies and management practices. Programs included visits by teams of U.S. experts, sponsored visits to the United States and to third countries of industrial engineers and other managers to observe U.S. industrial techniques, symposia at which techniques for increasing productivity were presented and discussed, consulting on individual plant production problems, and other related activities. We propose that the United States first identify the most useful programs of productivity centers and then revive support for them.

The successful program of the U.S. Bureau of Standards might be used to complement and support work with productivity centers. This program is aimed at strengthening industrial standards and quality control and is carried out in developing countries and at the Bureau's own facilities in Washington, D.C. and Boulder, Colorado.

### Initiative 4. Support Establishment of Centers for Small Industry and Rural Development in Developing Countries

The development of small-scale industry is important to the economic growth of developing countries. Here support is suggested for a mechanism that would provide technical and management assistance to small enterprises in those countries.

We propose that assistance be provided, on request, for strengthening or establishing "centers for small industry development," with extension services, in developing countries. These centers would comprise a network of small field offices and a central management center, analogous to the U.S. Agricultural Extension Service. Centers would provide technical and management consulting services, as well as bookkeeping, accounting, and other services necessary for the viability of small enterprises. Also, they could help business enterprises by mounting engineering clinics, workshops, seminars, continuing education programs, and short refresher courses. Many of these services would probably need to be subsidized.

The central management center could be affiliated with and located at an educational or other appropriate institution, preferably an engineering school or research and development center that has engineering, marketing, accounting, and management know-how as well as technical information and data useful to small

business. Of course, long-term financial support is essential for such centers if any degree of success is to be derived.

An excellent example of this kind of effort is the Technology Consultancy Centre at Kumasi University of Science and Technology in Ghana. The Centre is primarily concerned with small-scale industries and serves as an intermediary between specialists at the university and its "clients." It has not, however, created the field offices that might add to its already proven effectiveness. The Centre provides technical know-how and assists in the testing of new products in pilot plants. It also furnishes technical assistance in matters of quality control, commercial production, access to credit, and improvement of equipment.

In order to strengthen the impact of U.S. assistance in this field, we further propose that the United States offer to support one or more centers in this country that could provide training, demonstration, and technical support services as a model for centers in developing countries. A U.S. center could:

-- act as a training center for developing country personnel who would establish similar programs at home;
-- amass knowledge on small industry development useful for a wide variety of circumstances;
-- act as a collection and distribution point for data on technology;
-- perform research and development applicable to programs in developing countries, using both developing country and U.S. personnel;
-- teach management techniques, such as the "project management" concept, to developing country personnel.

This initiative is inspired by the success of a program undertaken by the Georgia Institute of Technology Engineering Experiment Station (EES). Initially this program was funded by the State of Georgia to aid small rural industry within the state. Many rural sections of Georgia are quite poor and backward relative to much of the United States; in some respects economic conditions within these areas resemble those found in developing nations. Within Georgia, EES programs are regarded as successful; enterprises aided by the EES have returned tax revenues well in excess of the total costs to the state government of maintaining the station.

During the mid-1960s, Georgia Tech extended its operations internationally, by means of federal funding, to work in rural areas of developing nations.

Although the scope of these activities is not large, a substantial number of entrepreneurial ventures in developing nations has received assistance. Georgia Tech and the Ghana Technology Consultancy Centre have had a working arrangement under the former's 211(d) program, which is now coming to an end. We recommend expanding this type of effort.

### Initiative 5. Expand Assistance to Improve Capabilities of Developing Countries to Conduct Industrial Research

Approximately 80 institutions located in various developing countries serve as agents for the identification, acquisition, development, and application of technology. Commonly known as "industrial research institutes" (IRIs), these institutions are characteristically government-sponsored; some, however, are autonomous and self-supporting. Their functions vary, but often include research and development, establishment of standards, product testing, quality control and certification, review and approval of technology for importation, industrial extension services, and collection and maintenance of data and documentation on technology.

Although the interest most common to these institutions is food technology (usually excluding agriculture), their scope includes many other industrial and commercial subjects. Staffs typically include engineers and scientists who are graduates of both domestic institutions and foreign universities. These institutes are a central point for the transfer of technology, since staff members usually work on joint projects with foreign educational institutions as well as on domestic programs.

IRIs generally serve both public and private sector industrial entities seeking technology-related services. These clients range from large, sophisticated firms to small enterprises. In some instances, basic research is carried out in much the same way as in a university science department.

The effectiveness of these institutes varies considerably, but many are relatively ineffective because of inadequate understanding of the technical needs of potential users, unfamiliarity with the ways to obtain information about those needs, lack of management and organizational skills, insufficient access to world sources of technical information, deficient research facilities, lack of resources for constructing pilot plants and prototypes, minimal operating budgets, and low staff compensation which

makes it difficult to attract and retain qualified individuals.

Experimental assistance programs, such as those supported by AID's Office of Science and Technology over the past five years, have demonstrated that selective assistance--both material and consultative, technical and managerial--directed toward these deficiencies can significantly increase effectiveness, which in turn can have a significant impact on industrialization.

We propose that the United States offer to increase its support of industrial research institutes, as requested, by such mechanisms as specific research project support through a grant program, development assistance for research and development management, facilitating access to world sources of technical information, and aiding in development of industrial extension services. A variety of means or "models" for supplying such assistance to IRIs has been developed and demonstrated with varying results (also see the U.S. Bureau of Standards program described in Initiative 3).

### Initiative 6. Promote Interchanges of Personnel and Programs Among Industrial Research Institutes in Developing Nations

The idea underlying this initiative is the adage that the whole may be greater than the sum of its parts. Currently, a large number of developing country institutions are performing industrial research, often generating information and experience that could be useful to other institutions. Mechanisms could be developed to facilitate and expedite the transfer of such information and experience.

One such mechanism is a society whose members (research managers) meet on a regular basis to exchange ideas (this is to be contrasted with professional societies normally organized by disciplines). Such societies exist in most industrialized nations and some developing nations. In the United States, the Industrial Research Institute, Inc. primarily brings together top managers of research departments in manufacturing corporations, who feel that this forum contributes substantially to U.S. private research efforts. The European Industrial Research Management Association plays a similar role for industrial research and development managers from the private market economies of Western Europe.

The World Association of Industrial and Technical Research Organizations (WAITRO), which is loosely affiliated with the United Nations, is composed of many

of the nonprofit research institutes in both the developed and developing countries. It is said to be underfinanced and constrained from full effectiveness by other limitations.

We propose that the United States support the creation of a formal international association of developing nation industrial research organizations. The activities of such a network, which conceivably could be related to or within WAITRO, could include regular meetings of managers of developing country research institutes, and exchanges of personnel, cooperation on joint projects, technical meetings, specialized organizations, and similar activities. The association would need a small staff to help plan activities, manage information services, and help raise financing for association activities. It might possibly be linked with programs of the United Nations University.

Such an association might also stimulate the development of more specialized groupings of individual research institutions within a country or among developing nations. Networking of this sort might take place within specific subject areas, as has been the case among the agricultural research institutes.

Initiative 7. Develop a "Technology Corps"

The U.S. International Executive Service Corps (IESC), a program with more than a decade of accomplishment partially financed by the U.S. government, sends experienced, retired U.S. executives, including technical managers, to developing nations to help local firms (predominantly small to medium-sized businesses) solve managerial problems at less than standard consulting costs. These consultants usually stay for about 60 days. At UNCTAD IV, the United States proposed a similar initiative that would send experienced engineers and consultants abroad in mid-career to stay as long as a year or more. A recent feasibility study suggests that this proposal could be pursued most effectively by incorporating the new dimensions within IESC.

We endorse this proposal and recommend that the United States renew its support in the context of the 1979 Conference if the feasibility factors such as those noted below can be worked out with IESC. The proposed broadening of professional services could prove a valuable additional resource to industrial firms, including state-owned industries, in the developing nations. Conversely, U.S. participants would learn more about what could be done to adapt

technologies to the economic conditions of developing nations.

The inclusion of personnel who are not U.S.-based could further expand the scope of a technology corps. European, Japanese, and, most importantly perhaps, developing nation personnel could participate, giving a technology corps an international status. The inclusion of personnel from developing nations could serve to make the corps more responsive to developing nation problems and could help to sensitize other members of the corps about them. It would be particularly desirable for nationals of the more industrialized developing nations--persons who have industrial operating experience in similar environments--to participate in the corps.

Potential problems with a technology corps can be identified. First, it may be difficult to find enough qualified persons in mid-career willing to take time to serve. Second, employers may be unwilling to grant leaves of absence. This last obstacle might be overcome if the company perceives that the employee's usefulness is enhanced by working in a country in which it may wish to do business in the future; that is, the company might look upon such service as a long-term investment. A third problem would be the cost of the program--participants would have to be compensated sufficiently to support their families, making the program quite expensive. Most of these problems are not found in existing IESC programs.

### Initiative 8. Support Continuing Research into the Process of Industrialization

The determinants of industrial growth in a developing economy, including the role of technology, are not fully understood. While this reflects our incomplete understanding of the entire economic development process, the relative importance of industrialization for national welfare in developing countries makes the need for sharply focused research especially critical. Better understanding of industrialization, and of the interactions among trends in technological change, factor costs, and global patterns of industrial production and trade, is a prerequisite to the making of sound decisions affecting industrial development by policymakers in all nations.

Some research in this area is now being performed in universities in the United States and elsewhere, in international agencies such as the World Bank, in private research institutes, and in government agencies. However, neither the volume nor the quality

is commensurate with the need or with the urgency of the questions that policymakers are facing daily.

The case for a wide-ranging, energetic program of industrialization research was stated as long ago as 1973 in a report, "Meeting the Challenge of Industrialization," by the National Academy of Sciences and the National Academy of Engineering:

> The majority of [the developing] nations are newly independent, intent on shaping modes and strategies of industrialization to meet their own goals, needs, and values. Their people are experiencing rapid social and political changes, and their opinions vary on the ways in which industrialization can serve their needs....
>
> The identification of suitable modes of industrialization is pivotal in selecting specific industrial activities that create productive complementarities both within and between countries, achieve rural-urban balance, and improve economic relations between developing and developed countries. This achievement will require innovative, interdisciplinary effort to study means of shaping industrial development to peoples' needs, to avoid the mistakes and human costs of past industrial transformations....
>
> Our present understanding of these dimensions of the industrialization process is clearly inadequate, as is our knowledge of the criteria that will guide developing countries in their new programs of industrial development. Moreover, existing approaches to problems of industrial location and international division of labor need reinterpretation in a world that is rapidly changing and in which markets are often slow to adjust to the growth of competitive new industries....
>
> Structural shifts in industrial activities in both advanced and developing economies are essential to these transformations. Steadily increasing access is required for manufactures of industrializing countries to markets of industrialized countries. Increased flows of capital from rich to poor regions are required in forms that will result in rising productivity and wages in developing regions, as well as in lower international costs....

> Advanced as well as developing countries lack adequate knowledge of how to harness the potentials of industrialization to the objectives of efficiency and equity: efficiency in the economic sense of the best use of the nation's (and world's) resources, and equity in the sense of an acceptable sharing of the benefits of growth and in the process of decisionmaking and implementation of industrialization itself....
>
> ...[S]ustained effort is needed to enable governmental agencies, financial institutions, and companies to determine the workable and acceptable criteria for selection of industry and to develop methodologies and information for applying those criteria. New depths of analysis are needed to help countries and enterprises understand the alternative benefit-costs of different industries or industrialization routes and to clarify the time phasing of the processes of selection and implementation. These analyses, clarifying the nature and magnitude of gaps between social and private benefit-costs in different industries, would assist national and internatonal agencies in devising more effective policy instruments to guide industry in investment and adjustment decisions.

Constraints on the level and quality of present research on the industrialization process include: lack of consensus (or understanding) of what the critical problems are as well as their priority, shortages of qualified individuals to do the research, shortages of research funds, and lack of coordination among individuals and institutions doing research that is itself often too fractionalized to contribute to policy and investment decisions. Not all of these constraints can be overcome simply by allocating additional resources to the research effort. Nonetheless, additional resources would help.

Beyond the need for resources lies the need for research that will have high credibility for all users in a field in which controversy prevails. Research directly supported by any single national government may imply bias or undue influence. Thus it is important that U.S. government support for research on the industrialization process be merged with that of other nations, the private sector, and foundations so as to enhance credibility of the research results. With this in mind, <u>we suggest</u> the following options:

Creation of an international foundation for the support of research on industrialization and economic development. This would not require the creation of a physical center for research into industrialization, but rather an independent, private foundation that would make resources available through grants and contracts to existing research institutions. Such a foundation would be run much like the well-known private foundations except that both the funding and staffing of the administrative apparatus, from the board of directors down, would be multinational. Ideally, a wide range of multilateral private and governmental sources would support such a foundation, with steps taken to assure that no one nationality or group of nationalities would dominate the internal administration.

Creation of a new international center for industrial development research. Such a center might be a private, autonomous organization incorporated with international status and governed by a multinational board of directors composed of knowledgeable and distinguished persons whose credentials would imply scholarly and objective standards. Its status and management would be designed so as to shield the activities of the center from the political process. Funding should be arranged with these objectives in mind.

This center would serve as a focal point for inquiry into the industrialization process. It is envisaged as a place where both experienced scholars and experts, including those from developing nations on leave from their regular posts, as well as young persons just entering the field, could work. The internal research activities of such a center should complement existing research programs rather than displace or duplicate them. One important task would be publication of journals featuring both in-house and outside research.

Creation of a research center (or expansion of existing research capabilities) within an existing international institution, such as the World Bank. This alternative would be virtually identical to that previously described, except that this research center, rather than being an independent institution, would be part of an existing international organization. One advantage of establishing such a center in the World Bank is that its staff already includes individuals who could form the core personnel; some of the staff have established international reputations for research of the highest quality. A center within the World Bank would have no need for an endowment since the World Bank is funded on an established basis. A potential disadvantage of such an arrangement, however, would be

that the center might not be seen as totally independent of control by governments.

## Improving Access to the Technologies of Industrialized Countries

One of the major needs of developing nations, according to their own leaders, is greater and more efficient access to information about the range of technologies available from the developed nations or other developing nations. The developing countries also want to increase their ability to make comparative assessments of these technologies. We have already noted that developing nations are likely to require technology from outside sources for many years. It is difficult to determine which of the variety of available technologies would be optimally suited to a given nation's needs and goals. The two initiatives offered here address this problem and the related need to enhance the ability of officials of developing nations to negotiate effectively with foreign firms that want to invest in industrial operations in their countries.

### Initiative 9. Create Expertise on the Search for and Selection of Technology

We suggest that the United States propose international support for an activity that would (1) train persons in how to search for and select industrial technologies, taking into consideration the comparative social and economic costs and benefits of alternative technologies; and (2) make these persons available to developing country governments or business firms to serve in what would be essentially a consulting capacity. The World Bank or an appropriate U.N. body might be the logical location for such an activity.

Consultation on the selection of technology is already available to developing nations from a number of sources, including private technical and management consulting firms, development finance institutions such as the World Bank, and other sources. However, under this initiative we would add the following to the existing capability. First, the competence of consultants on industrial technology choice would be upgraded, especially those within the development finance institutions. Second, the numbers of specialists who assess industrial technologies would be increased. Many of the experts on technology assessment specialize in agricultural or civil

engineering technologies; few specialize in industrial technology. Third, technical experts would consult with developing nations on the choice of technology for projects that are not now normally evaluated independently, such as major investments by multinational firms in the manufacturing sector within developing nations. Fourth, training in technology assessment might be given directly to government bodies within developing countries that are currently being set up to "screen" technology imports.

Consideration might be given to creating a center for the comparative evaluation of industrial technology. Establishment of such a center would not necessarily imply creation of a new organization. For example, the International Finance Corporation of the World Bank might be the locus for specialists prepared to perform technological evaluation. This function might also be attached to a research institution created in response to Initiative 8.

### Initiative 10. Provide Training in the Art of Negotiation on Technology Imports

Many would agree that the interests of all involved in any negotiation are best served if the parties on both sides of the table are informed and skillful in the subject matter and in the art of negotiation. Skills in negotiating with foreign industrial firms, though now found more widely, are still lacking in many of the world's developing nations.

To help correct this deficiency where it exists, we suggest that the United States sponsor workshops to develop negotiating skills. Such workshops are currently offered at Georgetown University and Harvard University, for example. The United Nations also sponsors such programs. Under this initiative, the U.S. government would add support to existing programs and assist in the creation of new ones. It might be desirable to hold some of these workshops directly under the auspices of an international organization such as the World Bank or an U.N. agency.

Both Initiatives 9 and 10 would help assure developing nations that they are receiving from foreign investors (and other foreign sources) technologies well suited to their national needs and goals. These initiatives could lead in some cases to new "matches" between developing nations' needs and foreign technologies which might not have occurred otherwise. Even in the absence of a significant number of new matches, implementation of these initiatives would be a step toward fostering confidence within developing

nations that national autonomy was being preserved in dealings with other countries.

## EPILOGUE

All of these initiatives represent approaches to improving developing nations' access to and use of technology in the industrialization process. While these initiatives do not represent a full U.S. response to the philosophical issues and positions regarding the transfer and use of technology raised by the Group of 77, they do represent an effort to respond to problems posed by developing country leaders. Three observations are pertinent:

First, as has been emphasized throughout this chapter, the industrialization process in developing nations is both complex and not fully understood. The initiatives proposed here do not individually or collectively constitute a solution to developing nations' problems, but rather they represent ways in which the U.S. government could help. Should the United States decide to advance any or all of the initiatives at the 1979 U.N. Conference, it would do well to keep their limited nature in mind.

Second, we have been mindful of the importance for the United States of not allowing itself to take a posture in this field in which it could seem to be trying to tell the developing nations what is good for them. Hence the proposed initiatives are designed to represent constructive responses to problems that are already recognized by developing nations themselves. Should an initiative offered by the United States not be seen as useful by the developing nations, it should be dropped. In the same spirit, the United States should be prepared to listen to proposals put forward by the developing nations. The overall U.S. position should reflect the fact that the United States possesses technologies and technical and managerial capabilities which would be useful to developing nations and that the U.S. government is willing to support certain programs which might help these nations acquire and use those resources. With respect to what these programs might be, the United States has ideas, but it is flexible and willing to consider other possibilities.

Third, while the United States is generally supportive of an open world economy, including an open international trading system and open transfer of technology, it should be prepared to speak frankly about the growing concern within this country that some technology transfers may have negative impacts on the

United States as a whole or on certain geographical regions, economic sectors, and income groups.

## NOTES

1. Historically, the Group of 77 is an informal association of developing nations which came into existence at the 1964 UNCTAD and which is now pressing the industrialized nations for a new international economic order. The Group of 77 now comprises 111 member countries of the United Nations.

2. Other terms in wide use are "light-capital," "capital-saving," "intermediate," and "alternative" technology, though not all who use these terms are in full agreement as to their content.

# CITATIONS

Chamber of Commerce of the United States (1977) Technology Transfer and the Developing Countries. Publication #5515, Washington, D.C.

Institute of International Education (1975) Open Doors 1973/74. New York: IIE.

National Academy of Sciences and National Academy of Engineering (1973) Meeting the Challenge of Industrialization. Washington, D.C.: National Academy of Sciences.

National Research Council (1976) The Role of Engineering Schools in Development Assistance. Washington, D.C.: National Academy of Sciences.

# Chapter 3

# HEALTH, NUTRITION, AND POPULATION

## INTRODUCTION

Among the most fundamental of all human needs are those relating to personal health and nutrition, which are embodied as universal rights in Article 25 of the United Nations Universal Declaration of Human Rights. Poor health saps vitality and the ability to live a fulfilling life. Improving health is basic to improving the quality of life in developing countries, and this is an important goal of U.S. foreign policy.

Despite increases in life expectancy since World War II, the developing countries continue to have high mortality rates, largely associated with preventable and treatable diseases. Typically these mortality rates reflect high infant mortality, which in turn is related to high fertility.

Infant mortality rates in developing countries are still three to 10 times higher than those in developed nations. Although many infectious diseases have been eradicated through mass campaigns, it is estimated that two-thirds of the children in developing countries are still malnourished to some extent, and half of the deaths among children under age five are due to respiratory and diarrheal diseases superimposed on varying degrees of malnutrition, to which they are synergistically related. As many as 0.5 to 1 billion people, mostly in developing countries, do not receive enough daily calories and/or protein.

As long ago as 1953, a report by UNICEF and the World Health Organization (WHO) noted that "probably three-fourths of the world's population drinks unsafe water, disposes of human excreta recklessly, prepares milk and food dangerously, are constantly exposed to insect and rodent enemies and live in unfit dwellings." Unfortunately, despite some progress, such descriptions are still applicable today.

Partly as a result of Western influence, health resources in developing countries have been heavily allocated to urban, medical center-oriented curative care which reaches only a small fraction of the population. As a result, more than 80 percent of the people in some developing countries lack effective access to modern health services. In some countries, government budgets provide as little as $1 per person per year for those services, an inadequate financial commitment, particularly where private services are not generally available. It is worth noting that many "tropical diseases," now largely confined to the developing countries, were seen as recently as 50 years ago in the developed world. These diseases may not be related to the tropics so much as to a lack of preventive care, inadequate services, malnutrition and other conditions of poverty, together with an inappropriate allocation of scarce resources.

Many of the poor in the United States suffer from similar problems, so that approaches developed abroad may have domestic application as well. There are lessons, for example, from experience in building community participation, controlling infectious and parasitic diseases, and developing effective delivery of health and nutrition services to both the rural and the urban poor.

Historically, it has taken some 35,000 years for the population to double; today, the world's population doubles within 35 years. It took all of humankind's history to reach a population of 1 billion people by about 1850; by mid-1977, the world's population had risen to approximately 4.2 billion people. By the year 2000, the population will be about 6 billion. Some developing countries are doubling in less than 25 years and growing as rapidly as 3 percent per annum, although the rates appear to be falling in Asia and parts of Latin America. Such growth rates impede the efforts of poor countries to achieve general socioeconomic development.

More than 80 countries, with more than 90 percent of the population of the developing world, have adopted policies aimed at lowering population growth and fertility, or making family planning services available for health and human rights reasons. Such policies are usually implemented by means of national family planning programs, ordinarily conducted through the public sector, but also frequently supported by the private sector. These programs are consistent with paragraph 29 of the World Population Plan of Action, adopted unanimously by 135 nations at the World Population Conference in 1974, which states in part that

> ...it is recommended that all countries: (a) respect and ensure, regardless of their overall demographic goals, the right of persons to determine, in a free, informed and responsible manner, the number and spacing of their children; and (b) encourage appropriate education concerning parenthood and make available to persons who so desire advice and the means of achieving it (U.N. Economic and Social Council 1974).

Family planning programs have been the most effective in Asia and parts of Latin America.

Population has been an important issue in the developed world as well. In the United States, for example, much attention has been given in recent years to fertility control, with emphasis on making family planning services more accessible to the poor. The 1972 report of the Commission on Population Growth and the American Future, entitled "Population and the American Future," was a unique and comprehensive review of issues relating to population growth in the United States. Although some of its recommendations were not implemented, it remains a model effort of its type and a useful reference for population commissions in other countries.

Health, nutrition, and population problems particularly affect women, whose status is low in much of the developing world and who are too often excluded from the benefits of development. Even more than many other developmental efforts, programs in these areas are likely to improve the status of women and open up new social and economic opportunities to them. At the same time, opening up new opportunities for women to work outside the home or family farm could make a major contribution to lowering the birth rate, which will in turn make other development goals easier to achieve.

This panel has identified seven areas in which the scientific and technological expertise of the United States could make a major contribution to the developmental efforts of developing countries. Both the developing countries and the international community have indicated the importance of each of the topics selected. In no special order of priority, they are:

1. Infectious diseases of the tropics
2. Water systems
3. Contraceptive technology
4. Nutrition
5. Infrastructure for primary health care services, including maternal-child health and family planning

6. Operational planning and management of health, nutrition, and family planning programs
7. Policy planning and basic data systems

Given the nature of the needs in the fields of health, nutrition, and population, the initiatives recommended are somewhat more concerned with "soft technology" (methods of management, organization, education, information, research, and evaluation) than with equipment. We suggest the need to develop new technologies, but, in general, we are more concerned with adapting and transferring existing technologies.

Several general needs run throughout the topical discussions in this chapter. For example, an almost universal need exists for more adequately trained personnel at all levels of developing country health, nutrition, and population programs. While training in the United States in certain specialized research and service-related fields is important, much of this training is too theoretical and parochial for the needs of developing countries. Such training contributes to the out-migration of skilled manpower from developing countries, particularly of physicians and nurses, thereby aggravating rather than reducing needs for skilled personnel.

The predominant need is to strengthen in-country training at all levels. Such training will tend to strengthen weak infrastructures in health-related sectors and permit more practical training programs that emphasize field apprenticeship in rural and urban low-income areas.

There is growing realization of the need to redefine the appropriate functions of the entire health care team, transferring many curative and most preventive functions from the doctor to other trained personnel, local practitioners, and village health workers. Training must be developed to meet the newly defined job descriptions in the latter two categories because not enough trained, modern health workers are available to provide universal access to health and family planning services. This problem is intensified by the tendency of the more highly trained personnel to reside in cities.

Finally, although this chapter does not focus on possible future health problems, one, occupational health and safety, requires mention. Industrialization and the use of new technologies can create a number of health hazards. Much can be learned from the U.S. experience in protecting workers and their families from physical dangers, toxic substances, and mental and psychological stress, without seriously inhibiting the contributions of industry and technology to development. U.S. government, labor, management, and

universities have experience and capabilities in occupational health and safety that would be useful to developing countries.

## OPPORTUNITIES AND PROPOSED INITIATIVES

### 1. Infectious Diseases of the Tropics

Infectious diseases--bacterial, viral, and parasitic--are a major cause of illness and death in developing countries and a serious retardant to development. The extent to which science and technology have been applied to these diseases has varied: for some an effective means of intervention is available but underutilized (e.g., tuberculosis); for others tools are nonexistent or inadequate for public health purposes (e.g., American trypanosomiasis). Improved disease control requires greater application of available technology; more research to develop new tools, techniques, and knowledge; and increased training in the United States and abroad to do both, all within the context of appropriate resource allocation and effective delivery systems.

Table 4 indicates those infectious diseases that panel members felt were of the greatest importance in developing countries, along with their estimates of current or potential interventions for controlling them. The diarrheal diseases (including cholera), malaria, certain immunizable diseases, and tuberculosis are accorded the highest priority. Schistosomiasis probably belongs with this group, but its public health significance is still poorly understood. Important, but of lesser priority, are filariasis (including onchocerciasis), trypanosomiasis, and leprosy. Other diseases such as yaws, cerebrospinal meningitis, and dracunculosis are also high priority problems in some settings but are not as widespread.

#### Rationale for Selecting this Topic

The impact of infectious diseases is enormous. Up to 25 percent of African children under five years old die of measles or its complications; many others are left partially blinded or otherwise handicapped. In some countries, control of endemic malaria has halved infant mortality rates within a few years.

The potential for overcoming these diseases varies, depending partly on whether a single, long-lasting intervention such as immunization is required (measles) as opposed to long-term treatment (leprosy) or repeated intervention against a vector (onchocerciasis). For

Table 4. Interventions and priorities for tropical disease control

| Disease | Most likely effective interventions | | | | Priority category* |
|---|---|---|---|---|---|
| | Immunization | Chemoprophylaxis | Treatment | Environmental control | |
| Diarrhea (multiple causes) | - | - | + | + | 1 |
| Cholera | ? | - | + | + | |
| Malaria | ? | + | + | + | 1 |
| Immunizable diseases (measles, polio, DPT) | + | - | - | - | 1 |
| Tuberculosis | + | + | + | - | 1 |
| Schistosomiasis | ? | - | + | + | 1? |
| Filariasis (including onchocerciasis) | - | ? | + | + | 2 |
| Trypanosomiasis | ? | ? | + | + | 2 |
| Leprosy | ? | - | + | - | 2 |

*Priority is a function of the importance of the disease and of the feasibility of impact.

Key: + = Likely effective intervention
- = Unlikely effective intervention
? = Uncertainty as to effectiveness of intervention
1 = Highest priority
2 = Secondary priority

diarrheal diseases, a simplified short-term therapy (oral rehydration) was recently developed which permits control at a public health level. The strategy for controlling smallpox by rapid surveillance and containment, which emerged from the global eradication campaign, is undoubtedly applicable to other diseases such as yaws. Some kind of effective intervention is now possible for each of the diseases listed in Table 4.

There are constraints, however, to applying science and technology to infectious diseases. These include the quantitative and qualitative inadequacy of health delivery systems; the large scale of these disease problems and the consequent high costs of applying solutions even when treatment is inexpensive on a unit-cost basis; the complexities of the scientific questions involved and the uncertainty of predicting breakthroughs; the long time it takes to find solutions; and the fact that development activities in other sectors may exacerbate these problems (e.g., when water impoundment for irrigation or power projects increases the incidence of schistosomiasis, malaria, or filariasis).

Where support for basic biological research is contemplated, it should be remembered that effective research can only occur in the context of an extremely complex set of supporting systems. It requires a critical mass of scientists, well-trained support staff, libraries, logistic support, parts, maintenance, an adequate supply of clean water, reliable electricity, and the like.

The interest of developing countries in addressing infectious diseases is apparent from past regional efforts to control smallpox, yaws, malaria, and measles and current support for WHO-sponsored programs for onchocerciasis control in six West African countries, for expanding routine immunization services (DPT, polio, measles, BCG), and for research and training in six other tropical diseases (malaria, schistosomiasis, filariasis, trypanosomiasis, leprosy, and leishmaniasis).

It is in the U.S. interest to help fight infectious diseases. Study of how trypanosomes, schistosomes, and leishmania block host defenses, for example, is likely to produce research leads of considerable significance to domestic health problems such as cancer. Also, since diseases do not respect national borders, there is some risk of importing such diseases as Lassa fever and Marburg disease (a hemorrhagic viral disease) to the United States and a continuing risk to U.S. citizens traveling abroad.

## Ongoing Work

These diseases fall roughly into three categories with respect to the knowledge and resources needed to deal with them. In the first category are diseases such as malaria and schistosomiasis for which existing methods of field control have only limited effectiveness. Likewise, the live vaccine for polio is reported to be ineffective in many instances. These diseases require extensive laboratory and field research.

The second category includes diseases such as measles and some nutritional deficiencies for which methods of control are fully developed and effective but reach only a limited part of the population. In these instances, more effective delivery systems must be developed.

A third category concerns health problems such as malnutrition, large and poorly spaced families, and unsanitary living conditions, where social changes are needed more than technological innovation. Here more social science research is needed on involving communities in new forms of health-related activities and on developing more effective delivery systems for preventive health information.

Although past research at U.S. institutions has not been as extensive as it might have been, work on infectious diseases is currently underway at several universities and federal government agencies such as NIH and the Center for Disease Control, and specialized research facilities such as the Gorgas Memorial Laboratory and the U.S. Army and Navy Laboratories.

An analogous set of university, industrial, and government research institutions exists in Europe and, to a lesser extent, in the developing countries themselves. Some of the internationally funded medical research institutes located in developing countries are the proposed International Centre for Health Research (formerly Cholera Research Lab) in Dacca (supported in part by NIH and AID), the International Center for Insect Physiology and Ecology in Nairobi, and national or regional institutions in India, the Philippines, Thailand, and elsewhere. Four relevant WHO programs are the Special Programme for Research and Training in Tropical Diseases (WHO 1977), the Expanded Programme for Immunization (WHO 1976a), the World Bank-funded Onchocerciasis Control Project in West Africa (WHO 1976b), and the new Special Programme for Appropriate Technology. As one part of its program, the Intermediate Technology Group, based in London, is seeking to adapt existing technologies and to identify needed new technologies of relevance primarily to health delivery in developing countries.

Proposed Initiatives

To provide a focus for government, industry, and academic research on these problems, we recommend that the United States create a new, highly visible program to improve understanding, prevention, and treatment of the infectious diseases of the tropics. This could be accomplished either by creating a National Institute for Infectious Diseases of the Tropics, or by providing an appropriate mandate and funding for an intensified program at the National Institute of Allergy and Infectious Diseases of NIH, which already has many of the relevant research capabilities. Either institution could help provide for an integrated problem-solving effort with a specific orientation to the needs of developing countries.

The new program should have the capability to handle all stages of technology development, adaptation, and transfer into various cultural settings. Assistance should also be provided in manufacturing, assembling, packaging, distributing, and marketing innovations.

Specific research might be undertaken on: long term prophylaxis against malaria and various parasitic diseases; heat-stable vaccines for such diseases as measles and malaria; simplification of the BCG vaccination procedure; new products and packaging for oral rehydration, particularly for children; and delivery mechanisms in areas without electricity for immunizations and medications that presently require refrigeration. However, the investment of fiscal, human, and organizational resources in the biomedical research issues described should not detract from, or overbalance, investment in the development of basic health services and the organization of health, nutrition, and family planning delivery systems. These are of equal or higher priority.

We recommend that the United States allocate increased financial resources to support public and private sector research and training. Research support should be balanced between support of domestic institutions, including the proposed new institutional arrangement, and the development and strengthening of institutions in developing countries. Support can be provided through both bilateral and multilateral agencies, especially through WHO for the special programs mentioned above. An appropriate balance should be struck between short-term and long-term goals (immediate control programs versus biomedical research) and between basic and applied research. Initially, most of the necessary biomedical research will have to be undertaken in developed countries, with gradually

increasing support for strengthening research capabilities in developing countries.

Many of the priority diseases will probably require investment of a decade or more before major advances can be applied on a wide scale. Thus a progressive buildup of trained manpower is needed in the United States as well as in developing countries to form an expanded next generation of laboratory researchers, epidemiologists, and program planners and managers. As far as possible, developing country personnel should be trained in their own or in other developing countries to strengthen the growth of local scientific institutions. However, some specialized training in developed countries would still be necessary. Support should be made available for the training of U.S. scientific and program personnel both in the United States and abroad.

## 2. Water Systems

More than half of the world's population has no reliable and safe water supply; 70 to 80 percent have no sewage disposal. And yet, whether in rural villages or urban squatter settlements of developing countries, adequate, convenient supplies of safe water and sanitary facilities are essential to improving the quality of life. Safe water prevents contact with debilitating, often fatal, water-related diseases like cholera, typhoid, enteric infections, hepatitis, schistosomiasis, and malaria. Hygienic conditions in the home help limit the spread of skin infections, lice, mites, and trachoma. Convenient supplies of water (not necessarily from costly in-house connections but from simple courtyard standpipes) reduce the daily burden of women and children who would otherwise spend hours hauling water from distant sources to their homes and permit more time to be spent on productive activities such as producing food and attending school.

The much larger use of water in towns and, particularly, cities alters the character of the primary problem from one of providing a reliable supply of water in rural areas to one of pollution by sewage flows in metropolitan areas. Improved disposal of wastes and waste water, an integral aspect of water systems, limits the transmission of waste-related diseases such as hookworm, roundworm, and others. Such systems need not be sophisticated, but appropriate to the needs and resource levels of the community and household.

Despite the availability of engineering capability in developing countries and substantial international interest, relatively little gain has been made in

providing village households or metropolitan areas with adequate, safe water. Although numerous small-scale water projects have been undertaken, many are no longer operative because equipment, motors, and chemicals cannot be maintained or adequately trained operators are not available; systems have been poorly managed. Some problems arise because developed country engineers, financial institutions, and advisers tend to select technology that is too sophisticated for the capital, organization, and management capabilities of developing countries. Systems need to be designed that are appropriate for site-specific conditions.

A further impediment to solving water problems is lack of adequate funding. In the United States, for example, water is paid for by the consumer; in most developing countries, it is a part of national budgets, and this tends to limit the support received.

## Rationale for Selecting this Topic

A major resolution of the U.N. Water Conference of 1977 states that the provision of safe, adequate water supplies is a number one priority in many developing countries (United Nations 1977a). U.S. support for this priority is also consistent with the congressional mandate to address the problems of the rural poor, the Percy Amendment on the impact of AID programs on the status of women, and the resolution of the U.N. Stockholm Conference on the Human Environment. The greatest environmental threat to human well-being in developing countries may well be the threat of infection, which stems largely from contaminated water and poor waste disposal.

More effective use of national and local planning and managerial capabilities, and of technology based on renewable energy sources, offers promise in this area. A broader understanding now exists of the problems of allocation, proprietary rights, and priorities for access to water; management of basic resources (e.g., river basin agreements); and provision for maintenance and operating funds. The fundamental relationships among water and health, nutrition, and in a larger sense economic development, are well established, though not precisely quantified.

The selection of appropriate water system technology by developing countries--systems that can be maintained and operated in-country--would permit scarce capital to go further and more water systems to be constructed and successfully operated. The United States has experience using a wide range of water and waste water treatment technologies, as well as planning and managerial capabilities that can be applied to the

selection of such systems. Water managers in the United States are accustomed to looking at the components of water systems as a whole, at both the "hard" technology (e.g., hardware) and the "soft" technology (e.g., methodological know-how, analysis, and management).

## Institutional Mechanisms

The mechanisms newly available in the Plan of Action adopted at the U.N. Water Conference in Argentina in 1977 and ratified by the U.N. General Assembly should be reviewed. Assessment of water resources, agreements on water access, as well as funding mechanisms and international and bilateral arrangements have all been considered under these auspices.

Other institutions and programs concerned with efforts in this field include: the International Reference Center (IRC) sponsored by WHO, which works on dissemination of information processes, analyses, and quality criteria; AID studies, which look toward development of managerial sciences and engineering to use socioeconomic and technical parameters for identifying appropriate technologies; and the World Bank, which is financing preinvestment studies and economic and engineering projects relating to rural waste disposal, development, and application. Other possibilities are using private voluntary agencies and the Peace Corps; the numerous training programs (AID, WHO, IRC); the Intermediate Technology Group (London) catalogue of equipment and approaches to rural waste disposal and water supply technologies; the Environmental Protection Agency (EPA), which deals with rural supplies and on-site technologies; and the Pan American Center for Sanitary Engineering and Environmental Sciences in Lima, Peru.

## Proposed Initiatives

The United States has already stated its intention to assist developing countries in the provision of domestic water supplies and waste disposal facilities (United Nations 1977b:5) by undertaking feasibility studies, project planning, and training. To ensure the success of such activities, planning should be undertaken in collaboration with host country ministries of health, water resources, and development/finance. AID could support studies on appropriate levels of technology, training, and management in collaboration with such institutions

(already supported in part by AID funds) as the Pan African Institute of Development, Cameroun; Inter-African Committee for Water Resources Studies, Upper Volta; Pan American Center for Sanitary Engineering and Environmental Sciences, Peru; and the Asian Institute of Technology, Thailand.

In addition, we recommend that the United States consider sponsoring regional seminars, workshops, or in-depth demonstrations for water resource planners, managers, and technicians to expedite the transfer of new technologies and the development of problem-solving experience.

WHO has begun a program to make country water assessments for community water supplies and sanitation. It is collecting basic information on present systems, personnel available and needed, projections for water demand, and the availability of water resources. U.S. sanitary engineers, systems analysts, and hydrologists could provide technical support for these baseline surveys through AID or HEW.

Finally, research is needed to develop firmer knowledge on how the use of water affects health at the village level. One recent report reviews a number of studies supporting the view that diarrhea is significantly reduced among infants and children when water is piped into the house. However, the overall report concludes that "Studies of the association between health and water supply and sanitation allowing an accurate prediction of health (and economic) improvements under a variety of circumstances have not been carried out (Saunders and Warford 1976:196)." Such studies could provide the economic justification for investments in rural water supplies, particularly if the effects of water on health and nutrition could be quantified. In 1976, such a study was supported in Brazil by AID; several replications carried out under different economic conditions would be desirable so that appropriate generalizations could be made.

### 3. Contraceptive Technology

Although men and women around the world enjoy a considerably wider choice of contraceptive methods than 20 years ago, the available technology is far from satisfactory. Advances during this period have included the development and various refinements of oral contraceptives and the intrauterine device (IUD), both widely used; new and simpler methods of female sterilization; the development of an injectable hormonal method; legitimation and increasing use of the condom as an acceptable public program method; use of foam in some programs; mass use of vasectomy in several

male-dominant societies; and greater knowledge of the sequence of events during the menstrual cycle and consequent refinements in the rhythm method. Several new contraceptive methods are in the research and development stage. The technology for performing abortions has also improved and this procedure is safer than in the past. The development of national family planning programs featuring one or more of these methods in many countries is probably one of the major social revolutions of the twentieth century.

Despite these advances, existing methods have drawbacks due to inconvenience of use or delivery, medical complications, or lack of acceptability. Consequently, there is an urgent need to develop additional safe, effective, low-cost, convenient, and acceptable methods of fertility control. Equally important is the need to adapt and apply existing technology to individual developing countries in more appropriate ways, taking account of social, cultural, moral, and physical factors.

## Rationale for Selecting this Topic

Improved contraceptive technology is widely recognized as a high priority need in both developing and developed nations, and was so identified in the World Population Plan of Action. More recently, the reproductive sciences and contraceptive development were systematically reviewed by more than 160 experts from 26 nations, under the sponsorship of the Ford and Rockefeller foundations and the International Development Research Centre of Canada (IDRC) (Greep et al. 1976). This report called for a significant increase in research in this field.

Since the great diversity of the world's cultures and peoples and the changing needs of men and women during the course of their reproductive lives more or less guarantee that a single, ideal contraceptive method will never be found, a variety of improved methods with greater cultural and moral acceptability are needed. Improved contraceptive methods could have a large impact, both in terms of the ability of couples to control family size and child spacing more effectively, and in terms of demographic effects on national fertility patterns. While the latter are controlled by the complex interplay of a number of social and economic forces, more acceptable methods of fertility control that might be adopted by larger proportions of couples for longer periods of time would certainly influence fertility patterns and family size, and could have a major impact worldwide.

The potentials for developing improved contraceptive methods and for adapting existing methods to diverse cultural needs are excellent, although the lead time can be quite long. Approaches already in the research and development stage and leads from past reproductive research offer promise if additional expertise and funding are applied. The United States, with its considerable experience in both basic and applied research in this field, is particularly well suited to play a leading role.

Although the need for improved contraceptive methods to bolster family planning programs is particularly acute in developing countries, many Americans also need access to more effective methods. Furthermore, there is growing medical concern about the potential health hazards of long-term reliance on oral contraceptives by millions of young women in the United States and other countries. Medical complications secondary to the use of the IUD are also of concern. For the most part, methods developed for mass use in international family planning programs would also be appropriate for use in the United States.

## Institutional Mechanisms

A variety of mechanisms exist for the development, adaptation, and transfer of science and technology in contraceptive research and development fields, including normal commercial channels, academia, and bilateral, multilateral, and private programs of support. Products developed within the private sector are generally exported directly or licensed for local manufacture abroad; they are rarely adopted specifically for developing countries. Any change would require a better understanding of the importance of the needs and a reorientation of the interests and priorities of government and private sector leaders. Careful review of incentives and constraints, particularly within the private sector, is needed. As has been suggested in a generally parallel statement,

> Traditionally the transformation of a promising laboratory finding into a practical birth control method depends on a corporate decision based on such product development considerations as sales potential, exclusivity, development cost and product liability risks. Government funding can assure that all feasible methods are evaluated fully, whether or not their development represents ideal corporate policy (Kegan 1978).

A number of existing implementation mechanisms can be expanded through increased U.S. efforts. U.S. universities have undertaken a wide range of research in reproductive biology of relevance to the search for improved contraception. The Center for Population Research at the National Institute of Child Health and Human Development, AID, the Population Council and its International Committee for Contraceptive Research, the AID-funded International Fertility Research Program and the Northwestern University Program for Applied Research on Fertility Regulation, and the Ford and Rockefeller foundations are among the U.S. organizations that have given priority to biomedical and contraceptive research and development, with activities ranging from basic biomedical research in the United States to contraception-related adaptation efforts in developing countries.

The Program for the Introduction and Adaptation of Contraceptive Technology is a new organization supported by both U.S. and multilateral funding. The Canadian IDRC has supported applied research in this field and WHO has given priority to its Special Programme of Research, Development and Research Training in Human Reproduction. The Indian Council for Medical Research also has an important program in contraceptive development. All these agencies have the organizational capacity for additional effort but lack the funds to expand current programs.

Although the necessary institutional base is largely available, there are major constraints to expanded work in this field. Primarily they are insufficient personnel and funding to carry out the kind of crash research programs necessary to meet the need and insufficient incentives for active participation by the private sector. An "adequate" worldwide effort by governments, foundations, and industry in this field was estimated in 1976 to cost $361 million annually, three times the available amount. Actual U.S. expenditures in 1974 totaled $62.3 million, with $38.0 million (61 percent) from government, $12.7 million (20 percent) from foundations, and $11.6 million (19 percent) from industry. With rising costs, the annual research expenditures would need to increase to about half a billion dollars in 1980. Expenditures for U.S. work in this field would be expected to be approximately two-thirds of the total. Worldwide costs for a "high priority" program (receiving 10 percent of medical research funds) were estimated at $566 million in 1976, rising to $766 million in 1980 with by far the largest share drawn from governments (Greep et al. 1976). Obviously, achieving even an "adequate" program level would require a major expansion in U.S. support.

Further constraints on research in the United States are the strict controls imposed by official regulatory agencies. Regulations regarding medical safety and informed consent typically increase the costs and lengthen the lead time from initial research to ultimate development of a new contraceptive method. At present the lead time is usually at least a decade.

## Proposed Initiatives

We recommend that the United States propose international support for a priority program of basic biomedically oriented contraceptive research along the lines recommended in the Greep report (1976), which would be mutually beneficial to both developed and developing countries. Contraception for the male should receive significantly increased emphasis, together with expanded efforts aimed at the female. Examples include biodegradeable systems for the delivery of injectable hormonal contraception, immunological approaches, and reversible sterilization procedures.

U.S. institutions ready to expand basic and applied research in human reproduction leading to improved contraceptive technology should receive additional financial support. Many of the basic studies can be conducted within the United States under the research programs of government institutions, foundations, and industries, and the applied clinical work should be conducted simultaneously in both the United States and developing countries. AID's effort in this field should be expanded. Funding should also be made available through the multilateral programs of WHO, the U.N. Fund for Population Activities (UNFPA), etc., as well as directly to developing countries through bilateral arrangements with appropriate local research programs. Within such a program, attention should be devoted to better adaptation of existing contraceptive methods to the sociocultural and institutional conditions prevailing in developing countries and to research and development on new methods. The smaller size and body weight of populations in many developing countries should be taken into consideration. Support should also be provided for local manufacture, assembling, packaging, distribution, and marketing innovations.

Finally, the constraints against private sector investment in contraceptive research and development oriented to developing countries and the efforts geared to overcoming this problem should be reviewed. This review should include consideration of the advantages and disadvantages of business, regulatory agency, and

governmental practices with respect to taxes; antitrust regulations; and trade.

## 4. Nutrition

Pregnant and lactating women, infants, and young children constitute an important segment of the population and the core of the serious nutrition problem of the developing world. They tend to get the least food or the least protein of all family members and are the first to suffer and the last to recover from temporary or chronic food shortages. The damage that malnutrition inflicts on these populations is visited upon both themselves and future generations (Stein et al. 1972, Gordon 1975, Winick 1976).

The goal is to provide each woman a diet that permits her to realize her full potential as well as to bear and nourish a healthy child, and each child a nutritional birthright that permits full intellectual, physical, and emotional development. The provision of nutritional supplements to expectant women has been found to reduce significantly the number of low-birth-weight infants. In Guatemala, the provision of only 20,000 calories during the entire pregnancy reduced the prevalence of low-birth-weight infants and also improved the lactation performance of mothers (Klein et al. 1976). Both factors contribute to infant survival. But more research is needed on such biomedical problems as the functional significance of improved nutrition on pregnancy, lactation, and infancy, and such behavioral problems as why certain foods are or are not given to infants. These needs point in turn to the need for additional information on dietary requirements, dietary potential in local foodstuffs, existing cultural factors that influence dietary behavior, and willingness or reluctance to modify this behavior.

In almost all societies, the key to reaching ideal nutritional levels revolves around women's roles in making such decisions as quality of diet, allocation of food within the family, and food preparation and handling practices, and the broader role of women in generating income, allocating time, and determining expenditure patterns. Problems of household nutrition are exacerbated in many rural areas by the shift toward cash cropping and the reduction in variety of family food formerly provided by subsistence farming. All approaches to improving nutrition must be sensitive to both micro and macro roles of women amidst the dynamics of change.

Nutritional status depends on household composition, family decision making, and many other sociocultural and economic forces, as well as

acceptability and actual utilization of food and nutrition programs. Some of the complex interrelationships are illustrated by breastfeeding, which involves not only the nutritional status of the infant, but also considerations of maternal fertility, child spacing, health and economics, and the woman's role in the family, industry, and education. Recent data have helped to document and clarify the linkages between breastfeeding and longer birth intervals (Berman et al. 1972). There is also some evidence that breastfeeding is associated with antibody protection and reduced likelihood of bacteriologic contamination which serve to protect the infant, lower infant mortality, and help reduce the necessity to have a large family in order to insure the survival of a given number of children. Associated health benefits include reduced incidences of gastroenteritis and respiratory diseases in children, in part due to less contamination from unclean bottles and less dependence upon curative medical services. In general, improved nutritional status in children significantly increases their chances of surviving diarrheal, respiratory, and other infectious diseases (Berg and Muscat 1973).

The relatively low priority given to nutrition in the social science and medical education adds to nutrition problems. One factor inhibiting a shift in emphasis is that many social scientists resist and look down on "applied" work, which is currently underemphasized in training curricula.

## Rationale for Selecting this Topic

Societies with skewed income distributions and inadequate access to food on the part of the poor can make their largest impact on the nutritional status of women and children (and indeed on the population as a whole) by dealing directly with distributional issues. The potential for effective action on these issues can be viewed from two directions. On the one hand, the scope for action is tremendous. Significantly improved maternal and child nutrition could help reduce infant mortality rates in developing countries from the present 50-250 per 1,000 to levels approaching those of the developed world (10-30 per 1,000). On the other hand, the problems of achieving success on a global scale are large and complicated; FAO calculates, for example, that more than 300 million children suffer from grossly retarded physical growth. On balance, however, this panel feels that appropriate scientific and technological interventions can have a major impact on nutritional status (Scrimshaw 1974, Puffer and Serrano 1973).

U.S. interests in such interventions have three components beyond humanitarian compassion for suffering: (1) an effective means of modifying dietary behavior will be important in relation to U.S. problems of obesity and excessive caloric and "junk food" intake; (2) understanding the functional significance of malnutrition for individuals will facilitate better food and nutrition policymaking and planning in the United States; and (3) most importantly, the reduced human potential caused by poor maternal and child nutrition has indirect but definite effects worldwide.

## Proposed Initiatives

We recommend that the United States propose international collaboration on an expanded program of nutritional research, and pledge expansion of U.S. research and development and cooperation with developing countries on nutritional questions that are important to those countries. This initiative could build on and extend work of this type already being planned by AID and USDA, and by the United Nations University and other U.N. bodies.

Increased collaborative research is needed on the relationships among dietary intake, local environment, and human performance (e.g., performance at work or school, the frequency and severity of infections, physical and mental growth, pregnancy, lactation, family spacing, and general vitality). Additional knowledge is needed to plan, design, and evaluate more effective nutritional interventions. Research on the modification of local diets could profitably be undertaken jointly at the village and university levels, with the introduction of a counterpart plan for having interested American scientists working with colleagues from developing countries, both in the United States and overseas.

Research should be greatly extended on the development of new foods, such as the vegetable protein supplement Incaparina, which could be used as a weaning food with local modifications of the basic formulation. Research might also be conducted on modifying local diets for infants, young children, and pregnant and lactating women to conform to known dietary requirements for total calories, protein, iron and other minerals, and vitamins. Similarly, test marketing of potential foodstuffs is needed, along with more exploration of the possibility of fortifying local staple foods.

More relevant training for all types of applied social scientists in the nutrition field is also important. Their training should be carried out both

in the United States (at institutions that emphasize applied sociology, anthropology, psychology, etc., and also provide training in nutrition) and in developing countries. More specific actions by the United States could include: (1) funding and institution-building for such training for domestic and foreign students in both the United States and developing countries; (2) appropriate support for existing international institutions involved in nutrition research and field training; and (3) recognition that social and behavioral scientists are essential rather than peripheral members of international health, nutrition, and population program teams.

Modern marketing techniques could be adapted to nutrition education to stimulate dietary changes by individuals and families; for example, finding culturally acceptable terms to "advertise" the value of an available high protein food and explaining how to prepare it could increase its use.

## 5. Infrastructure for Primary Health Care Services, Including Maternal-Child Health and Family Planning

Adequate health care is especially important for the "poorest billion" of the world's population, particularly the mothers and children among them. Primary care should be simple and easily accessible, and much of it can be administered by community health workers with extremely limited training.

The basic health services package includes: maternal and child health care, immunizations, direct nutritional supplementation, family planning supplies and services, environmental sanitation, primary treatment of acute illnesses and accidents, and the educational components of all of these. Recent experience in family planning and other health care programs with rural, village-based service delivery, using members of the local community as health workers, has been extremely promising in bringing services to those most in need.

A major reason for the inadequacy of such services in many developing countries is an inadequate health care system or infrastructure, which includes the personnel who work within it, physical facilities, the arrangement and logistical support systems, and the health care methodology and technology that flow through it. Among the deficiencies found in many developing countries are:

-- Services simply do not reach or are inaccessible to a large proportion of the population in need, perhaps as many as 80 to 85 percent.

-- Services are sparse in rural and urban slum areas largely as a result of a gross maldistribution of facilities and personnel.
-- The health care system is dominated by physicians; developing countries (and developed countries as well) often fail to make optimal use of other health personnel. Current efforts to train and utilize various paramedical workers and community health workers need to be encouraged.
-- A poor balance exists between curative and preventive care. Curative medicine (hospital-based, high technology) usually dominates, particularly in urban areas.
-- The health care system, following the Western model, is dominated by high-technology, difficult-to-maintain, costly, hospital-based approaches to curative medicine, which are demanded by those who can afford such care. In the United States, an extreme case, this system has led to per capita health care costs that exceed total per capita income in many developing countries.
-- The health care system is often strongly centralized, highly bureaucratized, "top-down," and inflexible. Recognition of the needs for decentralization and more community and local participation are increasing.
-- The system is usually male-dominated. The role of mothers in child care and feeding cannot be long ignored. There is increasing recognition of the importance of women as health workers and in social change generally.

Several of these problems stem in part from Western value systems. To the extent that these values foster rigorous scientific or problem-oriented approaches to health care delivery, they are useful. But where they foster elitism or superspecialization, they are counterproductive.

## Rationale for Selecting this Topic

The provision of reasonably accessible and economical basic health care and family planning services for the world's poor deserves the highest priority. It could mean improved nutrition, decreased morbidity, increased survival (especially of infants and children), smaller families, longer birth intervals, increased productivity, and expanded opportunities for women. All these can mean a basic improvement in the quality of life. The knowledge and technology needed to provide these services are available. There is no doubt that we know how to

prevent many deaths, to improve health and nutrition, and to facilitate family planning. Thus the potential for effective action is very great.

To stimulate interest and action in addressing such problems, politicians, planners, and decision makers need to be shown that basic health services can be provided and that desirable results can be produced. Furthermore, a carefully planned package, based to the largest extent possible on local or community resources (including community health workers) need not be extravagantly expensive. It has been pointed out that the current health care/nutrition package in Sri Lanka has produced a life expectancy at birth greater than that in Washington, D.C., at a cost of less than $15 per person per year.

However well or poorly the United States is providing domestic health care and "containing" health care costs, there is no doubt that it can help developing countries that want to improve their health care systems. The United States has the technology, much of the medical equipment, the organizational and management skills, and useful experience working in developing countries.

## Ongoing Work

Many governmental and nongovernmental mechanisms exist for the direct in-country transfer of technology. The former include bilateral (AID, the Swedish and Canadian international development agencies, etc.) and multilateral agencies (WHO, the World Bank, UNFPA, UNICEF, etc.). The latter include foundations (Ford, Rockefeller, Volkswagen, etc.), educational institutions, voluntary agencies (CARE, International Planned Parenthood Federation, the Oxford Committee for Famine Relief of England), religious institutions, nonprofit agencies (Battelle Memorial Institute, Management Services for Health, Research Triangle Institute, Population Council, etc.), and corporations (Westinghouse, Whittaker). Professional associations such as the American Public Health Association and the societies for medical anthropology and medical sociology are also active in this field. The effectiveness of these mechanisms varies, but generally, the record is probably better when the transfer concerns "hard science" or technology than when it involves institution-building.

Another important transfer mechanism is the education of physicians, nutritionists, and family planning specialists from developing countries in the United States or other affluent countries. This mechanism has been criticized on the grounds that many

of those trained never return home, many of those who do return do so as specialists trained to practice a sophisticated kind of medicine inappropriate to priority needs, and many return with life-style expectations and income demands such that their services are effectively denied to most of their compatriots.

Despite these problems, many developing country physicians trained in affluent countries have played crucial roles in the transfer of health, nutrition, and family planning knowledge and technology. Universities such as City College of New York and Ben Gurion University in Israel have undertaken programs specifically directed at training physicians in primary health care. The record of physicians trained in schools of public health in the United States and elsewhere may be better than that of those trained as specialists in hospitals because of the greater concern of the public health profession with community-related problems.

## Proposed Initiatives

Much of the knowledge and technology at issue have existed for years and a variety of implementation or transfer mechanisms has been tried. Many of these mechanisms have worked well on a small scale; fewer have been effective on a large scale. Yet we have done little to learn from these trials.

We propose that the United States encourage international support for an expanded program of concrete demonstrations of feasible, effective, reproducible ways in which health care systems can be improved. This is proposed despite a somewhat disappointing past record of replicating successful pilot and demonstration projects (for a recent review of experimental efforts in the family planning field, see Cuca and Pierce 1977).

Such demonstration projects should be carried out jointly by both developed and developing countries and funded in such a way that the project can be replicated on a broad scale with local resources once the initial period is past. Most likely, developing countries will be represented by governmental institutions, but wherever possible private organizations, medical education and training institutions, and service agencies should be included in order to stimulate the long-term institutional development on which broad-scale replication ultimately depends.

On the developed country side, the approach might be bilateral or multilateral, through one of the U.N. agencies or the World Bank; large resources will be

required. Funding will necessarily be governmental, although actual implementation may be through nongovernmental organizations.

The scale of a given demonstration should be large enough to include all elements of an effective system or infrastructure, but small enough to be completed in perhaps three to four years. Officials often lose interest in longer projects, particularly ones with highly sophisticated, Western-type evaluation systems. For the scale of demonstration projects envisaged, trained and experienced local leadership is essential, with a carefully selected team of nationals, supported where appropriate by foreign technical advisers.

In addition to demonstration projects to strengthen and test large-scale improvements in health care systems, we recommend that the United States encourage and support a major expansion in fast, flexible small grant programs to facilitate testing and demonstrating innovations in individual program elements. Such innovations may cumulate to large-scale change over time.

The economic slump of the mid-1970s in developed countries adversely affected private small-grant programs for primary health services, and some have completely disappeared. Such programs are not expensive, even when they involve significant administrative costs. Yet they may be just beyond the capabilities of limited or highly rigid health care budgets in developing countries or just outside the ken of administrators who are faced with bureaucratic constraints and who are unfamiliar with research and experimental traditions.

At the same time, administration of experimentally oriented small grant programs may be troublesome to large agencies and national governments. Accordingly, small grant support may be effectively channeled through universities and nongovernmental organizations in some instances. One such program operating in Asia and Latin America is the Population's Council International Committee for Applied Research in Population.

Specific technological innovations that could be developed under such grant programs and that would be particularly useful at the village level include: (1) a more efficient clamp for the umbilical cord, either easily sterilizable or disposable and inexpensive, linked with additional education for local practitioners; (2) an inexpensive receiving blanket for keeping newborns warm; (3) prepackaged disposable needle and syringe packs with measured amounts of an oxytocin to prevent postpartum hemorrhage, or vitamin K, etc.; (4) a prepackaged, fixed dosage pack for oral rehydration or peritoneal fluid administration; and (5)

safe combinations of vaccines for administration in the neonatal period (BCG, smallpox, etc.)

Education, training, and community information relevant to primary care are needed for individuals and their families, health practitioners, and local midwives, community health workers, family planning fieldworkers, nurses, doctors, etc. For example, existing medically sound techniques, such as warming the baby after delivery by placing it close to the mother and putting warm blankets over both, could be reinforced in the practice of local midwives, while new techniques, such as measures to stop postpartum hemorrhage, could be introduced through training. As another example, physicians need to be taught how to function in the absence of a fully equipped hospital as well as within one.

### 6. Operational Planning and Management of Health, Nutrition, and Family Planning Programs

A delivery system designed to improve the coverage of health, nutrition, and family planning services inevitably entails large-scale and unique problems of management and coordination at all levels. Three important needs are: (1) large numbers of appropriately trained managers; (2) adequately functioning support services; and (3) effective supervision, communication, and feedback.

Health professionals are usually not oriented toward community efforts or trained in the social sciences or management techniques, while general administrators usually lack medical knowledge and are accorded low status in the health sector. Yet, as the importance of decentralization and the provision of a wider range of integrated services becomes accepted, the need for professionals with a proper balance of technical and managerial knowledge and skills expands. While hospital adminstration is a recognized discipline, the management of primary care is not, and the latter has unique features that require innovative training programs.

Basic health, nutrition, and family planning services also require adequate support systems which typically do not receive enough attention relative to personnel development and training. Personnel effectiveness is frequently hampered by the inadequate and unreliable delivery of medicines and supplies, equipment ill suited to local conditions and not properly maintained, and inadequate transportation and communication facilities.

Finally, the collection of operational information for routine administrative reports consumes

considerable time and effort. Its value for program planning, management, supervision, and evaluation purposes is often minimal, however, because what the administrator needs to know for improved decision making and supervision is seldom emphasized in the design of management information systems. An information system that focuses on the identification and care of severely ill, malnourished, or otherwise high-risk children may be more useful than a system requiring the time-consuming collection and reporting of a more comprehensive body of data. Both the United States and developing countries stand to benefit from wider application of this approach in health sector management.

## Rationale for Selecting this Topic

Management institutes in many developing countries are already directing more attention to the health sector. The International Committee on the Management of Population Programs also has experience in this field. The potential for U.S. participation is colored by an apparent paradox. On the one hand, this country is characterized by a distinctly pragmatic, problem-solving orientation and considerable experience with the development and use of management systems. On the other hand, U.S. domestic progress in managing primary health care has lagged, so that attention to the issues addressed above could substantially benefit this country as well as developing countries. In short, this is a field in which the United States has much to learn as well as to offer.

However, one important constraint should be noted. The application of basic management principles involves questions of management style that are behavioral and highly culture-specific. Even within the United States, the health sector and industry have distinctively different management features. Thus the U.S. role is likely to be somewhat limited and specialized, although local adaptation of management systems and in-country development of management competence deserve strong support.

## Proposed Initiatives

Initiatives that the United States could offer relate to the three concerns discussed above.

Management Personnel. U.S. training programs in hospital administration are being broadened to encompass health services administration generally. Moreover, schools of business are joining schools of

medicine and public health in offering programs in health services management. We suggest that the resulting developments in curricula be shared with developing countries, and that support for U.S. training of those who wish to teach health management in developing countries be provided. However, due to the idiosyncracies and culture-specific nature of the management of social services, much of the training envisaged must be adapted to local settings and provided in developing countries themselves. Thus U.S. universities and management groups and concerned institutions in developing countries might work together to develop centers in those countries for training population, health, and nutrition system planners and managers.

Support Services. A number of private U.S. firms with considerable experience in the systems approach generally and with specific management support systems have begun to apply their expertise to the health sector. Federal assistance is already being used to some extent to channel this expertise toward the needs of developing countries. We suggest that this effort be encouraged, taking care that conditions unique to developing countries are recognized. For example, certain recent developments in communications technology, selectively transferred, might usefully be applied in developing countries. The United States has much to offer in the way of hardware (e.g., vehicles and equipment), although such assistance must be provided flexibly to account for local conditions. Even more important, however, is the transfer of appropriate software (e.g., training for maintenance capability).

Effective Data Collection, Communication, and Feedback. Innovative methods of collecting data and efficient methods of analysis and feedback to provide for minimal information needs are major planning and management concerns in both the United States and developing countries. In contrast to vital statistics and health statistics, however, the field of health management statistics remains poorly developed, apart from some activities involving American hospital management. Developing countries might find it useful to have statistical information systems for basic population, health, and nutrition services which would improve decision processes and afford at least minimal comparability among regions and among countries. We believe that private U.S. management groups, professional hospital associations, universities, and population/family planning organizations could assist in developing such systems.

The hardware and software available for analysis are developing rapidly. For example, large-capacity

minicomputers are increasingly available at declining costs, and mechanisms for facilitating their use should be encouraged. The resulting rapid feedback of information to operational levels could improve supervision and evaluation of program performance and would promote an appreciation of the importance of data among those who must generate them in the first place.

## 7. Policy Planning and Basic Data Systems

Effective planning and an improved data base are essential for successfully implementing the initiatives proposed in other parts of this report.

### Policy Planning

Population, health, and nutrition programs are closely linked in many settings and should usually be coordinated. This means creating, on a national basis, planning units in these and related fields with competence in economic analysis, quantitative planning technologies, management and administrative technologies, and sectoral technical expertise. A need for such a unit in the population field was enunciated in paragraph 95 of the World Population Plan of Action (U.N. Economic and Social Council 1974):

> Population measures and programmes should be integrated into comprehensive social and economic plans and programmes and this integration should be reflected in the goals, instrumentalities and organizations for planning within the countries. In general, it is suggested that a unit dealing with population aspects be created and placed at a high level of the national administrative structure and that such a unit be staffed with qualified persons from the relevant disciplines.

A social development and planning unit of the type suggested would draw on and relate to planning staffs within individual ministries or single-sector institutions such as a ministry of health. Its chief function would be to apply an integrated systems approach to analysis of development problems, programs, and policies, and to the implied needs to gear these more effectively to health-related goals.

In both its public and private sectors, the United States has competence in assessing technologies, analyzing environmental impacts, concepts of resource

allocation, cost-benefit analysis, cost effectiveness, forecasting models, and other planning techniques, all of which can be useful in implementing a systems approach to planning in developing countries. Except at theoretical levels, however, U.S. resources covering the requisite disciplines have not been well organized or applied in the integrated manner proposed. Thus successfully applying these resources would benefit the United States as well as the developing world.

The key mechanisms operative at present are largely in the private sector--universities, research groups, and business firms. By providing information and consultants and by training developing country nationals, these groups are in effect exporting an approach and a point of view on social programs. As matters stand, the approach taken is frequently a single-purpose one; so that these groups must seek to redirect thinking on these topics. This will not require developing new technologies as much as adapting existing technologies through new approaches to training and technical assistance. Integrative socioeconomic systems planning is a means of implementing technological adaptation as well as a technological change in and of itself.

The U.S. government can strengthen these moves by financially supporting the efforts of such groups to broaden their teaching and research and development approaches. AID's program in population and development policy is one example.

Proposed Initiatives. To facilitate socioeconomic planning related to health, we suggest that the United States offer to: (1) identify several leading institutions in the United States and developing countries currently using the systems approach to planning; (2) strengthen such groups financially to foster research collaboration among themselves and with developing country organizations; (3) offer scholarships to students from developing countries earmarked for studies in this field; and (4) select and publicize successful case studies of integrated planning and technology transfer in the family planning, health, and nutrition fields.

Three major constraints to successful action by the United States should be considered, none of them insuperable: (1) the technical/organizational/behavioral complexities involved in developing an integrated approach, (2) problems with adapting appropriate levels of the disciplinary technologies to be deployed, and (3) cross-cultural differences in the approach to and use of these technologies.

The stress should be on developing and strengthening national and regional institutions in deve oping countries (in the public and/or private

sectors) rather than on bringing large numbers of developing country nationals to the United States for technical training. U.S. training should be reserved for those involved in highly specialized programs that cannot be easily and economically established in developing countries. Cooperative relationships between U.S. universities and other institutions in developing countries to transfer needed planning skills have also been successful in some instances.

## Basic Data

National efforts, assisted in many instances by the U.S. Bureau of the Census and the United Nations, have considerably improved the collection of census data in many parts of the developing world, although technical assistance and research and development are still needed, especially to find lower cost systems. With respect to the registration of births and deaths, the situation is less favorable. Although vital statistics is an important field, neither the United States nor the United Nations has enough special expertise that is wholly and directly applicable to statistical systems in developing countries.

Three approaches to the collection of vital statistics might lead to major improvements: (1) increased emphasis on registration of vital events; (2) choice of representative sample areas where special care can be taken to register all vital events as in some of the projects assisted through the International Program of Laboratories for Population Statistics of the University of North Carolina (selection of such areas for statistical purposes should not necessarily mean that they receive additional inputs for health, nutrition, and other developmental programs); and (3) development of dual record systems which tend to provide considerably more complete reporting than can either single system alone. In dual record systems, vital events enumerated in the first source but missed in the second and vice versa are identified by matching (record linkage), and an estimate is made of those missed in both sources assuming independence of sources.

Household sample surveys are used for a variety of purposes, particularly in the population field (for example, to estimate levels and trends in employment and unemployment, migration flows, fertility patterns, and school enrollment). Similarly, they are used for establishing health status, anthropometric measurements, and use of services. The United States has found periodic sample surveys to be an important guide to improvement of services, and other nations are

likely to benefit from them. Either the U.S. Bureau of the Census or a body such as the International Statistical Institute could provide a training and advisory mechanism for organizing and carrying out low-cost household surveys relating to population and health, and perhaps to some aspects of nutrition. The U.S. Center for Disease Control and various university and private groups could also assist.

Periodic surveys generally require a permanent organization, with highly trained professional staff in a number of disciplines (mathematical statistics, operations research, applied statistics, social psychology, economics, and data processing), as well as qualified interviewers and supervisors. The United States could share its experience in developing, organizing, and operating survey systems, and could assist with the required adjustments to developing country conditions, including devising lower cost approaches, and with academic and on-the-job training.

Sample surveys can provide definitive information at an aggregate geographical level but may be inadequate for identifying programmatic implications at the local level. The United States has a need for, and some experience in, developing methods for obtaining synthetic estimates of local conditions from national data, and should welcome collaboration in further efforts in this direction.

Intensive interviewing, participant observation, and related microstudy field techniques yield a type of information that complements that obtained through surveys. Ideally, selection of study areas should be based on sampling frames. Intensive studies conducted over one to two years require trained, linguistically competent professionals. Shorter term studies using similar techniques can be aimed at more restricted, specialized problems. Such microstudies identify the socioeconomic context within which different levels of reproduction, health, and nutrition occur, and help in the interpretation of survey results. They shed light on validity (the extent to which a measuring instrument measures what it purports to measure), on process (not just "what," but "how"), and provide depth to complement the breadth of surveys.

Much time, effort, and money can be saved if efficient networks for information retrieval, dissemination, and storage can be devised, installed, and maintained. Many kinds of networks for sharing information could be established, and the United States has experience, and some expertise, in applying such systems in the health and population fields. While such systems tend to be demanding in terms of hardware and personnel and relatively expensive, they can be cost-effective in some instances. The United States

should share information and expertise upon request. For example, it could provide access to already developed computer-based information systems, together with the software necessary to operate such a system, and could participate in the exchange of new information on a continuing basis wherever this is cost-effective for all parties concerned.

Proposed Initiatives. While the long-run outlook for improving the social sector data base is good, there are several constraints. These include:

-- low priority accorded statistical systems in some developing countries;
-- lack of appreciation of the multiple values of vital registration for legal, health service, and economic planning purposes;
-- lack of need by individuals in some countries for birth and death certificates;
-- shortages of trained personnel;
-- lack of professionalization of statistical offices, with advancement based more on longevity than performance;
-- hardware requirements that are costly and demanding in terms of trained personnel for census processing and for information retrieval;
-- inadequate understanding of systems development for information storage and retrieval except by a few persons;
-- high personnel and monetary costs of operation and maintenance of currently available information retrieval systems.

Recognizing these problems, we nevertheless believe that the United States could usefully offer to expand its support for developing country initiatives to improve their basic social and economic data systems, particularly those most essential for planning health, nutrition, and family planning services. This would include support for research and development to develop lower cost systems designed to get at least the minimum essential information on a timely basis under specific developing country conditions. The United States could also facilitate the use of minicomputers by providing hardware, training, and the necessary editing, processing, and standard analytical routines.

## EPILOGUE

Some of those on this panel who have lived or worked abroad have come to question whether truly significant changes are likely in population, health, nutrition, and other social welfare sectors without

fundamental changes in political, social, and economic systems. Scientific and technological change will produce improvements in human welfare, but far greater advances could follow from a commitment to general social change and basic human rights. A most important barrier to social and economic development is institutional and bureaucratic indifference.

Evidence from developing countries indicates that where the standard of living of the poorest segments of the population has improved somewhat, health has improved, based on such indices as decreases in infant mortality and crude death rates and increases in life expectancy. Thus equity issues, specifically income redistribution, and standard of living are of utmost importance in achieving improvements in the fields of population, health, and nutrition. Indeed, without such equity medical science and technology may have limited usefulness.

In the industrialized nations, health indicators improved substantially even before medical science and technology had much to offer. Thus it should be stressed at the 1979 U.N. Conference that dramatic improvements in the quality of life in developing countries are possible without new technological advances in the health field, but rather through more appropriate and widespread adaptation, transfer, and application of what is already known and available.

A basic difference between the United States and most developing countries in the manner in which social services are provided must also be kept in mind. In this country, health, nutrition, and family planning services are largely delivered through the private sector, private doctors, private pharmacies, and other private institutions. Through marketing techniques, the private sector often has been more successful in disseminating innovation than has the public sector. On the other hand, much of the population of most developing countries depends on the public sector for these services, although, due to a lack of effective health care facilities and professionally trained personnel, many people also use private pharmacies, drugs from small general stores, and private, indigenous, or traditional health care providers. Since much of the technological and managerial expertise and many of the financial and other resources in the United States are found in the private sector, much of the technology is proprietary in nature. Consequently, if the United States is to make a major contribution to health and socioeconomic development in Africa, Asia, and Latin America, special efforts must be made to enlist the capacities of the private sector.

This panel also believes that Americans would do well to contemplate changes in their consumption

patterns--for their own sake as well as to accommodate the justifiable needs and desires of developing countries in a time of growing resource shortages. The extravagance of current American resource consumption patterns covers a broad spectrum, from medical facilities to diets to modes of recreation and transportation. The health benefits of a simpler diet, with less meat, fat, and sugar, could be substantial for the average American and additional benefits can be expected from less resource-intensive life-styles in other dimensions. The need for Americans to consume a smaller proportion of the world's resources should be taken as an opportunity to reap some of these benefits, rather than as a threat to material well-being. We recognize that changes in consumption patterns are generally difficult to achieve. But with research to clarify the anticipated benefits and with inspired leadership it may be possible.

In general, we support the widely held view that technical and financial assistance from the industrialized nations be directed to needs identified by responsible developing country officials. In some cases, however, such officials represent an elite whose perspective may well not represent the needs of the majority of the people. For example, a costly modern hospital or a sophisticated, specialized piece of medical equipment may benefit a few, but requests for such items must be considered in context; the need for support of rural primary care facilities is far more urgent. Two closely related problems, which unfortunately occur quite frequently, are (1) inappropriate and/or inexpert advice offered by medical and other foreign advisers, distinguished perhaps in their own fields in the United States or elsewhere, but inexperienced in international cross-cultural health problems and priorities; and (2) inappropriate advice from Western commercial interests, which also may not relate to the needs of the majority.

In the health field, a large number of pilot and demonstration projects have been conducted during the past 25 years, and there is a need to continue such projects. However, the success of pilot projects has often been related more closely to motivation, commitment, and dedicated local and foreign leadership at the project level than to general advances in organization, structure, or planning. Such commitment on the part of the central political and/or ministerial leadership is essential but often lacking. Without it, significant improvements are difficult, if not impossible. Similar good faith and commitment are necessary on the part of multilateral, bilateral, and private assistance agencies.

## CITATIONS


Berg, A. and R. Muscat (1973) The Nutrition Factor: Its Role in National Development. Washington, D.C.: The Brookings Institution.

Berman, M.L., et al. (1972) Effect of breastfeeding on postpartum menstruation, ovulation, and pregnancy. American Journal of Obstetrics and Gynecology. October 15.

Commission on Population Growth and the American Future (1972) Population and the American Future. Washington, D.C.: U.S. Government Printing Office.

Cuca, R. and C.S. Pierce (1977) Experimentation in family planning delivery systems: an overview. Studies in Family Planning 8(12):302-310.

Gordon, J.E. (1975) Synergism of Malnutrition and Infectious Disease. World Health Organization Monograph No. 62. Geneva.

Greep, R.O., et al. (1976) Reproduction and Human Welfare: A Challenge to Research. Cambridge: Massachusetts Institute of Technology Press.

Kegan, L. (1978) Statement on population. National Research Council Forum on Science and Technology for Development. New York Polytechnic Institute, Brooklyn, January 24.

Klein, R.E., et al. (1976) Effects of maternal nutrition on fetal growth and infant development. PAHO Bulletin 10:4.

Puffer, R.R. and C.V. Serrano (1973) Patterns of Mortality in Childhood. Washington, D.C.: Pan American Health Organization.

Saunders, R.J. and J.J. Warford (1976) Village Water Supply: Economics and Policy in the Developing World. Baltimore: Johns Hopkins University Press.

Scrimshaw, N. (1974) Myths and realities in international health planning. American Journal of Public Health. August.

Stein, Z., et al. (1972) Nutrition and mental performance. Science 178:708.

United Nations (1977a) Report of the U.N. Water Conference. New York: U.N.

United Nations (1977b) U.S. Position Paper on Community Water Supplies for the U.N. Water Conference. New York: U.N.

U.N. Economic and Social Council (1974) World Population Plan of Action. Proceedings of the World Population Conference, E/5585. Bucharest.

UNICEF/WHO (1953) UNICEF/WHO Joint Committee on Health Policy, 6th session, May.

Winick, M. (1976) Malnutrition and Brain Development. New York: Wiley.

World Health Organization (1976a) Expanded Programme for Immunization Programme Statement. November 30.

World Health Organization (1976b) Onchocerciasis. WHO Chronicle 30(1):18-21.

World Health Organization (1977) Special Program for Research and Training in Tropical Diseases. WHO Document, TDR/AR(1)/77.1, Annual Report.

# Chapter 4

# FOOD, CLIMATE, SOIL, AND WATER

## INTRODUCTION

### Scope of Assignment

This panel has taken a comprehensive view of food, focusing on the role of science and technology in its production, harvesting, marketing, processing, preservation, preparation, and consumption. We have given primary emphasis to those aspects of climate, soil, and water that contribute to food for human consumption, although concerns for the management and conservation of these resources extend beyond food. Natural resources in a more general and comprehensive sense are covered in Chapter 5.

### The World Food Situation

It is questionable whether enough food can be produced during the decades ahead to meet the caloric and nutritional requirements of the world's population. Thus few subjects are of greater concern than improving the methods and techniques used to satisfy requirements for food.

Discussions of the world food problem are too often put in global and national terms and lose sight of food consumption and production at the level of the individual. In advancing our proposals, we have attempted always to keep in mind their usefulness to the individual consumer and producer of food. Much of the world's food is grown and consumed within individual units or in relatively small areas. Stultifying drudgery is still required, particularly on the part of rural women, for agricultural production, the preservation and preparation of food, and the collection of water and fuel for cooking. Thus it is

difficult to imagine a greater return from the improved use of science and technology than the application of technology in the production, preparation, and preservation of food at the village level.

Increases in food production depend on the adoption of selected technologies by millions of consumers and producers, and governments must facilitate the continuous transfer of technologies that would be useful in particular circumstances. No one project, no matter how ambitious, will ever "solve" a developing nation's food problem.

High energy prices and the difference in capital/labor availabilities have forced the use of labor-intensive agricultural technologies in developing countries. Yet this does not eliminate the great need for labor-saving and toil-saving technology (e.g., animal traction and carts, hand grinders, drying ovens, pressure cookers, and pumps). Indeed, sight should never be lost of the individual users who ultimately decide whether a particular technology is "appropriate" to their needs and goals.

Most people depend on others for at least part of the food they consume, and some form of market organization is used to bring producer and consumer together. The role of governments in making markets possible, in regulating markets, or in substituting government activity for direct markets varies greatly. But, regardless of the type of marketing system used, food producers need incentives to maximize production.

Inappropriate price structures may be one of the more serious obstacles to the effective transfer of technology pertaining to food, climate, soil, and water. Most countries want to pursue policies that will result in low-cost food to the consumer for both political and humanitarian reasons. Yet a low-cost food policy may mean that farmers are insufficiently motivated to increase the amount of food produced over that consumed by their immediate families and close associates. Substantial literature exists demonstrating the remarkable response of food producers under quite different conditions to appropriate incentives (Schultz 1978). Of course, no matter how productive agriculture might become, food cannot be sold to people who cannot afford it. Thus progressive income distribution and programs to improve the income of the very poor are important in increasing purchasing power, while at the same time improving the farmer's incentives to increase productivity.

Food is a principal U.S. export and the question arises as to whether U.S. interests would be damaged by successfully undertaking initiatives that would help to increase food production in developing countries. In this regard, two forces are at work which typically

move in opposite directions. On the one hand, a "substitution effect" occurs rather quickly when food produced abroad results in a reduction of food exports. On the other hand, increased food production abroad will result in higher incomes and greater demand for goods and services generally, including food--this might be called an "expansion effect." Much empirical evidence indicates that the expansion effects will outweigh the substitution effects from increased food production abroad. Thus, while there may be adjustment problems for certain U.S. producers, they would tend to be offset by other gains for U.S. agriculture and the U.S. economy.

We emphasize six areas for enhancing the contribution of science and technology to food production, giving special weight to immediate impact and the development of local capabilities for both planning and research. These areas are:

1. Reducing food losses (harvest and postharvest)
2. Water management for irrigation
3. Weather and crop information systems
4. Farm and land-use planning for sustained food production
5. Plant and animal protection
6. Management systems for sustained crop production

U.S. capabilities for applying science and technology to food problems extend far beyond the six areas selected. Moreover, our ability to apply these capabilities to developing country problems has been greatly enhanced by extensive technical assistance in agriculture over the past 25 years. This selection is not intended to suggest any diminution of the past U.S. technical assistance role. Rather, we recommend that the United States stand ready to continue and expand its collaboration on food problems on a broader basis than the six areas emphasized here.

One outstanding example of such an opportunity is basic research on improving the biological productivity of crops, which involves genetic improvement, nitrogen fixation, and the enhancement of photosynthesis. This kind of research is being stepped up in the United States, and it has the strong support and cooperation of many developing countries. Such research contributes to the development of the science base on which increases in productivity ultimately depend.

## OPPORTUNITIES AND PROPOSED INITIATIVES

### 1. Reducing Food Losses (Harvest and Postharvest)

The maximum benefits of food production can only be realized by preventing as much as possible any losses between production and ultimate consumption. Food losses can take the form of decreases in quantity or quality, both of which diminish nutrition. Food products are prone to biodeterioration, chemical degradation, and attack from insects, birds, rodents, mold, and other microorganisms. To enhance the storability of foods or to convert raw foods into forms more suitable for human consumption, food usually undergoes conversion or processing. Often these conversion processes are inefficient and further losses are incurred.

A resolution of the Seventh Special Session of the United Nations General Assembly (1975) states that "...the further reduction of postharvest food losses in developing countries should be undertaken as a matter of priority, with view to reaching at least 50 percent reduction by 1985." Estimates of food losses from harvest to consumption range upward from 10 percent for grains and legumes and 20 percent for perishables, but exact figures on the different types of food losses in various countries are difficult to obtain. Whatever they are, their reduction would increase food supplies, with the virtue of not seriously disturbing the life-style of the people concerned. Such measures do not alter methods of producing food, nor do they require introducing unfamiliar types of food.

All societies use some method of food preservation. Many of the basic principles required to preserve food have been established and are immediately available through properly trained food technologists. However, there is a need for further research and development on low-cost preservation systems suitable for rural areas in the tropics.

Postharvest food losses may result from many causes other than those related to preservation. For example:

-- Harvest may not take place at the proper stage of development. If immature, the product may lack palatability or nutritive value, or both. If too mature, excessive spoilage will occur, resulting in large harvest losses.
-- Inadequate equipment may fail to harvest the crop efficiently, with excessive field waste.
-- Excessive moisture may lead to mold growth and the development of other microorganisms, while excessive dryness may result in shattering, breakage, etc. Postharvest losses are usually much

more extensive when moisture levels are high, creating conditions for increased fungal and insect attack.

Existing technologies and trained technologists could be used in the application of postharvest loss-reduction techniques geared to the differing needs of the following groups:

-- Small farmers and landless labor where little or no money is available, family labor is abundant, only local materials are available, and extension services are inadequate. Women are a particularly important target group in this category. Too often assistance programs have provided rural men with training, credit, and tools and deprived poor rural women of whatever economic status they possessed.
-- Medium and large farmers (including village grain merchants) where cash resources and hired labor are available but access to modern technology is limited.
-- Government and quasigovernment operations where international credit and aid and large-scale technology are available but technical skill is weak.

Some of these problems can be alleviated by appropriate use of known technologies. Others, in which technology is not known, present opportunities for further exchange of information and cooperative research, e.g., on protection of perishables from the excessive heat and humidity of the tropics. Social science research is also needed on why so much food is lost when the need for food is so acute; the results of such research will be of value in designing training and educational programs. Particular attention should be given to the need for more technically trained men and women, especially at the village level, and not necessarily to a need for more Ph.D.s.

## Rationale for Selecting this Topic

Governments, donor agencies, and research groups have usually emphasized two strategies for coping with current and future demands for food: (1) increasing food supplies by increasing production, and (2) reducing future demand by slowing population growth. A third strategy that would complement these has been given much less attention by the international development community: reducing and preventing postharvest food losses.

The reduction and prevention of food losses has important potential for developing countries. It would substantially reduce requirements for additional food production in the short and medium term, and, in some cases, would reduce dependence on imports. Some developing countries could also increase food exports. Finally, reduced losses may increase the disposable income of the rural poor, who often spend most of their income on feeding the family.

As a major producer and exporter of food crops, the United States has an array of research and development groups with some expertise in postharvest activities. A partial listing of these groups includes:

-- Federal government agencies, such as AID, USDA, the Peace Corps, the U.S. Food and Drug Administration, and the Overseas Private Investment Corporation.
-- Private, profit-oriented corporations such as Technology Resources, Inc., FMC Corporation, Del Monte International, Hunts, Archer Daniels, Ralston Purina, Pillsbury, and General Mills.
-- Universities and experiment stations, including land-grant or sea-grant universities, and groups such as the Consortium for the Development of Technology and the Midwest University Consortium for International Affairs.
-- Private sector research and development organizations such as the Denver Research Institute, Battelle Memorial Institute, and Stanford Research Institute.
-- Trade associations such as the American Soybean Association and National Canners Association.
-- Professional societies and associations such as the Institute of Food Technologists and the American Association of Cereal Chemists.
-- Private, nonprofit groups such as International Appropriate Technology, Inc., the Rockefeller and Ford foundations, Catholic Relief Services, CARE, and the League for International Food Education.

Nevertheless, understanding of postharvest losses remains inadequate and a development assistance agencies around the world are showing increased interest in generating further expertise. A dozen or more members of the Consultative Group for International Agricultural Research (CGIAR) have shown interest in informal consultation to coordinate efforts in this field. A collaborative program among three of these (AID, the Canadian International Development Research Centre, and the Canadian International Development Agency) is stimulating research and development in Asian countries. Another collaborative grouping (including U.S. participation via Kansas State

University) is GASGA (Group for Assistance to Storage of Grains in Africa). FAO and the United Nations University are seeking to expand their work on postharvest losses. AID is searching for productive new initiatives and has commissioned a preliminary fact-finding study by the National Research Council.

## Proposed Initiatives

A more effective mechanism is needed for involving the above U.S. and non-U.S. institutions more deeply in cooperative, action-oriented programs relating to postharvest food losses. In addition to expanding its own activities, we recommend that the United States propose and support establishment of an appropriate coordination mechanism charged with encouraging greater mutual support among the expanding worldwide activities. An international coordinating council could be responsible for meshing national and international efforts to reduce and prevent postharvest food losses, building on and consolidating the current partial efforts of coordination.

The council, aided by a small central staff but depending largely on implementation by member organizations, could support or foster the following types of activities and possibly others:

-- Developing loss assessment methodologies for such nongrain commodities as roots, tubers, fruits, vegetables, and fish, including field testing and publication of these methodologies and guidelines for policy planners and project planners on cost-effective means for reducing food losses.
-- Developing and maintaining an international inventory of resources and expertise to assist in programs to reduce postharvest losses.
-- Establishing suitable training programs. Examples might include regional programs in developing countries to train the personnel critically needed to conduct loss assessment surveys and to implement intervention schemes, or short courses and apprenticeship programs for nondegree professionals in such technical subjects as grain fumigation or construction of storage structures. Placement services for students in this field might also be useful. Coordination with the Peace Corps and nongovernmental programs in grain storage would be highly desirable.
-- Helping governments survey and assess losses and fostering research that would explain why food losses occur in areas where food is so badly needed; studying the role of women in postharvest

food handling with a view to maintaining or enhancing their economic security.

-- Assisting governments to design and implement multidisciplinary programs for reducing and preventing major losses identified by assessment surveys. This could include developing and studying economic and social indicators relating to postharvest food losses. These studies will help evaluate the role of loss prevention schemes in agricultural production programs and overall development strategies.

-- Strengthening information systems that can be used by researchers, policymakers, and project planners in developing countries, including support for collecting and cataloguing relevant documents, books, and periodicals, and producing up-to-date postharvest bibliographies.

-- Identifying and/or developing low-cost equipment to reduce food losses such as solar grain driers, low-cost refrigeration, or simple cooling methods; supporting research and development as needed to integrate these into food handling and marketing systems.

-- Monitoring postharvest activities of donor groups and research institutes and encouraging them to participate in cooperative projects likely to improve results or reduce costs.

-- Developing ways to involve the private sectors in both developing countries and the United States in programs to reduce food losses. Incentives need particular attention. Direct foreign investment, where it is compatible with long-term national objectives and capabilities, will continue to be a very effective way to improve agricultural output and to provide for long-term development of agroindustry. The U.S. private sector could be brought into these programs under proposals outlined by the U.N. Industrial Development Organization (UNIDO) in its Industry Cooperative Program for countries where conventional methods of involvement are not permitted or practical. The private sector in developing countries, either local or transnational, must be brought into programs early to increase the likelihood that the programs will be continued after the completion of the initial phase. Many good projects fail because governments, no matter how well intentioned, are poor business operators and lose interest when more pressing problems become apparent.

## 2. Water Management for Irrigation

Only about one-seventh of the world's 1.4 billion hectares of cropped land is irrigated, but in terms of value these lands produce almost as much food as all nonirrigated lands (Kovda 1971, NRC 1977:66-67). Irrigation makes it possible to produce crops or gain higher yields on lands otherwise too arid, to extend growing seasons and to increase the prospects for multiple cropping in wet-dry climates, and to insure against short-term droughts during abnormal seasons.

Heavily populated areas of developing countries essentially have no new lands to bring under cultivation, so that intensification of farming is essential if enough food is to be produced. For example, production of rice seldom rises beyond 1.5 tons per hectare without irrigation (Takase and Kano 1969:513-551); with it, this figure can usually be doubled. Moreover, water control can increase the impact of other inputs such as fertilizer and pest management, which are otherwise of little value. Such practices as soil management, crop and variety selection, fertility interactions, pest and weed control, seeding methods and rates all influence yields and are important before production can reach full potential in an irrigation system. For example, the combination of water control and other modern inputs can result in rice yields of 7 tons per hectare and up.

The situation is similar for upland crops grown under irrigation. If irrigation is employed in wet-dry tropical, subtropical, and even temperate areas, two or three crops can be grown where only one would otherwise be possible.

### Rationale for Selecting this Topic

Irrigation is a major area for capital investment in the developing countries, where there are already some 92 million hectares of irrigated land. Yet investments in irrigation have often failed to pay off as planned. Increases in yields fall far short of expectations and waterlogging and salinity too often accompany irrigation. The principal reason for these deficiencies is that the delivery of water to the fields and the distribution of water on the fields are remarkably inefficient, both physically and in terms of management. Water is not delivered when it is needed, and as much as 75 percent is wasted. Not only is this inefficient, but it is a major cause of waterlogging and salinity. The basic capability to diagnose and correct this difficulty is available. Therefore, we propose an accelerated program to help improve farm

water management for irrigation and thus production on the farmer's field.

It has been projected (FAO 1977) that the following new developments, estimated to cost $100 billion at 1975 prices, will be needed by 1990 to make even moderate gains in per capita food production in developing countries: 22 million hectares of newly irrigated land, 45 million hectares of rehabilitated irrigation systems, and 78 million hectares of improved drainage. But increasing production by only 10 percent on existing irrigated land in the developing countries would produce the same increase as 9 million hectares of newly irrigated land which, using FAO-estimated prices, would cost $25.2 billion. Moreover, unless yield potentials from irrigation are realized more fully, costly investments in new irrigation can hardly be justified. Although improvements in physical drainage works are important on many projects, good farm water management systems would help solve many problems of waterlogging and salinity.

## Ongoing Work

The United States possesses a large stock of farm irrigation technology, both hard and soft, and has had considerable experience in helping to adapt this technology to conditions in developing countries. Universities in the western United States began research on this problem about 80 years ago and for the next half century state extension services, the Soil Conservation Service (SCS), the Bureau of Reclamation, together with private manufacturers of irrigation equipment and a limited number of consulting firms, gained competence and experience. More recently, AID, with university and USDA assistance, has gained experience in developing countries.

Other experienced agencies and institutions include the international lending agencies, FAO, some of the international research centers, and agricultural organizations such as the International Agricultural Development Service (IADS) and the Agricultural Development Council (ADC).

CGIAR has since its formation been greatly concerned about farm water management. It is convinced, however, that the answer will not be found in an international research center in the mode of the International Rice Research Institute (IRRI) or the International Maize and Wheat Improvement Center (CIMMYT), because the problem is not primarily research, but rather diagnosis and innovative experimentation, i.e., a "clinical" approach is needed.

The key to improving work on irrigation problems appears to be improving the network for communication and training. This might best be done regionally and FAO could provide substantial global backup. The international agricultural research centers would probably not lead in this effort because their predominant focus is on specific crops and production systems. They can, however, gain as well as contribute by participating in any network relating to irrigation and water management.

Some rudimentary models for transferring farm management technology have been developed in Southeast Asia by the ADC and IRRI. FAO and the Asian Development Bank have held regional workshops and FAO has developed a substantial information-sharing effort.

One possible model for an international network on farm water management is the International Council for Research on Agroforestry (ICRAF), developed as a result of a study sponsored by Canada's International Development Research Centre (Bene et al. 1977). A small central ICRAF-like staff would be responsible for stimulating research and technology transfer efforts but would not engage in them directly. It would also synthesize, collect, and disseminate information, and provide opportunities for interested parties to assess the need for and to plan coordination of research and development. CGIAR is supportive of ICRAF, although it is not officially within the scope of CGIAR's activities.

Whatever networks may be developed, the concerned countries should have the major conceptual and administrative responsibility for national solutions.

## Proposed Initiatives

We suggest that the United States announce its interest in helping solve water management problems by:

1. Strengthening bilateral financial and technical assistance for such activities as (1) helping developing countries establish regional or national farm irrigation institutions for diagnostic analysis and the exchange of information (in most situations, on-farm facilities and schedules are left up to the farmers, so that there are invariably organizational problems with fairly complex human and social ramifications: in-country requirements include strong government program support and training of technical and extension-type personnel and water system managers); (2) regional or in-country farm water management workshops for technicians and administrators; (3)

training programs for technicians and extension personnel; and (4) offering, with other donors, to increase financial assistance under concessional terms and provide technical assistance to investment projects designed to improve farm water management, subject to suggestion 2 below.

2. Enunciating a policy that would encourage ties between financing for new irrigation and improvement of existing projects. Recipient countries could be asked to undertake to improve farm water management as part of lending packages for irrigation development generally. Many developing countries are now quite conscious of the problem and generally would welcome assistance. Concessional loans might be weighted toward improving the farm end of the irrigation operation.
3. Supporting a stronger FAO program of information dissemination about farm water management.
4. Promoting the organization of an international council on farm water management along the lines of ICRAF for the purpose of stimulating research and research collaboration, technology transfer, and the dissemination of information.

### 3. Weather and Crop Information Systems

Weather variability[1] is the single most important factor affecting fluctuations in world food production. Even if we had technology for modifying weather on a large scale, we would probably still have to live with weather variability for the most part. In terms of its effects on agricultural production, we can best live with weather variability through: (1) improved forecasting of changes in the weather, (2) taking protective steps to reduce the impact of unfavorable weather, (3) taking advantage of favorable weather, and (4) using our understanding of crop/weather relationships to project growing conditions so that improved policy decisions about food supplies can be made on a national and international basis.

More sophisticated modeling techniques for forecasting weather, reducing risks of weather impacts, and monitoring the impacts of weather variability are rapidly being developed. However, countries vary in levels of advancement in this area both geographically and with respect to different types of agriculture. Only about one-third of the world could be considered well advanced with respect to crop/weather data collections, with parts of Africa and the Caribbean being the least well covered. Countries also vary in their knowledge of crop/weather relationships; some countries are quite advanced, while others still

require basic model definition. For some important tropical food crops such as cassava and plantain, we do not even have a basic understanding of crop/weather relationships.

## Rationale for Selecting this Topic

Knowledge about the impact of weather on crops can be of value throughout the food production spectrum, from farmer to consumer. Farmers can reduce seed, crop, and water waste by knowing better when to plant, irrigate, and harvest. Specifically, they need to know whether or not the first rain of a season marks the advent of solid rains which will provide ample soil moisture. As a climatic profile of an area is developed, the most appropriate crops or strains of crops can be selected. At the national level, government can react more quickly to the conditions brought on by a drought or frost. In general, countries and individuals will benefit by developing confidence in making decisions through knowing the risks involved.

The transfer of crop/weather technology offers a large potential for increased and more efficient food production and marketing in developing countries; much of the technology and methodology is readily transferable. Many locales will require the development of new but simple instruments and trained personnel to record plant growth and weather data. But all countries have weather and agricultural services in place which can begin to install, maintain, process, and use such data.

The Sahel is a case in point. Weather services, largely devoted to aviation, were left in place by the French; however, they needed considerable renovation to provide the weather data and forecasts required to support agriculture and pastoralism. Observational coverage needed modest expansion and technicians had to be trained, a process that takes approximately two years. Now through an international effort funds have been provided for installing weather and hydrological equipment, and a regional training center has been established in Niamey, which is wisely focusing on integrated agricultural-meteorological-hydrological skills.

The development of global weather data systems from satellite information could also have far-reaching effects on improving weather forecasts in developing countries. With relatively small investments in ground receiving equipment, these countries would be able to make use of information resulting from relatively large investments in satellites by developed countries.

The United States is in a good position to help the developing countries by transferring experience in using weather information for agricultural purposes, and by providing improved access to satellite-linked information systems and other U.S. data. This country has a wealth of experience in assembling and analyzing data on the interaction of crops and weather in a form that is useful to the farmer; putting existing historical data into usable form is time-consuming but not expensive.

The United States would benefit from these activities. As the leading exporter of grain crops, and as an important importer of specialty crops (e.g., coffee), it needs to monitor world production continuously. Reliable estimates of production widely publicized could contribute to the smooth and equitable operations of world and national markets. By having timely information about weather trends, producers and importers could more nearly adjust to changes in supply and demand. U.S. researchers would also benefit from basic data on crop/weather relationships for crops on which little data now exists.

## Institutional Mechanisms

Both the United Nations Development Programme and the Voluntary Assistance Program of the World Meteorological Organization (WMO) can provide funds for stimulating and improving weather services in the developing world. Thus new institutional mechanisms would not be needed for effective action, and the time required to step up weather services to improve agricultural productivity would be considerably shortened. Any U.S. initiatives might best be undertaken through these organizations. Moreover, international mechanisms already exist to make weather data available for worldwide use. Further developments could take place on the basis of existing international agreements.

Constraints which impede efforts in developing countries include lack of training and education and the difficulty in obtaining funding despite clear economic incentives.

Communications can be another major constraint. Collecting information at central locations can be very difficult, and dissemination can be equally complicated. However, opportunities for early improvement already exist in some developing countries. For example, radio is usually nationally controlled, and agriculture-related forecasts and weather information could be featured on such broadcasts.

Nationalism may emerge as a constraint to efficient regional analysis. Countries are very sensitive about controlling what information goes out, especially in such areas as food stocks.

The mutuality of interests that could be served by the World Climate Program presently being developed by the WMO, in cooperation with other U.N. agencies and nongovernmental organizations, may be a means of reducing these constraints. This program is designed to provide climate information and data and to undertake research on the impact of climatic changes on various sectors of national economies. It could lead to near-term improvement of agricultural weather services.

## Proposed Initiatives

We suggest that the United States offer to collaborate on international programs to plan and implement improved agricultural weather services and undertake crop/weather studies. First, we propose that interdisciplinary symposia or workshops be organized through the appropriate U.N. agencies or under national sponsorship to identify deficiencies in various weather services. The actions needed to correct such deficiencies will vary from country to country. They may include installation of agricultural weather observation networks, data processing and communication systems, education and training facilities, or crop/weather model research.

It is worth noting that very simple but extremely useful observations can be provided on a continuing basis with little maintenance and at low cost. For example, as little as a thermometer, a rain gauge, and basic instruments for measuring soil moisture and solar radiation may be needed. Observations with these instruments could be made by villagers after brief training, thus providing a source of supplementary rural employment. In other cases, it may be necessary to provide extensive educational and training opportunities. Whatever the activity, crop/weather information must reach the farmer in a form helpful to him or her in making day-to-day decisions. For example, farmers can be provided with information on soil temperatures indicating optimum time for planting, prospects for weather favorable for harvest, and early warning of a delayed rainy season.

Research and development are also needed on the relationships between weather variability and crops. Specific suggestions for a typical program are: (1) identify weather indicators that are easily measured and useful for predicting yields; (2) develop and test

field-level crop production models responding to various weather sequences, testing and calibrating these for a selected number of varieties of important crop species; and (3) conduct field trials of selected indicator varieties on various soil types in selected climatic sites within the range of adaptability of the species. These trials would serve to calibrate the models, define the range of their reliabilities, and establish the forms in which the weather data should be collected.

## 4. Farm and Land-Use Planning for Sustained Food Production

Increases in world food production must be based on the sustained, productive use of inherently limited land and water resources over time. Unfortunately, erosion and flooding continue to destroy soil productivity and reduce food production in many parts of the world. Poor land and water management increase the uncertainties of food production, while causing damage both upstream and downstream of cultivated areas.

Farm and land-use planning is essential to increase food production, conserve natural resources, and create an agricultural society with an acceptable quality of life. And, even beyond that, planning must be undertaken for entire watersheds as integrated units for the interaction of forest, range, and cropland, and for the balance between cultivated and municipal/industrial land use.

Here we describe activities related to farm and land-use planning on which the United States has much to offer.

Land Classification. Despite land surveys and classification that go back many decades, some 75 percent of the world's land has not yet been inventoried. Even where soil survey information is available, it is often not used for planning purposes.

Methods for developing land-use classification from soil survey information are well known. The systems developed by FAO and various countries are somewhat different but comparable. The U.S. Soil Taxonomy, derived from work at USDA (1975), is particularly useful, although it calls for less than optimum amounts of weather data for making decisions on land-use capability.

Water and Soil Conservation. Rainfed agriculture is the principal source of the world's food. History is replete with examples of the disastrous effects that failure to control erosion and sedimentation has had on human welfare. Unwise cropping practices have resulted

in the destruction of land in many parts of the world. Erosion is a threat wherever sloping lands are used for food and fiber production. Today, steadily increasing pressure on the land has magnified the problem and reduced crop production at a time when food requirements are greater than ever before.

Sustainable production of food requires that surrounding lands receive appropriate management. In particular, soil and water must be conserved. Where upstream and adjacent lands are managed under conservation systems, such as national forests, national parks, wildlife sanctuaries, and similar types of reserves, food production can benefit from more stable water supplies, minimal erosion and flooding, and reduced loads of sediment. These management methods also affect forestry production, hunting and fishing, and the tourist industry, among other activities.

The United States has developed a particularly effective capability for managing natural resources, built on the combined efforts of public institutions (federal, state, and local), and research and experiment stations, universities, and private organizations. A better understanding of hydrology and the development of related management skills has led to improved watershed management in both humid and arid temperate areas; however, serious deficiencies remain in the tropics. In all regions, careful, technically sound water management would aid greatly in providing agriculture with long-term, stable production by reducing the risks of droughts and floods, and siltation of irrigation facilities and other downstream investments.

Farming Systems. Soil and water conservation measures are not applied in a vacuum, but must be tailored to the physical, institutional, and socioeconomic environment of the farm unit. Plans that integrate all these factors usually include an analysis of a locality's physical-biological information and economic-cultural practices. The Soil Conservation Service has specialized in farm-level business analysis. Its approach can be adapted to a wide variety of farming regions.

Still, it must be recognized that there is a wide gulf between advising a farmer in Indiana or Iowa and developing a rational plan in Nigeria. The capability for this kind of planning will be greatly improved as formal studies of different kinds of farming systems are conducted. For example, small holdings in Nigeria vary from a fraction of a hectare to several hectares in size, with intricate intercropping patterns that may include as many as seven species on one piece of land in any given year. Similarly, in Java remarkable

patterns of rainfed and irrigated crops, animal species, and fish cultures exist which can meet the total needs of a family of six on as little as 0.75 hectare of steep land. The factors that make for successful small farming in these areas are still little understood.

Thus the application of current technology must go hand-in-hand with formal study of farming systems options and their consequences. When integrated with practice, such studies should lead to continuous feedback that leads to progressively more relevant research.

We stress that new farming practices must meet the test of maintaining or improving the economic status of the farm family. New practices often call for complementary changes--economic infrastructure such as credit or transportation, as well as new products such as fertilizers, pesticides, improved seeds, and farm machinery--the lack of which could limit implementation of suggested farming systems. In addition, conventional modes of farming, community laws, and national laws frequently inhibit change because of the established property relationships associated with land and water. These constraints argue for striving to find catalysts for change, a primary task for farm planning and management.

## Ongoing Work

The United States has the technology for effectively evaluating natural resources and an excellent organizational system for applying this technology. Within USDA, the 40-year experience of SCS, in cooperation with the National Cooperative Soil Survey, is extensive and unexcelled in integrating physical-biological information into watershed and farm plans for land and water conservation. Although SCS began as an erosion control agency, it soon expanded its program to encompass farmer education programs on a full range of soil and water conservation practices; local organizations were created to sponsor and request federal technical assistance. In this way, recommendations were transformed into actual farm practices. SCS is now extending its operations to developing countries. Through arrangements with AID, for example, it operated a program on soil and water management practices in India, where clear-cut desires were expressed by the cooperating country.

USDA, the state agricultural systems, and the federal-state cooperative extension services all have research capability and field practice in combining production factors into effective farm operation

systems. Combined with experience gained from AID and FAO-sponsored projects and interaction with the international agricultural research centers and their research programs on farming systems, a sound basis exists for transferring this technology to developing countries. With USDA's new authority for foreign work (see Chapter 1, p. 35), SCS, the Agricultural Research Service, and the Forest Service could engage more fully in cooperative efforts.

U.S. universities have been involved in many international projects such as the interdisciplinary program on water management in Pakistan sponsored by AID, and they are likely to become more involved in the future through Title XII of the Foreign Assistance Act. Universities can better help developing countries if provision is made for continuity.

## Proposed Initiatives

We recommend that the United States indicate its readiness to intensify support for U.S. and international institutions (university, government, or private) capable, on a long-term basis, of supporting the foregoing activities and establishing technical training courses for short-term, nondegree skill development in conservation practices, soil classification, land-use capability determination, and farm management planning.

We also recommend that the United States indicate readiness to respond to requests from developing countries for joint development of farm managment and farm systems analysis capability; examples include: aerial photography, photo interpretation, and field evaluation of land resources; adaptive research to field test and evaluate proposed practices and to develop alternative farming systems; and demonstration farms to publicize the results and inform farmers.

Some of these activities are already being done, some could be implemented immediately, while others may require more time for full development. SCS and the land-grant universities, for example, could immediately provide training for and assistance in the adoption of the U.S. Soil Taxonomy in interested countries.

Success in any effort related to land and water management largely depends on developing a cadre of competent and dedicated practitioners within the target countries. U.S.-based training programs have been used effectively in the past, but they would be more effective if they specifically emphasized conditions in developing countries. Excessive emphasis on advanced graduate training in narrow disciplinary specialties

must be supplemented, if not replaced, with relatively brief, function-oriented training.

Not only the program recommended here, but, more importantly, the application of soil and water conservation practices will be enhanced if (1) formal recognition is given to a holistic approach to water management within watersheds, and (2) development assistance for agriculture emphasizes the implementation of soil and water conservation practices.

The United States is urged to strengthen its cooperation with and support of developing nations in the establishment of conservation land management systems through its bilateral programs (e.g., AID, Peace Corps/Smithsonian program), FAO, and regional and other international organizations. And it is urged to encourage all international development programs to include conservation management within food development projects to ensure maximum stability of production.

## 5. Plant and Animal Protection

The 100 species of plants and animals that provide more than 95 percent of the world's food supply are threatened by more than 25,000 species of such pests as bacteria, fungi, viruses, nematodes, insects, rodents, birds, and weeds.

Pests were given an advantage the day people began to cultivate the soil and grow repeated crops in the same area, when mixed vegetation was replaced by monoculture, and when livestock were confined instead of being able to move freely. It is estimated that they reduce potential harvests by more than one-third, in addition to the postharvest damage they do. Since we cannot obliterate these forces, we can only make conditions as unfavorable as possible for pests and as favorable as possible for crop plants and livestock.

Pest problems are so severe and widespread that large areas of otherwise productive land may be removed from cultivation because of the depredations of a few harmful organisms. In the Philippines, 6 million acres of formerly cultivated land have become highly infested with a low palatable weed *Imperata cylindrica* and abandoned for agricultural use. In India, weeds cost agriculture an estimated $600 million per year and in the United States as much as $5 billion per year. They reduce world rice yields by a third. In Africa, trypanosomiasis and East Coast fever largely prevent cattle production in a large belt south of the Sahara covering one-third of the continent. The part of this region infested with the tsetse fly, which carries the

trypanosomiasis blood parasite organism, could support 200 million head of cattle.

These injurious organisms are a diverse and dynamic group. They adjust so rapidly to chemical or other treatments that resistant strains of crops or new control methods must be developed each decade to keep them in check.

Intensive research in the United States and other countries has identified many of these pests, recorded their life cycles, and revealed numerous details about their strengths and weaknesses in relation to their management and control. Through such background information, several types of pest control technologies have been developed, including:

-- Selection and breeding of crop cultivars and strains of livestock with relatively stable resistance to specific pests. This effective and low-cost approach must, however, be reinforced with extensive collection, testing, and inventorying of resistant germ plasm resources for each crop species and breed of livestock. (The breeding of cereal crops is more advanced and successful than for most other plants. Comparable advances are needed for other crops such as the pulses, sugar crops, root crops, oil crops, fruits, and vegetables. Similarly, protection of livestock from diseases and insects has received far less emphasis than crop protection.)
-- Development of biological controls by identifying and promoting parasites or disease organisms that prey on specific pests.
-- Development of improved pesticides and methods of application that effectively control pests and minimize damage to the environment.
-- Manipulation of the environment to make it less favorable for pests and more favorable for crops and animals, and to enhance the positive effects of other control practices. Control methods include altered dates of planting and harvesting, irrigation, drainage, fertilizer use, tillage, crop residue management, and changes in crop varieties and crop sequences.
-- Animal inoculants and vaccines and pesticide dips for disease, insect, and tick control.
-- Use of information regarding adequate nutrition as a preventive measure in animal disease control and optimal feed utilization.
-- Combining the most advantageous of these practices into integrated pest management systems. Integrated pest management relates local conditions to practices that will minimize harmful pest

populations and activities and yet be favorable for selected crops or animals.

New pest control practices, chemicals, equipment, and procedures for their application are continually evolving from the numerous agricultural research centers and industrial laboratories worldwide. Many developing countries, however, lack the trained scientists, avenues of communication, or capabilities for conducting innovative applied research to select and adapt appropriate control measures to local situations. Individual countries require assistance in training scientists in appropriate disciplines, identifying problems, and carrying out effective pest control measures.

## Rationale for Selecting this Topic

Possibly no area of technical assistance to improve food production in developing countries has been as favorably received by farmers and herdsmen as has protecting crop plants and livestock from harmful pests. This adoption has been most notable in the breeding of cereal crops for resistance to pests and for high yield capabilities. In cattle, crossbreeding with the N'Dama and other selected strains has extended resistance to a number of diseases and insects. Romney Marsh sheep carry resistance to parasites and have potential benefits in sheep breeding programs. Further, the use of herbicides, insecticides, fungicides, vaccines, and inoculants has often produced dramatic controls for the epidemics that have threatened both the food supply and health of people in many countries. The successful application of these techniques and principles could mean dramatic advances in food production in the poorest parts of the world.

The United States has much experience in supplying and transferring pest control technologies, including:

-- Knowledge and techniques for breeding crops and livestock with genetic capabilities for resisting many different pests while sustaining high productivity and preserving the qualities desired at local levels.
-- Know-how and experience in devising cultural and management practices coupled with sanitary measures that reduce the damaging effects of various pests.
-- Ability to manufacture herbicides, insecticides, fungicides, vaccines, and nematicides that are relatively safe environmentally and that are available to the developing countries for use in integrated pest control programs.

The technologies developed in the United States are seldom directly transferrable to developing countries, however. Each ecological situation has unique strains of organisms or variations in population intensities, and the many interactions of the environment with hosts and pests require that different packages of technologies be developed and verified for each combination of factors.

USDA and the land-grant universities house a wealth of scientific capabilities in the many disciplines required for effective pest control programs. In addition, large numbers of students from most developing countries have been trained in breeding and pest control disciplines in this country. These students can provide a vital link between U.S. scientists and the government and farmers in their respective countries. Further, direct cooperative relationships between U.S. agricultural colleges and similar institutions in developing countries can evolve quality educational programs in pest control and related fields.

The United States will benefit from sustained efforts abroad. New pests may be identified that may later become difficult problems in the United States or elsewhere. Also, new strains of crops and animals can be tested under the more severe stress conditions often encountered in developing countries. A related beneficial result would be the identification of superior crop germ plasm materials and resistant strains of animals that can be used in U.S. breeding programs.

## Proposed Initiatives

We recommend that the United States propose broad international support for an array of plant and animal protection activities. These could include: (1) continuing support of CGIAR centers, which are deeply concerned with many important pest management programs as part of their work on crop and livestock improvement; and (2) support for efforts by individual developing countries to evolve quality research programs for the development of appropriate integrated pest management systems for both crops and livestock. Assistance should also be provided to strengthen extension programs for implementing pest management programs at the farm level. Particular emphasis should be placed on training national research personnel.

It is widely recognized that there is a gap between the work of the CGIAR-supported international research centers and other advanced research organizations, on the one hand, and national capabilities in developing

countries to adapt and utilize new technologies, on the other hand, particularly in the fields of pest and disease management. Thus U.S. assistance could usefully help developing countries strengthen their capabilities in these fields. The unique ecological, economic, and cultural situations of each nation need special attention. Nearly every developing nation needs assistance in devising and implementing integrated pest management systems that involve minimal use of expensive pesticide imports and that will not harm the environment.

To illustrate, a collaborative program might:

-- Identify scientists in developing countries who are trained in fields related to pest and disease control for crops and livestock, establish linkages with them, and determine their needs for developing effective in-country programs for breeding new suitable strains of crops and livestock and for devising other pest management practices.
-- Help these scientists identify and rank by priority the major pest problems in each country, keeping in mind how control of particular pests would affect the country's economy and food supply, and the potential for solving each problem with available technologies.
-- Initiate research and action programs on high priority problems; U.S. scientists could work as needed with local scientists.
-- Identify additional training needed for local scientists and conduct training programs with emphasis on in-country training. Limited numbers of scientists could be trained at more advanced levels in the United States or other countries. To further strengthen in-country training, cooperative relationships should be developed between appropriate U.S. agricultural universities and comparable institutions in developing countries.
-- Provide products such as environmentally safe pesticides for field trials, work out feasible combinations of cultural practices that secure maximum benefits from such products, and help develop suitable distribution networks for appropriate products.
-- Solicit support from local and international pesticide and medicinal industries for appropriate phases in the foregoing program.

We also recommend that the United States provide more support for building worldwide collections of germ plasm for crop plants. Germ plasm that possess unique resistances to specific pests should be assembled and preserved. Mechanisms are continuously being

established to provide for hemispheric and worldwide systems of reserves designed to conserve representative samples of major geographic areas and the genetic materials they contain. This includes a network of research stations that are providing new opportunities for international cooperative activities.

In this regard, the United States is a party to such treaties, conventions, and programs as the Man and Biosphere Program (UNESCO), Global Environmental Monitoring System (U.N. Environment Programme), World Heritage Convention (UNESCO), Western Hemisphere Convention (Organzation of American States), Trade in Endangered Species, the International Board for Plant Genetic Resources, and the international agricultural research centers sponsored by CGIAR. We recommend that the United States strengthen its cooperation with and support of these programs to help assure their continuation and expansion to include all important crop plants and their close relatives.

Germ plasm collections should be made available to all nations. U.S. computer capabilities could be used in developing a worldwide information system on available germ plasm. This work is being implemented for selected crops by the International Board for Plant Genetic Resources, working with the international agricultural research centers and other institutions. However, more complete coverage of crop plants is needed, and identification and preservation of livestock germ plasm also needs greater emphasis.

Finally, we recommend that the United States assist the development of collections of organisms injurious to all important crop plants and breeds of livestock. Current pest collections are fragmented and incomplete. Often they depend on the interest and dedication of individual scientists, and important collections have been lost due to retirement or death. The problems involved go beyond national boundaries; an international diagnostic service is needed.

### 6. Management Systems for Sustained Crop Production on Tropical Soils

Currently, about 40 percent of the world's arable land is used for agriculture. The bulk of the still unused or underutilized land with agricultural potential is in the tropics, with more than 500 million hectares each in Africa and South America and 200 million hectares in Asia. Tropical areas generally suffer from rampant, unplanned clearing and exploitation of forests and savannahs, which often leads to abandonment because of declining soil fertility, severe erosion, poor crop growth, or

uncontrollable weed growth. Thus there is a great need to define which lands should and should not be developed, and to develop crop and livestock production technology well suited to the generally difficult stresses common to these areas.

There is little doubt of the need to increase agricultural production on existing tropical lands. Although it is questionable whether certain tropical soils should be cleared and developed for agriculture or preserved as forest or conservation lands, these questions are frequently moot because decisions to develop are made by land-hungry farmers or worried governments without regard to land suitability or potential.

FAO has estimated that from 1979 to 1985 over 10 million hectares per year will be newly developed worldwide, with development proceeding at a faster rate thereafter, mostly in the humid tropics. Unless carefully planned and orchestrated, this process, which will involve major population shifts, may well lead to disappointment or even disaster.

Some tropical soils are not suited for cultivation with the production systems now available. Many are highly weathered, arid, low in fertility, and suffer from aluminum and manganese toxicity and phosphorus deficiency. Their generally low capacity to hold water makes them subject to frequent droughts. When these soils are cleared mechanically, nutrient deficiencies can be aggravated and erosion hazards are created. Notwithstanding these problems, it has been demonstrated experimentally that good production is possible, perhaps even exceeding that in similar soils in the United States because of the opportunity for more than one crop per year.

With current technology, it is possible to devise successful management packages for sustained productivity for some tropical soils. There are, however, numerous opportunities for strengthening the knowledge base and developing better, more appropriate, and less costly techniques for managing these soils. A partial list would include: plant breeding for aluminum or drought tolerance, evaluation of sources of rock phosphate to make phosphorus more readily available at lower cost, site-specific recommendations for minor element fertilization, microbiological amendments to fix nitrogen or extract phosphorus, and better placement of lime and/or fertilizers to improve response. Fertilizer storage, handling, and application techniques must be improved, and various cropping sequences evaluated to optimize total production. Experimentation is needed with combinations and sequences of new and old plants, soils, water use, cultivation practices, and soil

amendments. A study of existing farming systems and practices could lead to the development of additional appropriate technological and cultural aids. No doubt plant (and animal) breeding and selection for specific traits favorable in the high-intensity systems would take an important place.

## Rationale for Selecting this Topic

More careful management of tropical soils would have a significant impact on food production in developing countries. Indeed, the prosperity of many countries depends on informed, careful use of tropical soils, without land degradation or production failure.

The United States could make a significant contribution to work on the management of tropical soils and the conduct of soil surveys and appropriate land-use classifications. The United States could also advise on and demonstrate suitable soil and crop management packages, and work in cooperation with developing country scientists and technicians to demonstrate effective, nondestructive ways to develop and use these lands. In fact, much of this is already being done to some extent. Such work could result in increased food production and employment opportunities and prevent the destruction of natural resources and socioeconomic upheaval caused by crop failures.

Another opportunity for better use of tropical soils is found in perfecting ways to increase crop production in areas already in use and close to population centers. Relatively recent research has demonstrated that multiple cropping--growing two or more different crops on the same land in any one year, either sequentially or simultaneously or both--increases total production per unit of area, raises farm income, increases the range of produce available to diversify the diet, makes better use of fertilizers and available water, and can be adapted to control erosion and to protect and enhance soil fertility. Intercropping frequently reduces pest control problems.

Work at the international agricultural research centers has led to the development of small machinery to support more intensive farming systems in the tropics. For example, the International Institute of Tropical Agriculture has developed or modified simple, low-cost equipment, sophisticated in concept only, for precision planting of grain and for spraying with very low volumes of water. These tools do not require mechanical power (other than a rechargeable dry battery), and they reduce drudgery. Other opportunities exist in programs that are now underway

to include small ruminant animals and game farming in the total production system.

Some findings could be imported for use in the United States. For instance, the use of multiple cropping, while increasing, is still uncommon in the United States. (Some 25 percent of the soybeans grown in North Carolina are multicropped with grain, and interplanting of maize and soybeans in Minnesota has been shown to increase grain yields significantly.) Nowhere in the United States does one find the diversity of plant (and animal) species grown in close proximity and/or sequentially that are found in numerous places abroad. Almost nowhere does the United States reach the levels of production per unit of land achieved in some systems in developing countries.

## Proposed Initiatives

We recommend that the United States announce that it is expanding support to developing countries for making better use of tropical soils and that it would welcome greater international collaboration to this end. Several measures are called for to implement this initiative. First, the Consortium on Soils of the Tropics, comprising seven U.S. universities, needs to be strengthened and adequately supported on a long-term basis so that it can continue to play a leading role in research, education, and training, and provide a U.S. base for an expanded program in tropical soils. This AID-supported consortium conducts field work in many countries, including Brazil, Cameroons, Indonesia, Peru, and the Philippines. Its members maintain informal contact with tropical soil scientists around the world. They also publish a newsletter and have already held a series of workshops for training, information exchange, and research planning. The University of Hawaii has a soils data bank which makes it possible to cross-reference and search for information of use to major experiment stations of the tropics. Thus an effective delivery system already exists.

Second, the United States might offer to respond favorably to serious requests for cooperative programs on the development and demonstration of appropriate management practices for tropical soils. The United States has many resources for responding to such requests. It can call on the Consortium on Soils of the Tropics and invite participation by additional universities with strong programs in soil science, as well as by agencies within USDA such as the Agriculture Research Service and the SCS. Section 1458 of the 1977 Food and Agriculture Act provides a new avenue for

implementation by USDA (see Chapter 1, p. 35). Also, proposed additional funding for Section 406 of the 1966 Food for Peace Act could be used to support the study of tropical soils at U.S. universities situated in the tropics. And, finally, tropical soils was given priority under Title XII of the Foreign Assistance Act.

A third measure might be to expand and strengthen the evolving informal international network on the use and management of tropical soils by establishing an international program committee with a small secretariat to foster collaborative activities. Members of the network might include developing country institutions; the international agricultural research centers; developed country institutions such as Institute de Recherche l'Agronomique Tropical (IRAT, France), the U.K. Ministry for Overseas Development (ODM), the Commonwealth Scientific and Industrial Research Organization (CSIRO, Australia), the Ministry of Agriculture and Forestry of Japan; and FAO.

Finally, we suggest that the United States encourage the use of interdisciplinary teams in cooperative management programs, and the inclusion in such programs of training, whether formal education or otherwise, for counterpart scientists and technicians. Such programs should be closely tied to academies and/or research institutions in the host country.

## NOTE

1. Weather variability is defined here as changes in such parameters as precipitation or temperature over the short term, i.e., periods of days, weeks, or months, in contrast to changes over longer periods of time, which are referred to as "climatic variability."

## CITATIONS


Bene, J.G., H.W. Beall, and A. Cote (1977) The Tropical Forest--Overexploited and Underused. International Development Research Centre, Ottawa, Canada.

Food and Agriculture Organization of the U.N. (1977) Water in Agriculture. Prepared for the United Nations Water Conference, Paper No. E/CONF. 70/11, 20 January.

Kovda, V.A. (1971) The problem of biological and economic productivity of the earth's land areas. Soviet Geographic (revised and translated) 12(1):6-23.

National Research Council (1977) Supporting Papers: World Food and Nutrition Study, Vol. II. Washington, D.C.: National Academy of Sciences.

Schultz, T.W., ed. (1978) Distortion of Agricultural Incentives. Bloomington: Indiana University Press.

Takase, K. and T. Kano (1969) Development strategy of irrigation and drainage. Asian Agricultural Survey. Published for the Asian Development Bank jointly by the University of Tokyo Press and the University of Washington Press, Tokyo, Seattle.

U.S. Department of Agriculture (1975) Soil taxonomy: a basic system of soil classification for making and interpreting soil surveys. Agriculture Handbook 436. Washington, D.C.: U.S. Government Printing Office.

# Chapter 5

# ENERGY, NATURAL RESOURCES, AND ENVIRONMENT

## INTRODUCTION

The same processes that provided humankind with valuable biological, mineral, water, and energy resources distributed these riches very unevenly around the planet, and human activity is altering these imbalances still further. Limited petroleum and other natural resources worldwide have underlined our mutual interdependence. Further, high population growth rates in some developing countries are exerting heavy demands on already insufficient resources, thus exacerbating the situation. There is an analogous interdependence for access to technology and other fruits of human inventiveness, although every nation recognizes that for both resources and technology a significant degree of self-reliance is essential to its national interest.

In this situation, developing countries--and the world at large--cannot afford to neglect important resources that remain undeveloped or underutilized. More than 70 percent of the world's timber is in the tropics. Recent discoveries of petroleum in Africa, Latin America, and Asia illustrate the energy potential of the developing countries and, as exploration techniques improve, more and more major ore deposits are being found in the tropics. Fuller utilization of natural resources, including increased domestic processing, can contribute fundamentally to strengthening the economies of developing countries. Jobs, productivity, foreign exchange earnings and savings, capital accumulation, and national and individual incomes are all affected in major ways.

Before World War II, the world's environment was not severely affected by human activities. However, as with petroleum and mineral resources, assaults on the planet's air and water resources and associated climate have become a matter of concern for all peoples. The

world faces a new form of interdependence imposed by the nature and scale of human activity and the finite capacity of the earth to assimilate our abuses. The collective results of human activity, particularly in the use of energy, minerals, and biological resources, are causing or could soon cause undesired physical changes worldwide, including the possibility of increased cancer due to air and water-borne chemicals and threats to the ozone shield in the upper atmosphere; loss of ocean productivity due to pollution; and shifts in climatic and rainfall patterns due to atmospheric pollution, increased $CO_2$ from burning fossil fuel, and deforestation.

A search for better alternatives is underway, stimulated in part by concerned citizens who recognize that these issues, once thought to be peripheral, are central to improved quality of life. Fortunately, much can be done economically to substitute human ingenuity (technology) for resource consumption in supplying goods and services, and to improve many existing technological practices that make inefficient use of resources. Indeed, human ingenuity is the most fundamental of resources and should be the most important basis for future development. However, the conservation concept of substituting technology for resource consumption requires imaginative leadership and greater technological sophistication throughout the world. Heavy investments of time and human resources are needed to meet this requirement.

Realization of the imperative for improved resource management has resulted in new U.S. policies. This imperative has several dimensions, including a declining base of low-cost domestic resources and escalating problems of environmental and health costs associated with human activities. New policies aimed at improving resource management (which include regulations, financial incentives, and standards) have spurred the development and application of improved technology. Some undesired trends and conditions have been ameliorated by such improvements as:

-- reforestation for sustained yield production; agricultural practices (e.g., no-till cultivation, crop rotation, improved use of artificial fertilizers) to stabilize soils and maintain fertility; pesticides, herbicides, and biological controls with less environmental impact;
-- technologies to find and use lower-grade mineral, oil, and gas deposits;
-- controls on pollution emissions, sometimes resulting in recovery of valuable by-products; improved industrial processes that result in less pollution.

Despite its impressive achievements, the United States continues to encounter problems associated with the use of natural resources, including energy and "free goods" such as air and water. Much research and development is still needed, for example, on:

-- more efficient use of energy and materials in providing goods and services; recycling and reuse of materials;
-- improved technologies and procedures for coal mining and utilization;
-- development of acceptable technologies to facilitate the transition from fossil energy to renewable energy sources;
-- substitution of more plentiful resources for those that are becoming scarce, e.g., coal for petroleum, aluminum for copper, insulation and solar energy for heating fuel.

The United States has considerable experience and knowledge that can be shared with other nations. It began several decades ago to encounter problems somewhat analogous to those faced by developing countries (e.g., deforestation) and thus has had more time to develop responses than have many of the latter countries. The United States can also share its equally important experience of negative consequences and mistaken choices.

This chapter addresses ways in which the United States and other industrialized nations might use science and technology to help developing countries better manage their resources with minimal undesired environmental impacts. Most of our recommendations are aimed at producing greater technological sophistication in developing countries. Stronger science and technology in other countries is likely to benefit the United States in addressing its own resource and environmental problems. For example, development of improved photovoltaic or other solid-state means of converting sunlight into electricity could bring enormous benefits to developing countries and hasten the advent of commercial solar energy systems in the United States, with consequent savings of petroleum and natural gas resources.

Although some observers feel that concern for environmental problems will constrain development efforts, we believe that environmental protection can help achieve development goals at a lower cost. Prevention is usually less expensive than cure.

For many years, the U.S. government, industry, and universities have collaborated with developing countries in developing their natural resources and energy sources. The United States supports development

activities in these areas through the U.N. Development Programme and the international financial institutions, and it has recently begun to revive an interest in providing bilateral assistance. Its reputation for technological achievement continues to attract a steady stream of students, professionals, and orders for equipment from developing countries. Moreover, the United States and international scientific communities, stimulated by recent U.N. conferences, have expressed interest in broader collaboration on problems affecting the global ecosystem; many of the international scientific unions, U.N. agencies, and other international bodies rely heavily on U.S. support.

We recommend that activities in all these areas be strengthened and given higher priority within the U.S. development effort. In this chapter we identify seven topics[1] that seem particularly promising for an expanded U.S. role:

1. Comprehensive planning for energy development and utilization
2. Development of indigenous energy resources for local utilization
3. Sustained, multiple use of forest resources
4. Water resources planning and management
5. Effective use of marine resources
6. Remote sensing from space for resource mapping and assessment
7. Improved use of pesticides

These topics cannot be narrowly classified as addressing energy, natural resource, or environmental concerns because of their obvious interrelationships. For example, the multifaceted role of solar energy is highlighted in the discussion of indigenous energy resources, but it is obviously important in considering the use of forests. Environmental concerns, in particular, cut across all of the proposed undertakings.

We have not suggested initiatives regarding exploration or development of oil, gas, or minerals, even though the United States pioneered the development of many of the technologies now used worldwide and many countries will rely heavily on fossil fuels for years to come. For these and other areas, the commercial channels for acquiring relevant technology are reasonably clear and established. Similarly, countries interested in nuclear power are aware of the many governmental and commercial channels available for assistance in this area.

Most of the programs we propose would be supported by the U.S. government, although substantial contributions by U.S. industry would be needed for

several. Clearly, major investments are required to make discernible progress in sustained use of forests and water management and quality. At the other extreme, given the present sizable U.S. investments in remote sensing and coal technology, a rather modest additional expenditure could easily help extend these activities to developing countries. Further, the scope and complexity of energy problems warrant substantial funding, whereas the problems of marine resources and pesticides are more specialized and the absorptive capacity of the international system is limited.

## OPPORTUNITIES AND PROPOSED INITIATIVES

### 1. Comprehensive Planning in Energy Development and Utilization

During the past few years, most nations have been forced to reexamine their use of energy, to assess patterns of supply, to project future demand, and to evaluate plans for national energy use in the future.

Within the United States, this assessment is occurring at both the national and state levels, often with the help of industry and the academic community. One interesting finding has been that major differences exist in energy use and supply profiles among different states, sometimes even between adjacent states, and that significantly different policies are necessary from one state to another.

Similarly, most developing countries need to assess their own national energy picture before setting national policies related to energy. This is best done at the national level although, as in the United States, important regional differences will need to be examined.

Energy, mainly in the form of oil and gas, constitutes a large part of the imports of many developing countries, and severe balance-of-payment problems continue to mount because of the rising cost of these imports. At the same time, pressure on traditional sources of energy has grown rapidly. Firewood and charcoal for cooking have become a major expense for rural households and their use is presenting severe deforestation problems (see, for example, NRC 1976). The energy needed for even a modest standard of living has become hard to obtain, and that needed for transportation, small industry, and agriculture has become quite expensive.

## Strategies

We suggest complementary strategies for addressing the energy issue at the national level: (1) improving the national capability to plan for and guide national energy development; and (2) analyzing energy utilization and improving efficiency of use. Both strategies would use various analytical methods such as technology assessment, analysis of environmental impact, national planning, etc. In the first strategy, the energy supply and utilization system would be examined in both cross-section and time-series to seek trends and sensitivities. In the second, attention would be directed specifically to the usually underemphasized patterns of energy use and alternatives to achieve higher efficiency. Once these become evident, it is much easier to understand the implications of alternative policy decisions.

Strategy 1. We propose that the United States actively support efforts by developing countries to improve their national energy analysis and planning. We can use the experience of struggling with our own energy situation to assist in this field.

The ultimate purpose of planning is to make better investment, allocation, and strategy decisions about energy supply and utilization to meet both immediate and long-term socioeconomic goals. The environmental, social, and economic impacts of alternative energy choices and strategies should be included (see, for example, Palmedo 1978).

Early tasks for each country would be collecting baseline data and analyzing energy consumption patterns in urban and rural areas. There is generally an awareness of the need for an energy supply component in planning, but not as great an awareness of the need for energy use planning. Many developing countries already have relevant economic, environmental, and social planning activities that can be drawn upon for data.

Strategy 2. Traditionally, the United States has not sought to make the most efficient use of energy, but in the last few years many processes and products in this country have become more energy-efficient and new federal policies have mandated improved efficiency. New regulations require disclosure of mileage ratings of new automobiles and energy-efficiency ratings of consumer products such as refrigerators and air conditioners. New residences and commercial and governmental buildings are being designed with more efficient space heating and cooling, and construction codes are being revised. Industrial organizations are using energy management techniques to measure and monitor the energy used in various processes for minimum energy consumption. Waste heat is being

recaptured and new energy-saving techniques (e.g., better process control, new processes) are being developed. However, these techniques mostly affect new capital stock and it is premature to judge the extent to which energy consumption patterns are changing, although it is clear that new consumer purchases are more energy-efficient than the average existing stocks.

Further, research is progressing on energy sources that can be economically decentralized such as fluidized bed combustion, direct solar, wind, and biomass. The integration of several energy sources into a single energy-efficient system for use in rural or isolated areas is also being studied. Like the United States, developing countries could benefit from improved building technology for both energy and other considerations and more energy-efficient transportation and industrial systems. Of course, in some indigenous housing the overall energy efficiency, reflecting local building materials, cultural practices, and climate, may already be as great as feasible. Collaborative work could also be done on linking traditional and modern energy systems efficiently. During this process, considerable emphasis could be placed on the institutional development needed for improved energy management.

## Proposed Initiatives

We recommend that the United States offer technical collaboration and assistance to support energy planning and research and development in developing countries, along the lines of the two proposed strategies. Such assistance would include a comprehensive, multidisciplinary analysis of technology, economics, domestic resources, and public policy. In this regard, the United States could play a coordinating role in bringing together energy planners from the U.S. government, business, universities, and public interest groups for advisory tasks and in encouraging certain common approaches to energy planning in different regions of the world. The U.S. initiative could also provide a vehicle for supporting joint U.S.-developing country activities, perhaps broader based cooperative studies and major demonstrations on topics such as exploration and development of indigenous conventional and nonconventional energy supplies, the use of decentralized energy sources, energy needs and opportunities in areas remote from concentrated sources such as large electric power stations, and increasing the efficiency of energy-using devices such as cooking stoves.

To help implement national energy planning, combined teams of specialists from both developed and developing countries could study how best to plan national systems of energy supply and utilization. Planning activities could draw heavily upon the skills and experience found in the U.S. government, universities, and research centers. These activities should specifically include consideration of national goals that interact with energy goals (e.g., environment, water, and land use).

Regarding energy utilization and efficiency, joint teams of specialists from such energy-intensive areas as transportation, industrial processing, agriculture, and habitat could work on devising better design and implementation procedures to achieve higher efficiency of use and to shift from imported to indigenous energy resources. One successful model of such a joint effort is the AID/National Bureau of Standards project for low-cost housing in regions affected by high winds.

For the implementation of both strategies, we suggest the following:

-- The United States could invite proposals from developing countries, with or without an identified U.S. co-proposer such as a university, for assistance in comprehensive energy assessment. If a U.S. partner or team is not identified, such could be appropriately arranged by the sponsoring agency (e.g., U.S. Department of Energy, AID, National Science Foundation [NSF]). In all cases, the proposing country should be required to contribute significant in-kind support, committing serious attention from high levels of decision-making authority.
-- Host country or regional (international) training seminars and workshops could be arranged to focus on the energy issues within a country or region. Such seminars could be a valuable learning experience for both the developing countries and the United States.
-- Short-term training sessions, workshops, and visits at appropriate U.S. facilities could be organized for developing country personnel after relevant training in their own countries.
-- Provision could be made for developing country students studying in the United States to return to their own countries for dissertation or thesis work on local energy problems.
-- A number of U.S. universities have developed research centers that concentrate on comprehensive energy research and analysis. With NSF and AID support, some universities could undertake relatively short-term nondegree programs in energy

strategies for supply development and utilization efficiency. Such programs could train government officials and engineers from developing countries in the efficient operation and management of energy systems.

-- Jointly sponsored demonstration projects could be held in developing countries to provide local proof of the viability of technological innovation, especially in less energy-intensive methods.

### 2. Development of Indigenous Energy Resources for Local Utilization

Most developing countries depend primarily on imported fossil fuels--chiefly oil--for their industrial and agricultural growth and for rural development. Consequently, these countries have been hard hit by higher oil prices, a trend that is not likely to be reversed. Since most developing countries are unable to compensate adequately for increased oil prices by increased exports, they will be in a progressively poorer position to compete for fossil fuels on the international market and must turn instead to indigenous energy resources, including oil and gas where they exist.

In many developing countries, only a small proportion of the population is served by a power and fuel distribution network. The village and rural areas, where most populations live, generally depend on limited and expensive supplies of diesel fuel or kerosene and on "noncommercial" energy sources such as increasingly scarce firewood and dung or agricultural residues that might be used more productively for other purposes.

Thus developing countries have two distinct needs regarding energy technology. On the one hand, economic growth depends on conventional energy systems that use commercial energy sources and technologies. Agricultural development schemes pegged to irrigation, mechanization, pesticides, and manufactured nitrogen fertilizers also depend on these energy sources and technologies. On the other hand, rural populations, isolated from a central power source, continue to rely on firewood or dried dung, and would particularly benefit from technologies that exploit decentralized, renewable energy resources based on solar energy used directly (e.g., heating, distillation, photovoltaic conversion) or indirectly (e.g., wind, hydropower, biomass). Although much can be said in favor of rural electrication using large, central generating facilities and a widespread distribution grid, the

lower capital intensiveness of a decentralized system can be very attractive.

Past experience has shown that eliminating gross poverty in rural areas of developing countries will necessitate a much higher per capita consumption of energy. Achieving this goal by the turn of the century with conventional commercial fuels might require more petroleum than known world resources can provide even if developed countries reduce their petroleum consumption (Overseas Development Council 1977). Thus developing countries are almost forced to look elsewhere for fuels for their rural populations. A slowdown of population growth in addition to the development and highly efficient use of indigenous renewable resources are the most promising directions in which to look.

## Rationale for Selecting this Topic

Developing countries are aware of the seriousness of their energy supply situation and are seeking alternatives to conventional energy resources and technologies, particularly in the case of wood fuel and agriculture. Recent studies of energy use in rural areas of Asia, Africa, and Latin America have shown that noncommercial energy sources--wood fuel, crop residues, dung--supply between 61 and 96 percent of the total energy used. Between 69 and 97 percent of this energy is used for domestic purposes, mostly for cooking (Revelle 1978). Firewood for cooking is in increasingly short supply, resulting in rising costs, increased foraging distances, accelerated deforestation, and increased use of agricultural residues and dung as fuel instead of as fertilizer. Agricultural productivity is becoming more difficult to maintain or is dropping because of the rising cost of manufactured nitrogen fertilizers, the reduced availability of dung which is being used as cooking fuel, and higher cost of irrigation pumping by diesel pumpsets. Moreover, additional energy is needed in rural areas for agricultural mechanization and for rural industry.

The choice of energy technology and energy resources--renewable or nonrenewable, indigenous or imported--made by developing countries will have a long-term impact on their overall development. On the one hand, large-scale, centralized technologies will mean increased dependence on nonrenewable fossil fuels or a commitment to nuclear energy. On the other hand, small-scale, decentralized energy systems (e.g., solar heating and generation of steam and electricity, windmills, small-scale hydroelectric plants) will be

conducive to a dispersal of industry, the growth of small-scale industry, and an emphasis on sustainable agricultural improvements. All of these factors could contribute significantly, in the long run, to a self-sufficient but distributed population. Such an option can be an attractive complement to urban growth with its concomitant dependence on large-scale energy generation.

Unexploited resources exist in every country--nonrenewable fossil fuels, such as petroleum, coal, natural gas, and peat; nuclear and geothermal; or renewable resources, based directly or indirectly on solar energy. Most countries still do not know enough about their nonrenewable energy resources. Although the potential of such resources is restricted by their limited nature and uneven distribution, much attention is needed in developing and using them where they exist. (See the second section of this initiative, "Coal Conversion and Improved Combustion.") Over the long term, however, identifying and using renewable energy resources are the principal hopes of both developed and developing countries.

The chief barrier to greater use of renewable resources in the developed countries has been their high cost compared to fossil fuel alternatives based on cheap domestic and imported supplies. However, this barrier is diminishing as fuel prices rise and technology advances. In many developing countries, the cost barrier has ceased to exist because the cost of fossil fuel-based power in those countries, particularly in rural areas, is much higher than it is in industrial countries. Furthermore, conventional cost/benefit techniques tend to ignore "life-cycle" costs and to obscure the hidden subsidies involved in the entire system of central power generation and distribution.

Existing or prospective research and development in or for developing countries could produce technology of direct value to the United States:

-- Brazil, for example, is engaged in a major national program aimed at increasing alcohol production from sugar cane and cassava with the goal of providing 50 percent of the nation's need for liquid fuel by 1990 (Miccolis 1978).
-- Technology for using agricultural residues to provide most of the chemicals now based on petroleum was developed in the 1920s but was shelved because low oil and gas costs made the petrochemical source more attractive economically. This technology should be reexamined and upgraded through application of chemical engineering advances made during the past 50 years.

-- Information developed to maximize the production of methane from small-scale anaerobic digesters, for example, may well apply to large-scale urban sewage digesters or to U.S. work on converting kelp to methane.
-- Solar crop-drying techniques developed for regions of developing countries could also be applied in the United States with substantial energy savings.
-- Modular photovoltaic devices could be used to power high-cost remote communications (e.g., television, radio) and other electrical needs. The acquired production experience and resulting cost reductions will directly benefit the United States.

Such developments provide expanded markets for U.S. technology. Commercialization could mean accelerated price reductions and accelerated economic competitiveness in the United States of many technologies not yet economically competitive here but potentially applicable in rural areas.

Proposed Initiatives

We propose that the United States indicate its intent to increase support for a number of actions that would expand and strengthen the capabilities of developing countries to make greater use of indigenous energy resources:

-- Encourage U.S. government-sponsored research and development to be more responsive to opportunities for helping developing countries meet their energy problems, especially with regard to technologies for using renewable energy.
-- Establish a network of regional institutions to concentrate on the energy problems of developing countries. To the extent possible, the work of existing institutions should be broadened for this purpose. For example, forest research institutes and experiment stations in tropical countries could study rapidly growing species of trees for energy production (see the initiative on forest resources); research and development centers in microbiology could study improved strains of microorganisms to increase the efficiency with which methane, alcohol, and other chemicals are produced from agricultural residues and human and animal wastes; experimental and demonstration clusters could develop, test, and evaluate the technical and economic feasibility of various domestic energy supply approaches. The United States could also sponsor a continuing series of

regional summer institutes and symposia for a periodic exchange of information and ideas.

-- Establish a series of paired sites--one in the United States and one in a developing country with similar climatic conditions or common interests in certain technologies--to engage in cooperative research and development on small-scale technologies aimed at exploiting indigenous, renewable energy resources. For example, a site in the southwestern United States and one in a semiarid country could be paired to develop and test photovoltaic systems, solar collectors for heat and steam, and solar-driven systems for water pumping and mechanical drive. Or a U.S. institution particularly interested in combined production of fish (for food) and biomass (for energy) could team up with a host developing country especially interested in this area.

-- Expand scholarship/fellowship programs for the education and training of developing country personnel in the United States and U.S. personnel in developing countries, aimed at solving developing country problems in identifying and harnessing energy resources.

-- Create internships so that individuals from developing countries can work directly in the operations of U.S. energy companies, especially those involved in exploring and developing small gas and oil fields. Support could come from grants by major U.S. energy companies and scholarships funded by the U.S. government.

## 2A. Coal Conversion and Improved Combustion

The United States has both a strong interest and considerable capability in coal conversion and improved combustion. However, since coal is an important resource for only a limited number of developing countries, this topic is not given the same emphasis as the other seven areas described in this chapter.

Coal is an important fossil fuel in certain developing countries, and the development of technology that would allow it to be used more effectively could have a significant impact on the energy budgets of those countries. Higher petroleum costs in developing countries may provide opportunities for economically competitive synthetic fuels from coal before that situation occurs in the United States.

Principal among the technologies for better coal combustion or conversion is that dealing with fluidized beds. This technology could permit more efficient use of lower-grade coals and lignites, the development of

small-scale conversion units for decentralized electric power generation, and better control of coal impurities or of attributes which otherwise harm the environment. The end products of conversion--liquids and gases--are more easily handled in the distribution system than is the coal itself, thus enabling coal to displace petroleum distillates in transportation.

Further development and application of coal conversion and combustion technology could result in (1) the production of gases and liquids for further use as fuels or chemical feedstocks; (2) the improvement of combustion efficiency in existing methods and procedures for using coal; (3) the improvement of fluidized bed processes and techniques; (4) the development of small-scale conversion units for decentralized energy systems; and (5) improved handling of wastes and consideration of the toxic or carcinogenic effects of the by-products of conversion on workers and communities.

## Proposed Initiatives

A large effort already exists in this field. The Soviet Union has operated underground coal gasification for years, and current U.S. research, both governmental and nongovernmental, is substantial. About 16 plants using the Lurgi process for coal gasification now operate throughout the world, and pilot plants for newer processes are in existence both here and abroad. We suggest that sites in other countries be identified for pilot testing or for commercial demonstration of coal conversion technology, thus broadening the spectrum of testing conditions.

In the United States, the Department of Energy (DOE), private corporations, and industrial consortia such as the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), and others are already working in this area. These consortia might be urged to open their membership to developing country participants. Another possibility might be the establishment of a new international research and development consortium for coal combustion and conversion technology.

The United States could also seek sponsorship for an international conference to display the hardware as well as the software of coal combustion and conversion technologies and to bring together representatives of both developed and developing countries for an exchange of information. This type of conference is already being held in the industrialized nations. For example, the Offshore Technology Conference, which operates as a nonprofit group, is held annually in Houston and

attracts over 50,000 participants from all over the world. Hardware exhibitors represent a dozen or more countries.

We also suggest that the United States support adoption of a program, such as that followed in some of the U.S. national laboratories, in which "guest workers" from developing countries would work in laboratories that are conducting research on coal conversion or improved combustion technology (nonproprietary). Moreover, since coal conversion and fluidized bed technology are considered areas of advanced technology, U.S. universities would also have an interest in this work. A program might be established to provide postdoctoral training on coal utilization applications at existing facilities for developing country scientists and engineers.

Finally, much of the technology base for coal conversion can be traced to German sources during the 1930s and 1940s. These sources are covered in documents now in U.S. possession which are being translated and catalogued by DOE at Oak Ridge. These documents should be made available to other countries.

A principal constraint in addressing the problem described here is that much of the current technology for coal conversion is covered by proprietary rights. On the other hand, much research and development is now being supported by U.S. government funds and through large consortia such as EPRI and GRI, so that the proprietary issue may be diminishing.

### 3. Sustained, Multiple Use of Forest Resources

In many developing countries, as well as in some parts of the United States, forest resources are being used much faster than they can be regenerated. Forest exploitation is increasing rapidly in these developing countries in response to pressures for export earnings, building materials, fuel, and forage, as well as to make way for habitable lands and farms. Exploitation practices seldom reflect optimal use of forest resources either in the near term or over the lengthy time cycle needed for truly sustainable forest management. For example, many secondary species that could be used for pulp, wallboard, and other applications are simply being destroyed. Further, unsound harvesting practices often degrade the future productivity of the land, destroy wildlife habitats, and invite erosion which destroys adjacent farmland and aggravates the problems of sedimentation and flooding. Finally, insects, disease, and fire continue to take a heavy toll in wooded areas.

## Rationale for Selecting this Topic

The United States supports about half of the world's forest research. Although this country cannot claim expertise in or commitment to all the principles of sustainable forest management, it does have active programs for developing fast-growing species, optimizing seeding and harvesting patterns, using secondary species, and extracting chemical substrates. The United States is in the early stages of experimentation with "energy plantations." Also, its recently acquired capability in remote sensing offers new opportunities for assessing forest resources, assessing the impact of development activities, and monitoring for disease and other conditions. It should be noted, however, that much of the forestry research done in developed countries is not directly applicable to tropical forests.

As a major consumer of the world's wood products, the United States has a significant economic stake in forest development and use in the developing countries. A dozen U.S. industrial firms import plywood, veneers, and pulp from the developing countries, and several are directly involved in logging, marketing, and sales activities on a worldwide basis. Also, any progress in satisfying energy demands for local markets through forestry is of considerable interest as the United States intensifies its domestic search for small-scale energy supplies for rural areas. Finally, the United States could benefit scientifically from collaborative research on (1) suitable environments for different species and varieties; (2) genetic and physiological improvement of trees; (3) influencing nutrient concentration processes; (4) protection of trees from fire, insects, and diseases; and (5) finding substitutes for forest products (such as using cement in construction instead of lumber). Technologically, collaborative efforts should provide us with new insights into techniques for converting timber to valuable chemical products as well as for improved processing of species with different physical properties.

## Ongoing Work

AID has been concerned with improving the development and use of forest resources in developing countries for many years. The U.S. Forest Service, in collaboration with researchers throughout the world, maintains an international germ plasm collection as well as the world's foremost repository of wood samples. In addition, the Forest Service conducts a

variety of Public Law 480 research projects in developing countries, and a number of U.S. agricultural and forestry schools maintain international contacts.

FAO has also been active in this area. Several regional forest projects have been attempted at the research institutions in developing countries, usually under FAO auspices. Furthermore, the World Bank, U.N. Development Programme (UNDP), and the Organization of American States (OAS) have supported numerous forest surveys, although many of these surveys have not been used.

The current worldwide concern with energy resources offers many incentives to expand collaborative efforts. A forestry industry provides numerous employment opportunities and a potential for developing rural areas without depleting the soil as crop farming unfortunately does in many geographical areas, especially in the tropics. Finally, the physical evidence of forest abuse has become very obvious in many countries.

## Proposed Initiatives

International Forest Research Institutes. Building on CGIAR's experience in establishing an international network of agricultural research institutes, we propose that the U.S. government, supplemented by the U.S. private sector, support a comparable effort in forestry research. Efforts recently undertaken, such as those of the International Council for Research on Agroforestry, to identify research priorities in tropical forestry could, with U.S. support, be the mechanism for accomplishing this goal.

Central to this expanded effort would be the establishment or designation of two or three first-class regional institutes in the developing countries, patterned after the international agricultural research institutes and oriented toward different ecological zones. These institutes would support research in forest ecology, development and testing of improved varieties, reforestation, determination of sustainable yields, resistance to insects and disease, and innovative use of forest products. Selected transnational corporations that are already involved in research and conservation efforts as part of concession arrangements should be invited to participate in the activities of these institutes.

Research Stations in Developing Countries. In addition, we suggest that a strengthened array of research and experiment stations in the developing countries be integrally related to the regional institutes through collaboration on research and

development and training. These stations would help ensure that regional research activities were focused on real problems and would help train the better qualified specialists that are sorely needed. Research facilities of the U.S. Forest Service, university forestry schools, and industrial firms should also be integrated into this network. These organizations could assist developing countries both by training personnel from those countries in the United States and by providing advisers.

Comprehensive Analysis. This scientific thrust must be accompanied by improved forest planning and policy capabilities in developing countries. For example, as new demands for forest products arise (e.g., for fuel production), it is important to identify uses that can be filled by other resources (e.g., stone, ferrocement, and gypsum for lumber). Other constraints on more effective management of forest resources include: institutional factors including laws and regulations that inhibit effective management and utilization, inadequate education and training, and inappropriate land ownership and concession policies; inadequate harvesting, transportation, and processing facilities; poor information on forest inventories, species identification, wood properties, and potential uses; undeveloped markets, inadequate industrial capability, and inappropriate marketing practices; inadequate perception of the economic and environmental significance of forestry potential; and a propensity to focus more on near-term increases in forest productivity (generally energy-intensive) than on long-term, sustainable forest management. In the past, a number of developing countries have sought assistance from the United States and FAO on forest planning and policy, and both should be prepared to respond to such requests in the future.

### 4. Water Resource Planning and Management

The basic goal of water resource planning and management is to provide, to the greatest extent possible, water in sufficient quality and quantity for a specific use without adversely affecting its availability and quality for other uses. A related management problem is to set priorities for water use given various needs and water availability.

The planning and management of water resources in developing nations pose many of the same problems that confront the United States. These include effectively managing water as a natural resource given its many essential uses--for agriculture, energy production,

domestic and industrial consumption, waste discharge, transportation, recreation, and fish and wildlife production--and maintaining related natural resources such as soils, forests, and rangelands. All these uses are interrelated. In Chapter 4, for example, the point is made that long-term agricultural purposes cannot be effectively served unless water and soil on surrounding nonagricultural lands are appropriately managed:

> Where upstream and adjacent lands are managed under conservation systems, such as national forests, national parks, wildlife sanctuaries, and similar types of reserves, food production can benefit from more stable water supplies, minimum erosion and flooding, and reduced loads of sediment.

Water resource planning should thus be integrated into a comprehensive river basin plan in order to mitigate problems of drought, floods, erosion, pollution of drinking water, and damage to agricultural land, vegetation, and wildlife. Because rivers often define and cross international boundaries, this planning and development process is perforce frequently international.

## Rationale for Selecting this Topic

In many countries, water has traditionally been considered a free good (much like air) and, as a result, has been used and abused in a variety of ways. For example, water quality has been affected by economic development activities, and the construction of dams and irrigation systems in many developing countries has led to the increased transmission of water-associated diseases, destruction of downstream fisheries, and increases in soil salinity.

The developing countries' interest in addressing these problems was evidenced by their participation in the U.N. Water Conference. The Conference Plan of Action (United Nations 1977), approved by 117 countries, stressed the need to identify the extent of national water resources, to draw up plans to manage them, and especially to consider the supplies of water needed for drinking and agricultural development.

The United States is in a particularly strong position to provide scientific and technological assistance, including data acquisition, processing, and analysis in certain areas of planning, management, and water-use technology. Recent scientific advances in understanding the dynamics of watersheds and hydrologic cycles provide a new framework for these activities.

New technology and techniques that could be applied in developing countries are already available in the public sector, including the use of remote sensing to conduct water resources inventories, and waste water treatment techniques such as ANFLO.[2]

A model for the successful transfer of scientific and technical assistance in this area might be the work of the Tennessee Valley Authority (TVA), the U.S. Geological Survey (USGS), the Agricultural Extension Service, or regional water planning commissions such as the Interstate Commission on the Potomac River Basin. In addition, U.S. universities, either through AID or on a university-to-university basis, can continue to help train in-country personnel in data collection and assessment, water quality monitoring, and management techniques.

Although the United States has played a leading role in the development of water resource programs through governmental and private institutions,[3] it has generally focused on dilution and capital-intensive treatment facilities. It can gain insight from the experiences of other nations in other areas of water resource management (e.g., irrigation practices in the Middle East). The development of next-generation treatment methods, especially smaller unit size, and low-cost water treatment systems could be encouraged by the development of new markets abroad, possibly preceding U.S. domestic market use.

## Proposed Initiatives

We recommend that the United States offer to follow up on the U.N. Water Conference by collaborating with developing countries in such activities as examining the feasibility of (1) using systems such as ANFLO that are commercially available or in the public domain; (2) developing new standards for water quality evaluation that may be more appropriate than *E. coli* counts and other traditional measures; and (3) introducing systems for internal recycling and recovery in industrial plants during construction (e.g., pulp and paper mills).

In preparation for the U.N. Water Conference, the U.S. Water Resources Council and the State Department identified U.S. programs and personnel with capabilities in water resource planning and management that are available to work with developing countries. We suggest that the United States assess this information and make it available to developing countries. Proposals from developing countries for financial assistance (cost-sharing) to use these

resources should be invited, especially in the following areas:

-- developing and implementing operational water management programs based on available data, technologies, know-how, and present-day needs;
-- developing more comprehensive, long-range plans for integrated water resource management including collecting data on water availability and quality; forecasting demand in different sectors; analyzing the adverse secondary effects of previous water resources development; and evaluating the economies of using alternative or new technologies to minimize adverse effects and maximize benefits from water use, including techniques of recovery and recycling.

The Oak Ridge National Laboratory National Inventory of Selected Biological Monitoring Programs is an appropriate prototype activity that could be used to advise both U.S. institutions and developing countries of available scientific programs, technologies, and personnel. Any teams the United States sends to developing countries should include a balanced contribution from those who are familiar with the science, those who know how to apply science in the form of technology, and those who have special skills in finance, planning, and management.

## 5. Effective Use of Marine Resources

Traditionally, estuarine and coastal waters have been used as inexpensive avenues for commercial fishing, shipping, and transportation; dispersal of toxic wastes and thermal effluents; and, in more recent years, for recreational purposes. In certain areas, they have been mined extensively for a variety of raw materials, including petroleum, and they remain the primary source of the world's fisheries, both finfish and shellfish. However, increasing competition for the use of these resources has created the problem of managing marine resources in such a way as to obtain the highest long-term net social value.

Planning and proper management can be used to minimize the deleterious effects that expansion in one area of marine resource use might have on other areas. For example, planners need to consider whether sewage disposal in the marine environment, with the resulting pathogens, sediments, toxic substances, and the like, will jeopardize the use of that environment for fishing and recreation. Then they can assess the trade-offs between the two. Such conflicts have already arisen in

many developing countries as a result of, for example, locating large industrial sites adjacent to coastal waters which are also being developed for tourist purposes and which have traditionally served the region as a primary source of fisheries products.

We need to learn more about the earth's estuarine and coastal resources, including how to manage them to ensure sustained, multiple use wherever possible. In certain cases, as in the rather complex array of water movements from within estuaries to the continental shelf and along the continental shelf where the ocean meets the more shallow water, adequate background information has not been available. However, we are now seeking this information, and it should add considerably to our understanding of coastal fisheries, distribution of wastes, and the extent to which offshore mining and recovery of other mineral resources may affect the potential for using marine resources in adjacent areas.

## Rationale for Selecting this Topic

Partly as a result of the U.N. Conference on the Law of the Sea, coastal countries will acquire new rights to, and responsibilities toward, living resources and protection of the marine environment within 200 miles of their shores. The effective exercise of these rights and responsibilities (for example, as they pertain to the rational management and conservation of living resources) will require much more scientific understanding than is now available. Coastal countries will also gain complete control over marine scientific research in their exclusive economic zones, which has prompted many scientists to fear that research sponsored by laboratories in developed countries will be seriously inhibited at a time when most developing coastal countries lack capabilities for conducting their own research.

It is in the long-term interest of the United States that we learn more about the oceans and apply that knowledge worldwide to the management and conservation of resources and to protection of the marine environment. Thus the development of foreign marine science capabilities by means of cooperative research programs is clearly to be desired.

Recent, large-scale international oceanographic programs such as the International Decade of Ocean Exploration and the Global Atmospheric Research Program (GARP) have begun to analyze ocean/atmospheric coupling which contributes to the variability in structure, function, and productivity of the world's oceans. Testable hypotheses and theories now exist on the

causality of large-scale effects, in particular on the coupling between the oceans and the coastal shelf circulation in a number of areas of the world and how these events may fuel the fluctuations observed in basic productivity in major fisheries.

We need to learn more, perhaps by continuing IDOE, about the nature of the linkages involved in these oceanic processes, extending our understanding of atmospheric/oceanic coupling so that eventually we will be able to predict biological productivity in major world fisheries, destructive climatic forces such as typhoons, and beneficial conditions such as the onset of the monsoons.

Within the U.S. oceanographic community, there is considerable interest in extending large-scale international cooperative studies through the 1980s. However, such extensive studies will be possible only with the availability of the oceanographic facilities and ships of the developed countries, coupled with the interest and participation of developing countries so as to provide open access to specific geographical areas of the global marine environments.

Future U.S. research in foreign waters will necessarily be cooperative if access is to be approved. Foreign scientists should participate in the planning and conduct of the research and in the analysis of its results. Data and samples should be shared, and coastal states should receive assistance in assessing both.

And yet, many developing countries are only now beginning to recognize the need for personnel trained in an understanding of the marine environment and for an accurate evaluation, both short-term and long-term, of its resources. The five to seven years required for advanced training in foreign universities, coupled with the fact that some postgraduates elect not to return to their home institution, has further delayed the development of those trained scientific and technical personnel necessary for assessment and management. Even where trained personnel exist, shorebased marine facilities are often inadequate and ocean-going capabilities completely lacking.

Cooperative research programs will likely help coastal developing countries strengthen their marine science capabilities. This process can be accelerated by means of a systematic, adequately funded, and deliberate assistance effort aimed at the cooperative creation of strong marine science institutions.

## Institutional Mechanisms

Within the United States, research activities directed toward marine resources come within the purview of a number of federal agencies, including the National Marine Fisheries Service (National Oceanic and Atmospheric Administration [NOAA]), the U.S. Office of Sea Grant (NOAA), USGS, NSF, DOE, and the U.S. Office of Naval Research, as well as the individual state marine fisheries commissions. Since the passage of the U.S. Coastal Management Act in 1972, virtually all coastal states have developed agencies to assess and manage marine resources, coordinated through the Office of Coastal Zone Management of NOAA.

Examples of mutually beneficial cooperation between U.S. and foreign scientists are already documented. Through IDOE, the National Science Foundation has been involved in cooperative studies with scientists from many nations, and the U.S. Office of Sea Grant recently initiated an international program to communicate results of studies on marine resources through colleagues in other countries having similar problems. Multi-institutional programs such as that of the Coastal Upwelling Ecosystem Analysis project of IDOE have also had a successful record of international cooperation. Furthermore, many scientists from developing countries have received advanced training and education in U.S. academic institutions. But these cooperative activities have always been ad hoc in nature, and there has been no systematic program for their development.

At the international level, the International Council for Exploration of the Seas, the Intergovernmental Oceanographic Committee, the Scientific Committee on Oceanic Research, the Committee for Coordination of Joint Prospecting for Mineral Resources in Asian Offshore Areas, and FAO are devoted to a better understanding of marine resources. Still other institutions are encouraging and supporting training and research involving scientists from different countries (e.g., the Division of Marine Sciences, UNESCO) and a number of regional associations are also at work. Thus adequate mechanisms already exist for disseminating information and technology, assuming that the need is recognized and that there is a legitimate desire on the part of all parties to pool information and resources, especially in areas in which resources are shared or, in the case of migratory species, where movement of species among territorial waters is involved.

Proposed Initiatives

The effective utilization of marine resources within developing countries will require the development of concurrent programs that provide (1) trained scientific and technical personnel with adequate shorebased and research vessel capabilities at their disposal; (2) a multifaceted program of coastal management involving government agencies, academic institutions, and business interests; and (3) a commitment on the part of both scientists and governments from developed and developing countries for increased cooperation in marine research and development.

We recommend that the United States declare its readiness to support suitable elements within a three-pronged program providing for training, extension, and cooperative research, such as:

-- Training programs, using U.S. universities, community colleges, technical institutes, and government agencies to present integrated aspects of planning, research, and management in coastal environments and to help developing countries acquire the expertise necessary to evaluate and use their marine resources.
-- Cooperative training and research programs involving U.S. and developing country laboratories and universities, emphasizing areas of mutual interest and expertise and designed to strengthen the capabilities for research and teaching in developing country institutions.
-- Use of the U.S. Sea Grant Program to help promote marine resource programs in developing countries, including extension programs in planning, research, and management of coastal areas. Such programs could emphasize common areas of interest such as mariculture and biologically active substances available from marine animals and plants. Under such programs, universities and agencies could provide extension training to develop all levels of expertise through short courses, reorganization of existing programs, and design and construction of necessary new facilities.
-- Regional institutes of marine resources established by those countries wishing to pool available scientific personnel to work on regional problems. The United States might offer financial support for the purchase of modern facilities and equipment.
-- Continuation of the International Decade of Ocean Exploration as a cooperative mechanism for better understanding the coupling between the atmosphere and the oceans, thus improving our ability to

predict fluctuations in biological productivity of the oceans and to give early warning of catastrophic climatic conditions.

### 6. Remote Sensing from Space for Resource Mapping and Assessment

The distribution of natural resources in the developing world is inadequately mapped. Thus many countries do not know the full extent and condition of their arable land, forests, rangeland, water resources, or promising areas for mineral exploitation and as a result are unable to harness these resources and protect their environment effectively. This lack of knowledge results partly from a lack of the trained personnel and facilities necessary to analyze and interpret existing information, and partly from a lack of good basic data.

#### Rationale for Selecting this Topic

Resource mapping and assessment are activities of major interest and potentially high impact in developing countries. Mapping is used here in the broad sense of locating and charting resources. Resource mapping may involve preparation and display of information in ways other than topographical maps; numerical data stored in computers can be part of the resource mapping technique, for example.

Good potential exists within developing countries for capitalizing on the use of remote sensing from space for resource mapping. Much of the technology has already been successfully demonstrated and used in developing countries and LANDSAT imagery is readily available to them. Most countries already possess a nucleus of the scientists, engineers, and technicians needed to make use of the information generated by remote sensing, and some have already started.

Developing countries have strong economic and social incentives to use resource information from remote sensing and other sources to forecast crop yields, establish the quantity and location of water resources, detect the erosion of land and pollution of water, recognize alterations in land use and support land-use planning, give warning or assess the damage of natural disasters, observe other aspects of environmental change, and make wise use of water resources and control flooding through long-term river basin planning. Remote sensing can also be used to help locate mineral deposits, assess the content and

potential production of forests and rangelands, trace desertification, and obtain demographic information.

We must note that the use of remote sensing technology has been viewed with ambivalence by some developing countries. Despite the potential technological benefits, concerns have arisen about whether other nations or companies might exploit information about a country's resources for political, military, or economic advantage. As countries have gained actual experience with the LANDSAT program, however, it is the impression of the panel that these concerns have been dispelled.

The use of remote sensing from space is, of course, only one of several important means of gathering information for resource mapping and assessment. Photography and other techniques of remote sensing from airplanes can be highly useful, and various ground survey and exploration techniques are important, even necessary, to verify and add detail to remotely sensed information. Remote sensing from space warrants special attention in the context of the 1979 U.N. Conference, however, because it represents technology in which the United States has clear strengths and in which the potential benefits from its use are great both to developing countries and to the United States.

New or improved programs of remote sensing of natural resources and the environment are likely to have several advantages for developing countries:

-- they would provide information critical to better long-range economic planning and pacing of resource use;
-- they can substantially lower the costs of locating and assessing natural resources of significance for economic and social development;
-- better resource information and planning would strengthen a country's position in negotiating trade agreements or contracts for the exploration and use of resources;
-- the modular character of remote sensing technology permits countries to use it gradually and incrementally (i.e., the "entrance cost" is low);
-- data can be obtained that cannot otherwise be gained (e.g., synoptic coverage, multispectral data that can be digitally processed, and repetitive data).
-- a user with only a modest photo-interpretation background and equipment can extract useful information (although more and better information can be extracted with higher levels of training and improved facilities).

As a major user of raw materials and a major supplier of food, the United States also has an interest in better mapping and assessment of the world's natural resources. U.S. economic forecasting and planning can be significantly aided by better information on strategic resources. Better information also enhances the possibilities for U.S. public and private organizations to collaborate in exploration and utilization activities with other countries. Greater use of remote sensing technologies increases the commercial opportunities for U.S. firms to provide equipment and support services related to data analysis and interpretation. Finally, monitoring changing resources and environmental patterns may enable the United States to work more closely with other countries to prevent or alleviate serious environmental problems that would be harmful to all nations. And, of course, remote sensing technology can have important applications in all the other resource sectors discussed in this report.

## Ongoing Work

Several U.S. programs are experienced in applying remote sensing information to natural resources so that better policy decisions can be made. For example, the National Wetlands Inventory (U.S. Fish and Wildlife Service) uses remote sensing as a basis for mapping and characterizing wetland ecosystems. Likewise, a number of state governments, Oak Ridge National Laboratory, TVA, and several universities are using remote sensing and associated technologies to assess changes and trends in land use. The Western Energy and Land Use Team in Fort Collins, Colorado has worked with the technologies that must accompany remote sensing, including information storage and retrieval, pattern recognition, composite mapping, and ecosystem characterization.

Advice and assistance to developing countries for remote sensing processing, analysis, and interpretation of imagery, or for organizing national remote sensing programs, is available through a small number of U.S. commercial or nonprofit consulting firms, some universities, and, for applications relating to the geological sciences and mapping, the U.S. Geological Survey. NASA, of course, has been involved in the actual operation of LANDSAT and in assistance with receiving and analyzing data, and map libraries are available for a nominal cost. Furthermore, AID has sponsored a program designed to assist developing countries with the use of remote sensing data and to support experimental application projects.

International organizations such as the UNDP, FAO, WMO, UNESCO, and the World Bank have engaged in a variety of remote sensing projects through funding, technical services, or informational activities, as have the development assistance agencies of several countries. The Earthwatch program sponsored by the U.N. Environment Programme monitors environmental information of global significance. Most of these efforts have been on a relatively modest scale.

In many developing countries, as well as in the United States, organizational and budget problems are major constraints on wider applications of remote sensing. Most countries acquire resource information through a variety of separate agencies, gathered by a variety of means; current and accurate information frequently is unavailable because of this dispersal of responsibility.

Aside from budgetary constraints, the shortage of trained personnel for the processing, analysis, and interpretation of information is perhaps the primary limiting factor in the ability of developing countries to use remote sensing technology effectively. A National Research Council study has roughly estimated the various personnel developing countries need over the next decade to provide visual interpretation or quantitative analysis of data from remote sensing (NRC 1977:133-134). The needs are large and the world's ready capacity to provide training in these skills falls far short of the magnitude required.

## Proposed Initiatives

Weighing the importance of remote sensing technology to improve natural resource mapping and assessment against the constraints involved in its application, this panel believes that important opportunities exist for U.S. actions that would benefit both this country and developing countries. Thus <u>we propose</u> that the United States:

-- Declare its intent to continue the development of remote sensing (satellite) technology for resource applications and to provide continuity of sensing coverage and data transmission to users everywhere. At the same time, the United States could work with other nations and international organizations toward international collaboration in establishing and operating receiving stations and ancillary services. International efforts could help prevent wasteful duplication that might come from multiple receiving stations with overlapping coverage, and provide for efficient choices of ancillary data

processing equipment, as well as ease fears that any one nation would gain unilateral advantage.

Such efforts might take several organizational forms including the establishment of centers for data storage and processing by regional organizations; multilateral funding and participation through a specialized agency; or ownership and management of a network of regional stations and distribution centers through an independent consortium of sponsoring nations or through a U.N. body.

-- Increase assistance to developing countries to establish and strengthen capabilities for remote sensing data-gathering, analysis, interpretation, and assessment. Some of these countries have already begun to make use of the LANDSAT system. It is probably advisable to continue this activity through U.S. government agencies such as AID, USGS, and NASA, drawing on the expertise of universities or private sector organizations as appropriate.
-- Train and support the personnel needed by developing countries for resource mapping and assessment using remote sensing. A combination of U.S. and developing country funds could be used to strengthen and expand degree programs related to remote sensing and resource analysis at selected U.S. universities, focusing on problems of developing countries. In turn, university teaching and research activities could be used as a resource for establishing nondegree training programs for technicians at several regional centers in the developing world.
-- Support periodic seminars in cooperation with U.N. regional commissions on remote sensing applications and technologies.
-- Expand cooperative research projects with developing countries on the application of remote sensing to resource studies.
-- Introduce new satellite systems into use for remote sensing as they become available.

Both institution-building and training activities should attempt to increase the level of awareness of possible uses of existing data generated by the LANDSAT (formerly ERTS) program and other remote sensing activities. Even without gathering additional data, many developing countries can find highly useful applications for existing information.

## 7. Improved Use of Pesticides

Pesticides will continue to be used for the foreseeable future to reduce losses of crops and livestock and to limit insect-borne diseases in many developing countries. Even though improved insect-resistant crops and operationally feasible biological control techniques (e.g., sterile male, juvenile hormones) may ultimately reduce dependence on pesticides, chemical products are likely to remain an important component of sophisticated approaches to integrated pest management.

In recent years, environmental and human health problems have emerged attributable to the excessive use of pesticides, the use of long-lived pesticides, and the use of inappropriate pesticides, particularly insecticides. In the 70 or so developing countries that grow substantial quantities of cotton, for example, misuse of pesticides has resulted in injury to farm workers, evolution of insecticide-resistant pests, reduced cotton yields, and contamination of nearby food crops and animals, including commodities scheduled for U.S. markets. Moreover, in some places concentrated efforts to eliminate primary pests have upset the ecological balance, and insects that had previously been of only secondary importance have become primary pests. While the environmental damage from misuse of pesticides cannot be quantified, this topic is of concern to health, agricultural, and environmental officials in many regions of the developing world.

Developing countries also lack trained entomologists to deal with pest problems and policies for planning and controlling pesticide application, and they have difficulty in conveying the information that is available to policymakers, local formulators, farmers, and rural medical personnel. Further, developing countries often buy pesticides on the basis of competitive bid, and the cheapest supply sources are seldom helpful in providing a technical outreach to the local formulators and applicators.

### Rationale for Selecting this Topic

U.S. capabilities and experience in basic entomology, the development and use of chemical pesticides, the measurement and analysis of pesticide residues, biological approaches to control, and integrated pest management have been recognized throughout the world. Indeed, the efforts of the United States and other developed countries have made major inroads into the control of harmful insects, particularly at home and to a lesser extent in the

developing countries. Further, the United States is the world leader in developing sophisticated regulatory approaches for pesticide use to reduce undesired impacts. At the same time, effective approaches to pest management, including such techniques as water management and crop rotation as well as use of pesticides, are just evolving and are not well understood or even fully appreciated in developing countries. Thus there are many opportunities for collaborative efforts to address a problem of common interest to many countries.

The United States has many reasons to support continued emphasis and work on improving pesticides in developing countries. First, entomology is a complex science, and field experience in many ecological zones can have a significant impact on the advancement of this science. Such advances could directly benefit work on important problems in the United States, such as those associated with insect immunity and with continuing disregard of the alternatives to heavy pesticide use.

Second, for the protection of U.S. health and agriculture, it is desirable to avoid reintroducing insect problems into this country that are currently under control, or introducing new problems from the tropics. The possible influx of the Mediterranean fruit fly or insecticide-resistant mosquitoes from Latin America is of special concern, as is the health of U.S. personnel and other travelers to developing countries.

Finally, on the commercial front, U.S. industry is the leading producer and supplier of chemical pesticides to developing countries, particularly in Latin America. To the extent that markets of significant size may develop for new pesticides (e.g., for cotton and cocoa production), U.S. commercial interests clearly have a stake in these countries. However, without a potentially large and long-term market, U.S. firms are not interested in making large investments in research and development to develop the types of short-lived pesticides that would be most suitable for local problems. Similarly, U.S. pharmaceutical and veterinary supply companies are interested in markets in developing countries, particularly where markets are sizable.

## Ongoing Work

U.S. involvement in international collaboration on pest control, particularly insect control, goes back many decades, especially in its relations with Central America and more recently during World War II in Asia

and Africa. Since the early 1950s, WHO and FAO have had this topic near the top of their agendas, and U.S. institutions have been major contributors. The United States subsidizes several percent of the chemical pesticide purchases by developing countries, both through AID and the international banks, but it exercises stringent control over the pesticides it supplies directly. Unfortunately, within developing countries only a few scientific institutions are seriously involved in various aspects of insect control, and routine application of chemical pesticides by untrained personnel often prevails.

USDA, EPA, NIH, and NSF support extensive research in the United States on the effects of pesticides and on integrated pest management, and some of these activities already have overseas extensions in the developing countries. AID also supports a consortium of U.S. universities which is providing technical assistance and training. CGIAR supports some pesticide activities at its international centers. The International Center for Insect Physiology and Ecology (ICIPE) in Nairobi is an unusual collaborative experiment initiated by the scientific community and directed at a variety of insect problems of Africa. ICIPE's effort to train and use local talent as fully as possible has engendered wide support.

Many of the international mechanisms are in place for an expanded U.S. effort in this area. The two weakest mechanisms are arrangements for bilateral programs with the non-AID developing countries and effective channels for conveying U.S. industrial expertise to users in developing countries.

## Proposed Initiatives

We propose that the United States offer assistance, as requested by developing countries that are committed to improved use of pesticides, in three ways:

Strengthening Scientific and Technical Personnel. The strengthening of selected departments of entomology in universities in developing countries is a top priority need. U.S. chemical firms with interests and personnel in the developing countries should be encouraged to provide on-the-job training for local technical personnel.

Upgrading Local Management Capability. Symposia for senior governmental officials in developing countries to discuss the implications of the problem and the need for national regulation should be continued and expanded. While some work in this area is sponsored by U.S. exporters, it is essential that this be bolstered by intergovernmental and/or

international cooperative activities. For example, the United States could invite proposals from developing countries to organize and cosponsor workshops and projects designed to develop pesticide management programs. Assistance could be provided in the development and drafting of model regulations, which will undoubtedly vary among countries. Typical regulations could be drawn up as models for other countries. The concept of government certification of pesticide applicators should be strongly advocated, and major educational efforts are needed at all levels on integrated pest management.

Improving Understanding of Available Technologies. Information on the efficacy and effects of alternative pesticides needs to be made available in easily understandable terms to governments, formulators, applicators, and farmers. U.S. pesticide manufacturers should be encouraged to supplement AID efforts. For example, exporters could be required to furnish importers with specific, but easily understood, information on toxicology, safe methods for use, and the effects of misuse. Also, development banks, which do not now have environmental programs comparable to those of the United States, should be encouraged to expand their safety efforts, including loan conditions.

## EPILOGUE

The initiatives we propose would benefit not only the developing countries but also the United States. U.S. scientists and research and teaching institutions would be stimulated to deal with problems that this country must solve in the near future, particularly the development of alternative energy sources and the economical use of raw materials. Better planning strategies for using nonrenewable resources and developing alternative materials and processes will benefit the U.S. economy, as will the increased trade and more stable supplies of commodities that will result from resource and environment-related activities in developing countries.

To the extent that the United States initiates or expands the kinds of activities we have outlined, it should do so in a manner that reflects the diversity of its scientific and technological resources. Technical assistance or collaboration with developing countries should flow through a multiplicity of transfer agents, including government agencies, universities and nonprofit institutions, private sector organizations, and individuals. There is a special need to provide incentives that will encourage and enable universities and firms with international interests to apply their

experience and resources to the crucial energy, natural resource, and environmental issues.

Certain common requirements must be met, however, to provide the scientific and technological context that will give the proposed activities better prospects for success. For many years, persons connected with problems of national development have been espousing better training, better management, a stronger indigenous capability to address problems, and stronger linkages among private and public organizations concerned with similar problems. A new sense of urgency has been added to these old perspectives, however, as the problems of energy, natural resources, and the environment have become critical for all nations. Managers concerned with natural resources and the environment need to be aware of the complex implications of the problems they must address. Our interdependence demands greater collaboration in finding ways to use resources wisely and also demands broader training and awareness for persons working with these problems.

All this requires an expanded commitment by the United States, through both public and private organizations, to research and development focused on the global problems of energy, natural resources, and environment. An essential aspect of this expanded effort should be work aimed at increasing the efficient of use of energy and other natural resources in developing countries.

## NOTES

1. An additional write-up coal conversion and improved combustion is presented as a subsection to Initiative 2 because it concerns only a small number of developing countries.

2. ANFLO, the basic patents for which are in the public domain, is a packed bed anaerobic digester system capable of processing a wide variety of organic wastes. It features high throughput and appears to be cost-effective at relatively small size.

3. AID, EPA, USDA, Department of the Interior, TVA, and the U.S. Army Corps of Engineers; capital development assistance from private industrial firms; and possible aid in the development and use of less sophisticated technologies from private, nonprofit foundations. International agencies such as the World Bank, UNESCO, UNICEF, and the Canadian IDRC have also been active in water development and management, especially in providing loans and grants for capital components.

## CITATIONS


Miccolis, J. (1978) Alternative energy technologies in Brazil. In: Renewable Energy Resources and Rural Applications in the Developing World, edited by N. L. Brown. Boulder, Colo.: Westview Press.

National Research Council (1976) Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries. Washington, D.C.: National Academy of Sciences.

National Research Council (1977) Resource Sensing from Space: Prospects for Developing Countries. Washington, D.C.: National Academy of Sciences.

Overseas Development Council (1977) Draft Report to the Rockefeller Foundation. Washington, D.C.

Palmedo, P., R. Nathan, E. Beardsworth, and S. Hale, Jr. (1978) Energy Needs, Uses and Resources in Developing Countries. Policy Analysis Division, National Center for Analysis of Energy Systems, Brookhaven National Laboratory (with contributions from Cornell University, Overseas Development Council, University of California, etc.). Prepared for AID, No. BNL 50784 UC-13, Genl., Misc. & Progress Report (nonnuclear) TID-4500.

Revelle, R. (1978) Requirements for energy in the rural areas of developing countries. In: Renewable Energy Resources and Rural Applications, edited by N.L. Brown. Boulder, Colo.: Westview Press.

United Nations (1977) Report of the United Nations Water Conference, Mar del Plata, Argentina, March 14-25, #E 77.II.A.12. New York: United Nations.

# Chapter 6

# URBANIZATION, TRANSPORTATION, AND COMMUNICATION

## INTRODUCTION

The rapid growth of major urban concentrations in developing countries is creating enormous demands for shelter, water, sanitation, education, health care, transportation, and communications. Although most people in these countries are not now living in urban areas, the trend toward urbanization continues. An estimated 1.2 billion more people will be living in urban areas by the year 2000, including at least 40 percent of the population in developing countries. This calls for strategies to help accommodate the inevitable expansion of existing big cities, to divert more growth into intermediate cities, and to improve the productivity and satisfactions of rural life.

Urbanization is an important dimension of economic and social progress. Countries with the highest percentage of urbanization have the greatest life expectancy, the highest literacy rate, the largest school enrollment, the highest newspaper circulation, the most favorable ratio of doctors to population, the highest caloric and protein intake, and the highest per capita income. But there are wide variations between the poor and the affluent in cities. Ideally, growth should be encouraged in medium-sized rather than major cities, and in ways that assure all urbanites access to urban opportunities.

Better understanding of urbanization processes and improved technical skills in building and managing cities could yield high payoffs. Potentials include better construction techniques and materials, new sources of energy, innovative physical designs, more efficient waste management, recycling, improved communication systems, and more. Land-use planning and the use of telecommunications and transportation can make possible improved national patterns of urban

settlements. The beginnings of integrated community-building around the world, from self-help sites-and-services projects to massive planned urban development, indicate the potentials for better cities, more jobs, and the stimulation of economic activity.

The potentials of transportation technology are linked in part to problems associated with urbanization and the entire urban-rural continuum of human settlements. In the cities, traffic congestion, inadequate transport, and the poor condition of public transit reduce efficiency, opportunity, and the quality of life for entire communities. Obstacles to mobility are especially injurious to the lowest income families.

Transport problems in developing countries go beyond the problems of human settlements, however. Nearly every aspect of socioeconomic development depends in part on the ability to move people and goods. Access to land and other resources, and ability to obtain fertilizer and other agricultural inputs and to market farm surpluses, are frustrated by lack of all-weather transport. The ability to tap mineral and forest resources and to extend the areas for trading in goods and services depends on the availability and reasonable cost of transport. Today, even the transfer of knowledge and ideas depends on the ability to transport information physically. A primary need, therefore, is to supply the transportation necessary to support other objectives of development without excessive use of resources.

In this regard, one of the most promising possibilities of science and technology lies in new methods that might shift part of the communications burden from the transportation sector, while simultaneously surpassing the effectiveness of old methods of transporting information. Modern telephone, television, radio, and information systems could make telecommunications a major means of overcoming the time and space barriers that inhibit development. Use of these systems calls for both enhancing the capacities of developing countries for assembling and using knowledge and creating new, low-cost international communications networks for global transfer of science and technological innovations.

In the three areas of urbanization, transportation, and communications, a set of common conditions is evident in which U.S. science and technology might be used to accelerate development and improve living conditions in developing countries.

A central problem is that for most poverty-stricken people, the opportunities for betterment are inaccessible--spatially, economically, and socially. The quality of their lives remains below what might be reasonably expected in both urban and rural places.

Managerial and technical capabilities are typically insufficient for implementing programs to improve these conditions. Rising land values are also pushing the cost of decent housing far beyond what low-income families can afford. And they are forcing land-use patterns that separate employees' homes from job locations, compelling long-distance and expensive commuting and hence reducing employment opportunities for those who are least mobile. At the other end of the spectrum, rural isolation insulates the bulk of the population from economic and social opportunities and often leaves the women to raise their families alone while their husbands search for work in the cities.

This chapter identifies five priority topics which present promising opportunities for reducing these difficulties, in particular for improving conditions for the poorest people and increasing the effective use of available resources. In situations where urgent needs call for a constructive response, the emphasis should be on how to deal best with the constraints imposed by economic realities. American standards and technology that are wasteful, unnecessary, and costly are to be avoided, while solutions that create jobs and foster supporting economic activities deserve priority. Often new technology offers the greatest hope for major breakthroughs, but frequently the wise application of long established and common sense solutions adapted to a particular setting prove to be more appropriate.

Major problems and major opportunities for effective action are:

1. The rapid growth and resulting deterioration of the largest cities and the need for a global initiative for building and rebuilding whole communities.
2. The neglect of smaller cities and rural communities and the need for policies and technologies that will help channel growth into intermediate-sized communities and improve conditions for the majority of people in the countryside.
3. The staggering intercity transportation requirements still to be met in developing countries, the mounting costs, and the need to make transportation programs more relevant to the needs of agriculture, industry, resource development, and other national goals.
4. The special problems of the cities resulting from traffic congestion and the necessity for low-cost solutions that permit more resources to be allocated to other basic needs.
5. The gap in communication between the developed and developing areas of the world, and within developing countries themselves, and the need to apply modern telecommunications technology to

education, training, information exchange, and cooperative international research.

## OPPORTUNITIES AND PROPOSED INITIATIVES

### 1. Deterioration of Large Cities under Conditions of Rapid Growth

Between 1950 and 1975, the world's population increased from 2.5 billion to 4 billion. By the year 2000, there may be some 6 billion people to house, feed, and supply. But even these figures fail to measure the full implications of the tasks involved. Along with absolute increases, there will be a continuing increase in the percentage of people living in urban places (variously defined), from 25 percent in 1960 to probably more than 50 percent by the year 2000.

Most of this urbanization is occurring in the major metropolitan concentrations. The world had only 71 cities of a million people each in 1950 compared to 181 in 1975.

What can be done to alleviate the critical problems of people living in the largest cities--the millions who live in slums and squatter settlements in the so-called informal sector, and the millions who inhabit the modern sector which is the primary source of economic growth and social change? Both groups require more urban services, but the severe needs of the lower income groups call for major national and international efforts.

Recent experience with building and rebuilding whole communities points out the general directions for initiating community development and redevelopment on a worldwide scale. The United States has made only a beginning in such community-building to date, and in fact has had some disappointing experiences. However, it does have the technology, skills, and capability for systems design that could be useful in cooperative undertakings with other countries. The United States is also aware of some of the factors that have frustrated remedial action, and it can share its lessons with other countries that are beginning to struggle with the same problems.

Remedies should be tailored to reach as many people as possible within prevailing resource constraints. This requires realistic standards, stage construction methods, self-help housing, and other labor-intensive approaches, as well as integrated community-building efforts that permit effective management of land use and community investment decisions.

Although each country must formulate urban strategies according to its own constraints, policies,

resources, culture, and climate, there are universal elements in urban problems:

-- A wide range of aggregated human settlements is necessary to support both urban and rural development: (1) villages and market towns to serve rural populations, to strengthen marketing channels, and to introduce agribusiness and nonfarm employment opportunities in the rural sector; (2) secondary cities to achieve regional balance and population distribution; and (3) major cities, including national capitals, to provide positive and unique contributions to national development, and to absorb marginal labor, reduce development risks, achieve economies of scale, and express national aspirations.
-- Most large urban centers have a dual nature. They contain: (1) a core of high-standard buildings served by relatively adequate levels of public services; and (2) a large surrounding area of unplanned, unserviced marginal settlements consisting of low-quality or makeshift housing. Each requires different planning and action to respond to its needs and opportunities.
-- The ultimate success of any national urban policy will be largely determined by the availability of an adequate supply of urban land at prices people can afford. Decision makers need to learn more about the variety of instruments available to control land speculation through various forms of land taxation, land redistribution mechanisms, land banks, and land development agencies.
-- The per capita costs of urbanization need to be lowered by adopting appropriate standards and technologies. The objective of the urbanization process should be to meet the basic needs of people for jobs, shelter, land, water, sanitation, and health and education services in urban centers, located and designed to achieve satisfactory communities and to promote development. Since capital resources will remain scarce in many countries, basic needs will have to be met through the innovative application of resource-conserving technologies. Simple technological innovations that provide more urban-type amenities in the rural sector will also be required to make rural life more attractive.

## Ongoing Work and Future Needs

Discrete elements of the urban problem are included in development plans--water, sanitation,

transportation, industry, schools, and clinics. But these elements, although their location may be urban, are rarely conceived in terms of the total life-support systems needed for a decent human existence. The world is only just beginning to approach the concept that complex, interacting physical systems are needed to provide the economic and social conditions for human survival, to contribute to work productivity, and to stimulate economic activity.

In recent years, however, new institutional arrangements have emerged that treat community-building as a business and provide for the management and financing of whole settlements. Urban development corporations and similar public and private agencies have been building entire new communities or parts of communities, and have been applying the same techniques to the redesign and reconstruction of existing obsolete cities.

Singapore, for example, has channeled its expanding population into eight satellite cities on the outskirts of the old city, and the latter is being completely modernized through long-term redevelopment of the slums. Singapore has not only provided modern apartments and urban services for all low-income families, but in the process it has employed and trained thousands of workers, created a network of building supply industries, stimulated the construction industry, attracted international industrial establishments, and tripled per capita income. Other pioneering efforts have been undertaken in India, Brazil, Ghana, Japan, Sweden, Malaysia, the Netherlands, the Soviet Union, the Philippines, and many other countries.

Many of these efforts have been very costly, have ignored the poor, or have created communities that people find unsuited to their needs. Nevertheless, they demonstrate the feasibility of building whole communities through urban development corporations that attempt to lay out workable, physical plans consistent with economic and social goals. Use of the profits from increasing urban land values to finance community facilities has been a major aid to financial feasibility. Spatial arrangements that locate jobs and housing in closer proximity have helped reduce problems of transportation. Improvement of the concepts and methods tried to date can lead to better planned living environments and new opportunities for the fulfillment of human aspirations.

Planned communities and unplanned cities share the same heritage of obsolete urban technology. Most big cities are using technology first introduced in the late nineteenth century. Major inventions of the 1880s still dominate the urban scene, from elevators and

steel skyscrapers to subways and automobiles. The need now is for new inventions aimed at meeting today's critical needs.

The scale of metropolitan areas in the beginning of the twenty-first century is likely to be many times the size of the largest cities of the beginning of the twentieth century. The population densities in major cities will probably increase, most likely achieved by higher average building heights. There will be concurrent changes in movement patterns, supply systems, and waste management processes. Multi-use facilities that combine living, working, education, and recreation spaces will emerge. New sources of energy, new types of communication/information techniques, and new working schedules will also influence urban conditions.

An international effort is needed to develop performance requirements for urban hardware that are appropriate to local conditions and stated in terms of human requirements for education, health care, administrative services, employment, and recreation. Today, requirements are too often expressed in mechanical terms. Building codes in all parts of the world, for example, prescribe solutions that involve unnecessarily high standards and excessive use of materials. It is often impossible to use new materials and innovative construction methods because the specifications in these codes do not allow for their performance capabilities.

## Proposed Initiatives

Two major actions are recommended. First, we recommend that the United States support an international program to help plan neighborhoods and whole communities, and to upgrade slum areas. This will require integrated systems of urban facilities and services capable of meeting the major economic and social requirements of daily living.

Second, we recommend that the United States encourage an organized international effort to marshal information, experience, technical assistance, and research capabilities to help carry out the tasks of providing acceptable minimum standards of living for the hundreds of millions in urban areas who now lack them. A stronger network of urban research centers is needed in the United States if its scientific and technological potentials are to contribute effectively to an international effort. The results could produce both major advances in the handling of domestic urbanization problems and new insights for contributing

to the worldwide challenge of change in human settlements.

A Global Community-Building Initiative. We recommend that the United States offer to contribute to an expanded international program, involving a central role for the new U.N. Habitat Center in Nairobi, that would support global community-building efforts aimed at providing minimum shelter and services for all people of the world.

Such a U.N.-sponsored program might begin by providing capital assistance for efforts to organize metropolitan growth and redevelop urban slums and blighted areas. Examples of the kinds of programs that might merit support are in Bogota, Colombia, and Karachi, Pakistan.

For relatively affluent countries, a total city-building effort may be feasible. Bogota has planned three massive satellite cities around its periphery to help accommodate the expected rise of population from 3 million to 9 million by 1990. This expansion will help meet the need for shelter, jobs, water, and other services in the existing central city and prevent the unplanned spread of urbanization that would destroy nearby sources of food (American City Corporation 1974).

The construction of the satellites is to be accompanied by two major new city-in-city projects within Bogota, predominantly for low-income residents. One of these is near the center of the old city, in an area of plentiful jobs that lacks satisfactory nearby housing and services and requires substantial upgrading of the neighborhood. By the end of the century, this new city of Sans Facon is expected to house 300,000 people (American City Corporation 1976a). The other city-in-city will introduce job opportunities and services in an area devoted mainly to housing. Ciudad Kennedy and other areas devoted exclusively to housing have imposed substantial commuter problems on their residents, who must travel long distances to find work. Techo, the new city, has been designed to correct these conditions. Total population of the area will be increased from 150,000 to 500,000, jobs will be expanded in retail services and office employment, and a development corporation established to carry out the work will capture increasing land values to help finance the project (American City Corporation 1976b).

Another type of community-building effort for the very poor is demonstrated by sites and services projects. The "metroville" program in Karachi, proposed by a U.N.-sponsored study, calls for a series of compact communities of 40,000 to 50,000 people who would build their own housing on sites equipped with water, sewer, streets, schools, clinics, markets, and

light industry capable of employing some 40 percent of the labor force (City of Karachi 1974, Government of Pakistan 1977). Four such "metrovilles" were scheduled for the program and one has been completed. The view that Karachi could limit its size by refusing to provide new housing has halted the other metroville projects, but metrovilles will be built in other cities.

Metroville neighborhoods are provided with a primary school (two shifts), a marketplace, a bus stop, a plaza, and a storage area for firewood for cooking. For all nine neighborhoods, there is a health center, social center, a small industrial estate, scattered small industries, and an administrative center for dealing with loans, land sales, and the various operational aspects of the community. Housing loans are available for 15 years with a small downpayment.

The metroville land-use plan allocates over half the area to housing and one-fourth to the street system. The streets may be used as extensions of the house for social gatherings, play space, and meetings. A main pedestrian shopping street is provided within easy walking distance of all 50,000 residents. A total of $10 million was spent for capital outlays for the first planned community, with the government supplying help for home builders through technical assistance in house construction and by selling such items as concrete blocks, doors, windows, and plumbing materials at reasonable prices.

The Karachi development program focused on two major potentials for the city's redevelopment: capturing the rising land values that would be created by the planned urban areas, and creating accessible jobs in order to use the large supply of unutilized labor.

The launching of a worldwide city-building program would be designed to apply innovative scientific and technological approaches to urban development, including new home-building techniques, water supply, new sources of energy, waste management, waste water recycling, and resource-conserving methods of expanding educational and health care facilities. Adequate transportation and communications would also be important.

City-building efforts and the management of urban growth through urban development corporations depend on having enough capital to pay for the initial, or front-end, costs that cannot earn an immediate return (i.e., for the purchase of land and the installation of basic infrastructure). What is needed by most developing nations is an international fund that would provide loans for community-building by urban development agencies or corporations. The United States should

support the creation of such a fund which could promote the undertaking of integrated urban development projects and apply the profits from increasing land values to the community. Planned communities in many parts of the world have demonstrated that, where land can be purchased at prices that do not already reflect development plans, the very substantial increases in value that are subsequently realized can be captured in the lease of properties to industry and commerce. Where this is possible, loans for the construction and reconstruction of human settlements could be secured by rising values, and city-building agencies could use part of such returns to finance community facilities. Either the World Bank or the U.N. Habitat Center could administer this support program.

An International Research, Information, and Training Network. Urban settlements in developed countries share many of the same difficulties suffered by cities in the developing world, and such a situation favors cooperative efforts. What are often lacking, however, are the institutional arrangements for both sharing knowledge and carrying out mutually beneficial research and development. Continuing arrangements are needed to support such collaboration, on an international and domestic basis, among organizations working on similar problems.

For the United States to be in a better position to support long-term relationships with urban agencies in the developing countries, however, a greater effort needs to be made to strengthen U.S. institutions in this field. Stronger and more numerous U.S. institutions could develop training courses in community structuring and management relevant to developing countries, conduct collaborative research, with each other and with institutions in developing countries, and exchange experiences on urban problems.

International cooperation in support of urban research and training will build the capacity for these undertakings within developing countries. Research projects need to be funded where the results are likely to contribute substantially to global knowledge.

Near-term solutions based on currently available technology are of primary interest to all developing countries, but it is also important to expand the long-term alternatives. Unless this is done, we will still be looking for solutions to today's problems rather than anticipating the problems and possibilities of the future.

The U.N. Research and Training Programme in Regional Development, over a decade old, needs to be expanded. It has proved to be a useful arrangement for education and research in regional development, defined to include both urbanization and rural development, as

well as concern for social, economic, and physical issues. Many people from developing nations have been trained under this program, and its research and communications activities have been helpful to those working in developing countries.

U.S. financial assistance might be directed at several objectives:

-- To help enlarge the scope of U.N. activities to include the provision of reports that could be used for training programs and the distribution of course outlines, reading lists, and materials in urban and regional development, and information on major studies in these fields.
-- To provide additional fellowships (beyond the very limited number now provided by the United Nations) for study in training programs at various international and national centers for regional development.
-- To fund one or more centers in the United States which can carry out studies in urban and regional development, help train the trainers at the various international and national centers (that is, to elevate the quality of persons doing the training throughout the world), and participate in U.N. informational activities.

The other side of the coin in the search for "new initiatives" is that many existing programs, including those of great merit, are overlooked and often starved for funds. A U.S. initiative in the United Nations gave birth to the U.N. Research and Training Programme in Regional Development in 1965, and it would be appropriate if the United States now helped this program achieve a higher level of excellence and greater scope for a worthwhile set of activities. A strengthened U.S. center within an international research and development network could help supply services for the system.

The benefits of such collaboration would be as great for the United States as for other countries. Inner city blight and slums, poorly planned suburbs, unemployment, and lack of financial resources are major problems in this country that could be more readily solved through a global exchange of information and experience. The United States would especially benefit from monitoring and analyzing the experience gained from new approaches to community redevelopment being used in city-building projects. For example, efforts in Bogota and elsewhere to bring people and jobs in closer proximity may suggest better solutions to U.S. problems of urban congestion and resource waste. More effective international research, training, and

analysis for community-building and rebuilding programs could help provide a global economic stimulus and extensive new opportunities for jobs among the world's unemployed.

### 2. Upgrading Intermediate Cities and Rural Life

Most of the world's poorest people live in rural areas and small villages, cut off from the help that science and technology could provide. The low productivity of rural economies and the hundreds of millions of people in subsistence agriculture are reason enough for the immediate relief that innovative technologies could supply. A major task is to increase the attractions of rural life in order to assure the future of agriculture and other resource development and to reduce the waves of migration that the largest cities are unprepared to absorb.

More desirable living conditions in intermediate-sized cities (100,000 to 500,000 population) could also act as a counter-attraction to the metropolis (see Rivkin 1976). These cities are less committed to costly infrastructure than the major cities, and could serve as models for the application of new technology and new ideas in community development. New technological approaches could be introduced into such settings: solar energy, waste management, water recycling, desalination, innovative public transport, and new applications of telecommunications.

## Proposed Initiatives

We propose that the United States allocate grant funds for a series of projects to demonstrate new applications of science and technology in smaller cities. These projects would emphasize resource-conserving approaches to urban development, such as those mentioned above. Such an effort could be administered either bilaterally or through the U.N. Habitat Center, and would require a program comprising the following steps:

-- an inventory and assessment of existing resource-conserving technologies and of their applicability to developing countries;
-- packaging information for discussions and planning with selected countries for the application of appropriate technologies;
-- establishment of evaluation and monitoring mechanisms, development of case studies, and

identification of priority areas for further research and development.

A further possibility lies in modern communications, which can help modernize rural and village life as well as increase the attractiveness of intermediate-sized cities to business and industry. Some of these possibilities are discussed later in this chapter.

### 3. Transportation to Support Goals in Other Sectors

Industry, agriculture, trade, urban activities, and other elements of the economy depend to an important degree on the availability of various transportation services. Farmers rely on road transport for delivery of their fertilizer and for the marketing of their crops. Coal, iron ore, and other minerals generally move by rail or water; pipelines are playing a larger role in the movement of energy resources; and airplanes, buses, and automobiles are major methods of travel. Ports and merchant shipping provide the major facilities for international trade.

The basic infrastructure and equipment needed for transportation absorbs a large proportion of the total public investment in all countries, often as much as 25 to 35 percent or more in developing economies. And, since each method of transport is likely to be built and operated independently of the others, the opportunities for waste and inefficiency are great. For example, on main routes, railroads often badly need rehabilitation; there are long delays in the pick-up and delivery of merchandise; cars are often in short supply; terminal delays are long and costly; and business of all kinds suffers as a consequence. Trucking has grown in importance and frequently fills the gap for high-valued commodities, especially manufactured goods and short-haul transport, but roads are often poor, trucks too few, and management unreliable.

A program for more productive rural living will require all-weather access to farms. Rural areas without roads means that extension workers and improved production techniques are not available to farmers; fertilizers cannot be delivered, or are delivered too late or at too high a cost; produce cannot be marketed or farmers must rely on middlemen who absorb too much of the profit; milk and other produce are sold locally at nonremunerative prices; and trained teachers, doctors, and veterinarians cannot be persuaded to serve the local population.

Where there is reasonably good access from the farm to the market or main transport network, the situation is often the reverse. Farmers are familiar with new techniques, and they are often eager to apply fertilizers, to change from traditional farming methods, and to shift to growing crops for market. An all-weather road often means bus service to the nearest town, new employment opportunities, as well as medical care and a variety of public services. Schools can be upgraded because teachers can be attracted from greater distances, and buses permit consolidated schools. Electricity becomes more available because the lines can be more easily installed and maintained. Farm machinery can be more easily repaired and new methods of farm management introduced. A variety of consumer goods appearing for the first time in the local market provides new incentives to producers.

Developing countries are confronting all at once the need both to modernize their railways and to expand their road transport in order to support industrial and agricultural growth. Volumes of freight increase even faster than increases in economic activity. Thus a 6 percent annual growth rate may involve an increase of 10 percent or more in goods movement. Passenger travel can be expected to increase at an even faster rate.

If developing countries double their total output of goods and services over the next decade or so, as many assume, freight capacity will be a primary requirement. Yet transport remains primitive in large areas, and the gap between developed and developing countries is in many instances widening. There is clearly a need for new strategies to establish realistic standards, to set priorities, to increase transport efficiency, and to determine how transport technology can be combined with communications and with solutions outside the transport field to reduce transport burdens and avoid waste.

Mobility of people and goods on a global scale is also essential to socioeconomic development. From 1950 to 1975, as the world population increased by 1.5 billion and per capita income in almost all but the poorest countries doubled, world trade increased very rapidly. In the 1960s, international trade increased twice as fast as gross world product. New technology helped the international transportation network to respond. The stepped-up tempo of worldwide business transactions was aided by supertankers, container ships, specialized cargo vessels of many kinds, and wide-bodied jet cargo planes. But the achievements of transport technology on the domestic side were far less impressive (Willoughby 1976).

Projections of world trade now indicate that very large increases in the movement of both raw materials

and manufactures will be needed to adequately support expanding world population and income. It is estimated, for example, that despite record production in countries such as India, many poor tropical nations may have double the food deficits experienced during the crisis of 1974-75 within the next 10 years. Thus transport will be needed for substantially larger amounts of food imports. Transport capability will have to be flexible in both areas of surplus and shortfall to meet quick routing requirements. In some cases, the transport bottleneck may be ships; in others, ports; and in many cases, local roads, rail capacity, and the availability of trucks and storage facilities.

## Institutional Mechanisms

The needs of the developing world call for integrated, resource-conserving systems for carrying freight and passengers. The United States has an impressive record in the design, construction, and operation of transport facilities and in materials research. It has been a leader in trucking, barge operations, and port development; in many facets of airline, railway, and pipeline systems; and in low-cost road design, airport construction, and various navigation aid systems. Europe, Canada, and Japan, among others, also have important experience to contribute. However, in all countries experience has generally been divided among companies and organizations that deal with only one form of transportation. The U.S. experience in particular has been to adopt unnecessarily high standards. And, in urban transport, neither the United States nor other developed countries have made much more progress toward satisfactory solutions than have the developing countries.

No U.S. agency is concerned, on an adequate scale, with transportation as a whole in relation to development. Some university centers are moving in that direction, however, and the federal government, through the creation of a Department of Transportation, is currently positioning itself to view the transportation field as a whole and to exploit the relationships between the ways people and goods are moved and the broader socioeconomic goals of land use, energy, environment, employment, etc.

U.N. efforts in the transportation field also fall far short of what needs to be done. They are currently dispersed among a number of technical agencies which, although performing effectively, are not organized to promote the use of transportation for socioeconomic

development. For over a decade, the Economic and Social Council and the U.N. Development Programme have been aware of the organizational gap existing in the United Nations for the furtherance of transportation system development. Lack of funds and failure to agree on the nature and location of a world transportation organization have prevented a solution.

## Proposed Initiatives

An International Transportation Research and Information Network. The World Bank is the most appropriate agency to determine the dimensions of the world's transport needs and how these needs are to be met. We recommend that the United States, in collaboration with other Bank members, support such an effort. We also recommend that the World Bank make the analysis and dissemination of information and experience one of its major responsibilities. Training, conferences, and activities to permit intercountry technical discussions among officials and practitioners should be carried out by the Bank's Economic Development Institute. The U.N. Habitat Center in Nairobi can also contribute, since mobility and accessibility are integral parts of the location, design, environment, and viability of human settlements. The extension of information services and technical assistance through the Economic Development Institute and the U.N. Habitat Center could help focus on resource-conserving solutions. An alternative organizational solution would be the creation of a World Center for Transportation and Development to serve the purposes of the United Nations.

We also propose that the United States support, through cooperative international research and development, efforts to promote innovative transport technology geared specifically to the needs of developing countries. More suitable motor vehicles and the development of nonpetroleum fuels are examples. Transport technology is constantly changing and the rate of change may be expected to accelerate in response to energy problems. Better technological forecasting is clearly needed for more intelligent and less costly choices. Transport technologies suited to countries like the United States may be totally unsuitable or excessively costly for many countries. Yet most transport research and development is conducted outside the developing countries and is not oriented to their needs.

Organizing a Transport Center in the United States. If research and training in the United States are to address the problem of transportation and development

more effectively, domestic institutions will need to be strengthened. We recommend, for example, that the United States seek to make better use of the Department of Transportation's new Transportation System Center (Cambridge, Mass.). This is a broad-gauged center for transport research, training, and information analysis and dissemination, but its work is presently oriented primarily toward highly technical research on short-term transport problems, mostly in the United States. The Center's work would be enriched by the addition of economists and social scientists and by the ability to draw on and contribute to research and experience worldwide. The Transportation Research Board of the National Research Council, with appropriate support, could also provide continuing help for the purposes of the 1979 Conference by furthering the development of reciprocal relations with other countries and participating in international technical exchange.

Some government aid to university transportation centers is being provided through the Office of the Secretary, Department of Transportation. But this program has opted for distributing limited resources over a large number of recipients rather than building up a small number of highly competent centers. We believe that AID might help overcome this situation by providing funds for centers willing to give greater attention to the economic development aspects of transportation and to the creation of curricula relevant to the training of students from developing countries.

Building Industrial Support for Transport. In the United States, Europe, and Japan, the complex of industries and services supporting the transportation sector constitute a major source of jobs and economic stimulus. Automotive industries are particularly powerful factors in the development process. Developing nations, with 70 percent of the world's population, have only 15 percent of the world's motor vehicles. As their road network expands, their needs for mobility will create heavy demands for equipment. Yet few of these countries are prepared to manufacture the components that will be required.

The establishment of a domestic motor vehicle industry could be a key element in the economic development of some developing nations. The obvious purposes are to raise the overall level of industrialization, to stimulate construction of the highway network, to create a system of suppliers and supporting industries, and to provide employment and wages for prospective domestic customers. More specifically, the formation of a domestic vehicle industry would give developing countries new opportunities for self-help in economic growth and

productivity, would provide a framework for the transfer of special skills and nonproprietary scientific and technical know-how, and would provide management and technical training which is essential to industrialization. Most importantly, it would help create a variety of jobs and a means of acquiring skills.

Three elements in vehicle design and development are of critical importance. First the vehicles manufactured should satisfy local needs in vehicle use or operating requirements (due to stage of economic development, topography, climate) while maintaining a substantial interchangeability of parts for manufacturing cost, maintenance, and repair efficiencies. Second, a propulsion system or energy source should be used that is compatible with the energy resources available in the host country. Petroleum will need to be replaced by other liquid or gaseous hydrocarbons or by fuel sources such as electricity or hydrogen or ammonia derived through electrolysis. Third, measures are needed to reduce the air pollution produced by the large numbers of motor vehicles in urban areas.

We recommend that the United States convene a group of experts to explore whether there are viable actions that the U.S. government could take to accelerate response to the needs described above.

## 4. Overcoming Urban Congestion

A special category of transportation problems involves the movement of people and goods within cities. Most big cities are heavily burdened by traffic congestion and poor public transportation, and many cities in the developing world suffering from these conditions find the cost of conventional solutions beyond their means. Lagos, Manila, Sao Paulo, Mexico City, Bangkok, Cairo, and many others are suffering from air pollution, high accident rates, and the high costs of conducting trade and commerce. The conflict between cities and cars continues to intensify, and the buses, taxis, and animal and human-powered transport that share the streets with the automobile are caught up in the congestion. Everywhere public transit is providing poor service at ever-increasing costs. And telephone service is often so bad that the city, once a center of communication, finds itself grossly undersupplied even with the means of exchanging information. People carry messages as a substitute for making phone calls, but even this expedient is proving to be inadequate.

Despite rising costs and the outlook for dwindling petroleum supplies, the upward trend in vehicle ownership continues. During the 1960s, the number of vehicles worldwide increased more than 100 percent--by a total of 120 million. One-fourth of the gain was registered in Asia, Africa, and Latin America. By the mid-1970s, there were 300 million motor vehicles in the world, one for every 14 people, most of them in cities. It is estimated that there will be over half a billion motor vehicles in the world by 1985--103 million trucks and buses and 407 million cars. Well over 100 million will be operating in Africa, Asia, and Latin America (Gilewica et al. 1976).

Transportation investments are key elements in the character and quality of the urban environment. Streets make up a large percentage of the total area of the city, often as much as 20 to 30 percent. Streets are the structural framework of the city, they insulate neighborhoods, separate industry from housing, and delineate industrial estates, neighborhoods, markets, and recreation areas. They even serve, in many communities, as expansions of the home, where social and economic activities of the household take place.

Urban transportation also affects other aspects of the urban environment. Modern transport solutions are often so costly that they influence the level of resources available for schools, water, sewer, health, and other municipal services. In many cities, per capita outlays for transport infrastructure are several times greater than the combined per capita outlays for health, education, and utilities.

It is important, therefore, to avoid unnecessary expenditures for transportation. Expressways, subways, and other rapid transit may not be feasible if other needs are to be met. Thus the wise choice of transport technology and the ability to make effective use of existing streets and other transport investments may turn out to be a key factor in urban living standards.

## Proposed Initiatives

The world's cities operate largely without the benefit of systematic analyses of the successes and failures of innovative approaches to transportation in other countries, and even in their own countries. Cities in developing countries do not have ongoing analyses of such important subjects as the design and operating experience or financial results of various rapid transit systems, the possibilities of alternative busway solutions, or the effects of pricing and regulatory measures on transportation supply and demand. The world's cities provide a laboratory that

is virtually unused because no agency is responsible for analyzing the experiments and distributing the kinds of information that would be relevant and useful. A beginning has recently been made, through the U.S. Department of Transportation and the World Bank, to finance such a service. But a much larger effort, backed by appropriate research and analysis, is needed to help cities make transport decisions.

We recommend, therefore, a concerted international effort to provide a continuing, effective, and timely source of information exchange, to be fostered by the agencies recommended in the previous section: the U.S. Transportation System Center, the World Bank, and the U.N. Habitat Center. Such a network would explore low-cost solutions designed to strike a balance between public transit and the automobile, and between transportation supply and the traffic implications of urban land uses. Measures that would be of maximum help to low-income people should also be stressed. Resource-conserving solutions that might be advanced and monitored include:

-- Charges for auto use in central cities, including peak and off-peak pricing to pay for urban streets. The automobile has been heavily subsidized in all cities when the appropriate policy should be to limit its use to assure the effective operation of buses.
-- Enforcing traffic laws and discipline.
-- Spreading peak-hour traffic over longer time intervals by staggering beginning and closing hours of work.
-- Relocating major traffic generators away from the city's congested areas, and creating housing near places of work to reduce long cross-town commuter journeys.
-- Designating all-bus or all-bicycle lanes or streets.
-- Creating pedestrian ways and vehicle-free zones.
-- Using traffic signal systems geared to traffic demands.
-- Prohibiting parking on major thoroughfares.
-- Removing rail and truck terminals from congested areas.
-- Restricting heavy truck deliveries to nighttime hours.

These and many other measures for making better use of existing facilities are beginning to be applied throughout Europe and to a lesser extent in Asia and Latin America.

The magnitude of urban transportation needs and the high costs and negative environmental impacts of

current solutions also call for research and development on new, more effective transport methods, new sources of energy, and greater consistency between urban design and choice of transportation technology. The institutions suggested as centers for transportation research and training in the United States and in the U.N. system should help support or carry out these activities.

## 5. New Initiatives for the Use of Communications

In most developing countries, basic communication services are woefully inadequate. The communications gap[1] in telephone service, radios, television, and printed matter is an obvious factor in the income disparity between rich and poor.

Modern communication and information technologies now make it possible to shift part of the communications burden from the transportation sector. Improved communications can now help break down rural isolation and promote better education and health care, changes in urban design, and more dispersed regional settlement. Recent reductions in costs and improvements in performance indicate that improved communications technologies could become a major new force in development.

### The Promise of Modern Telecommunications

Modern telecommunications offers new opportunities for rural development. The United States has played a leading role in India's Satellite Instructional Television Experiment (SITE), for example. This one-year project supplied 2,400 remote villages with television through direct telecasting from a satellite transmitter to village television sets. By the end of the year, between 120,000 and 190,000 people were watching on any particular night. Television to date has been an urban service limited to the immediate vicinity of the big city, but SITE made it possible to contact the most impoverished people who have always been completely cut off from information sources. SITE instructional materials were produced specifically to help overcome the rural gap in knowledge, focusing on the classroom, the community viewer, and the teacher.

The SITE effort related its programs to agricultural techniques, health and hygiene, family planning, and education. Feedback studies indicate a high interest in do-it-yourself approaches of all types, and in agricultural techniques and animal husbandry. More mixing of castes by the viewing

audience was noted. School children found new interest in making things that had been demonstrated on the television screen. More people began to visit the extension agencies and other sources of information to ask about subjects treated in the daily telecasts.

The SITE program was made possible by an agreement between the United States and India that gave the United States responsibility for the space hardware and India management of ground installations and program content (Chitnis 1976, also see Pal 1975). The cost has been estimated at between $15 and $20 million (or about 50 cents per person per viewing hour) without considering the outlay for the ATS-6 Satellite which was lent by the United States.

From a technical performance standpoint, the SITE project was a success, and it was also managed effectively. In-school programming was considered successful as was the teacher training program, but effects of the community programming were more difficult to measure. In any case, India is continuing instructional television for rural areas with the use of terrestrial facilities, covering 40 percent of the villages served by the satellite.

India has also made a firm commitment for an operational satellite system, INSAT, and has requested a 1981 NASA launch. It is expected that a hybrid system of national satellite programs and local telecasting by terrestrial means will provide an economical mix. Further decisions on the mix of radio, television, terrestrial, and satellite uses will rest on a number of considerations, including the extent to which satellite use for development purposes complements other planned uses of the satellite to expand India's telecommunications capabilities.

The potential economic justification of telecommunications for the delivery of technical assistance and information to rural villages is indicated by the high cost and limited effectiveness of current procedures: one-third of the roads serving India's half a million villages have no surfacing and are generally impassable when it rains. Thousands of villages are served only by foot paths and animal tracks. Agricultural extension workers, literacy workers, and other technical assistance personnel traveling by jeep or by bicycle can visit only a few villages a week, and their help is highly intermittent. The use of radio, telephone, television, and other methods of communication, however, can provide complete coverage and continuous service almost immediately, without awaiting the long and costly process of building all-weather roads, providing vehicles, and training the large number of extension workers required

when information is transported rather than delivered electronically.

Modern communication technologies can also offer new opportunities for the delivery of higher education in developing countries. In most of these countries, the greatest obstacle is a lack of adequately trained teachers. Institutions trying to staff new programs typically have two alternatives: attract foreign academicians to temporary visiting faculty appointments, and/or send their own nationals abroad for training. With the advent of expanded communication facilities, such as those discussed in this report, other alternatives for pedagogic assistance and instructional support to educational institutions are now possible.

## Proposed Initiatives

Here we recommend several specific activities which might enable the United States and developing countries to evaluate the relevance of communications and information technologies to development and to initiate the necessary transfers of technology, where appropriate.

Rural Telecommunications. We propose that further telecommunications experiments be carried out in a number of countries, including the United States. Different mixes of technology and different types of services (health, education, agriculture, etc.) could be mediated via telecommunications facilities, with all experimenters committed to evaluating their projects and sharing the results with other U.N. member countries. The United States might support such an experimental program in a number of ways, ranging from the gift of telecommunications equipment and services (such as time on a U.S. satellite) to technical assistance, training, and the planning and financing of projects.

A good vehicle for this purpose would be AID's proposed program to use the Syncom IV satellite for experiments in rural communications of the Indian type over the years 1980-87, covering countries in the Caribbean, Andes, and Sahel regions. This coverage will demonstrate what modern science and technology can do to bridge the communication barriers of water, mountains, and deserts. The United States has built up strong technical resources that can collaborate with developing countries in these regions in working out the critical problems of software and supporting local service systems.

Careful analysis of such test projects would provide the information that the World Bank and other

development lending agencies need before committing major new funds. Concentrating equipment in rural areas and making a concerted effort to develop a wide range of telemediated social services would enable the poor and disadvantaged segment of the population to benefit directly. The United States would also benefit through the improvement of its own rural telecommunications, and would be able to share in the successes of other countries through evaluation and information exchange. The fact that a more active market for telecommunications equipment and telemediated software would be stimulated by such test projects should benefit U.S. industry and universities.

Engineering Education Exchange. Recently, a group of U.S. engineering schools, which have for some time been offering off-campus continuing education courses in engineering subjects via television, formed the Association for Media-based Continuing Engineering Education (AMCEE). In some cases these offerings have constituted a complete accredited graduate degree course. This association permits the group to share resources and to serve new geographic areas. AMCEE is currently developing a specific plan to use satellite communications to extend and strengthen their services. The satellite links will be used to:

-- Distribute televised course material to member institutions and to industrial sites where engineers enroll in the courses. In some cases, the material will be redistributed via the local institution's broadcasting facilities.
-- Conduct video conferences and coproduce new video courseware with more than one AMCEE member participating in the organization.
-- Provide an interactive channel between students and AMCEE institutions which can be used to monitor performance, answer questions, provide access to data banks, and permit rapid ordering of new course material.

It may now be appropriate to open AMCEE to participation by foreign universities. Where satellite coverage makes it feasible (in Latin America), the satellite interconnection could be established and a two-way sharing of course material initiated. By having the participating local university act as the mediator and reviewer of incoming video course material as well as providing counseling and grading services, it is possible to avoid imposing U.S. educational output directly on nationals of another country. The opportunity for foreign universities to distribute their own video courseware over the system lends a needed element of reciprocity.

A Communications Facility for Problem-Solving Networks. Over the longer term, other possibilities for using U.S. satellite technology may become cost-effective; for example, to improve communications within international networks of geographically dispersed individuals and organizations that share common missions, interests, or activities. The effectiveness of networks can be increased markedly by facilities that allow for improved national and transnational communication among problem solvers to attain more efficient sharing of data, information, and expertise.

Bringing information to bear on problem-solving is complex, and simplistic solutions such as subsidizing the establishment of document depositories are inadequate. Several other lines of cooperative activities are indicated if the results are to make a difference in the quality of decision making. These include: (1) providing more accurate local data; (2) making recorded information known and available in usable form such as knowledge generated worldwide by research and development, reference data, standards, case studies, and models; (3) providing international person-to-person communication facilities to permit more extensive contacts beween individuals and agencies with related interests; and (4) creating a local environment capable of receiving data and information and bringing them to bear on problems.

We suggest that the United States study the feasibility of using modern commercial or other communication systems, possibly through a joint public/private intermediary, to support the networks recommended in many places in this report.

Technical designs and cost estimates remain to be carried out, but current developments indicate that a number of components will be available commercially in the not too distant future to meet the technical requirements for such systems. For example:

-- Satellite Business Systems (SBS--a partnership of IBM, COMSAT General Corporation, and The Aetna Casualty and Surety Company) expects to offer voice and data transmission facilities, including document facsimile transmission, in January 1981.
-- Western Union and RCA currently provide special satellite communication services using earth stations that transmit and receive voice and data messages directly through small diameter antennas.
-- American Satellite (AMSAT) is scheduled to market in mid-1978 voice/data communication services, also using small diameter antennas. A dynamic mix of voice and data communication, a sharing of channel capacity by multiple users, and accommodation of a

range of terminal devices (such as digital voice and facsimile) are planned.

-- AT&T, in competition with SBS, plans a satellite communication system using earth stations with a 10-foot antenna diameter. The satellite will poll earth stations (in the United States) 80 times per second, collecting and rebroadcasting messages to addressees.

-- In the facsimile area, Japan is reportedly planning to market, within the next two to three years, a home facsimile machine at a purchase cost of $400. IBM is reported to be working on a four-second-per-page facsimile machine, which might significantly lower document transmission costs, perhaps below those of first class mail.

Although commercial facilities of the kind proposed here will be in existence in the United States in about three years, the development of global communications facilities for research and development networks requires preliminary studies to (1) estimate the nature, size, and growth rate of the user clientele; (2) develop tentative technical design scenarios and estimate their costs; (3) study alternate ways of cooperative design, funding, and management of the communication facilities by the U.S. public and private sectors; (4) identify international and economic policy issues including those related to national efforts to restrict the flow of data across borders; and (5) develop strategies for involving developing countries and country regions.

Since intracountry communication facilities are woefully inadequate in most developing nations, the value of these systems at the local level would also be high. One must not underestimate the magnitude, costs, and problems associated with such an undertaking, however. A major portion of the systems cost would be in the equipment of satellite ground stations and user communication terminals. Thus, while the United States could offer to support and encourage preliminary studies of the sort suggested here, it is recognized that actual realization of such global systems lies in the future because of the complexities and expense involved.

NOTE

. In Europe most nations have 25 to 50 or more telephones per 100 people, and some countries, like the United States, have more than 60 phones per hundred people. There is less than one telephone per hundred inhabitants in India, Pakistan, Ghana, Nigeria, Indonesia, and Thailand. There is only one phone per thousand people in such countries as Niger, Zaire, and Afghanistan. The United States has 1,752 radios for every 1,000 persons: Nigeria has 49 and India 24. Television sets in the United States number 532 per 1,000 people, compared to .3 and 1.4 receivers in India and Nigeria, respectively.

## CITATIONS


American City Corporation (1974) El Salitre: A City in the City. Department of National Planning, Bogota.

American City Corporation (1976a) Feasibility Study, San Facon-Paloquemao-Usatama. Study done for the National Planning Commission, Bogota, Colombia, April.

American City Corporation (1976b) Feasibility Study, Techo. Study done for the National Planning Commission, Bogota, Colombia, April.

Chitnis, E.V. (1976) Introduction to SITE. Paper for the SITE Winter School, Ahmedabad, January 16.

City of Karachi (1974) Karachi Development Plan, 1974-1985. Master Plan Department, Karachi Development Authority.

Gilewica, P.J., A.C. Gross, and W.W. Ware (1976) World motor vehicles. Columbia Journal of World Business. Spring:81-92.

Government of Pakistan (1977) Low Income Settlement in Karachi. Final Report, National Pilot Project No. 3. January.

Pal, Y. (1975) Some experiences in preparing for a Satellite Television Experiment in rural India. Proceedings of the Royal Society. London.

Rivkin, M. (1976) Land Use and the Intermediate-Size City in Developing Countries. New York: Praeger.

Willoughby, C.R. (1976) Significance of the Transport Industry in an Increasingly Diversified World Economy. Address at the Hamburg International Transport Exhibition, November 16.

## Appendix

## CONTRIBUTORS TO PUBLIC FORUMS

The following persons submitted written or oral statements as part of the Executive Committee's request for public contributions to this study. We regret that, as a result of incomplete records, some names may have been inadvertently omitted, but the Executive Committee wishes to express its appreciation to all those who participated so constructively.

Loren Abdulezer, Center for Regional Technology, Polytechnic Institute of New York
Robert F. Acker, American Society for Microbiology
Scott Adams, Louisville, Kentucky
Nancy Adler, American Psychological Association
Karim Ahmed, Natural Resources Defense Council
Harry Ausprich, State University College at Buffalo
John Bannigan, Asia Foundation
Merton R. Barry, University of Wisconsin at Madison
William Bevan, Duke University
William E. Biles, University of Notre Dame
David Black, Southwest Research Institute
Dan Bolef and Ellen Irons, Washington University
Estelle Brodman, Washington University
Ronald Brooks, General Electric Corporation
George Burnet, American Society for Engineering Education
Edmund J. Cantilli, Polytechnic Institute of New York
Raul R. Cardenas, Jr., Polytechnic Institute of New York
Robert L. Carter, University of Missouri at Columbia
C.R. Chapman, Bradley University
David Chatfield, Friends of the Earth
Gastone Chingari, IIT Research Institute
K.M. Chung, Polytechnic Institute of New York
Jerry Coiner, Columbia University
John A.D. Cooper, M.D., Association of American Medical Colleges

James Cowan, National Association of State Universities and Land-Grant Colleges
DeWayne Coxon, Jordan College
Eric Craven, Northern California Coalition for Full Employment
David W. Delasanta, Edwardo Perez, and Jennifer Byram, Washington University
Nicholas Demerath, Washington University
David Devor, Dr. Dvorkovitz Associates
Theodore C. Doege, M.D., American Medical Association
Mohamed M. El-Gasseir, University of California at Berkeley
Leo Ellis, Bechtel Corporation
J. Morley English, World Congress on Educating Engineers for World Development
Douglas Ensminger, University of Missouri at Columbia
Marshall E. Findley, University of Missouri at Rolla
Weston Fisher, Missouri Energy Agency
S.S. Flaschen, ITT Corporation
Paul Flum, Paul Flum International, Ltd.
Ona B. Forrest, Polytechnic Institute of New York
Kenneth E. Foster, Office of Arid Lands Studies, University of Arizona
Peter Gajewski, Louis Berger International
R.S. Ganapathy, University of Michigan
James R. Gay, University of Tennessee
Robley E. George, Center for the Study of Democratic Societies
Norman Gilroy, Institute for the Human Environment
James A. Gold, State University College at Buffalo
Margarete Goldberger, B'nai B'rith Women
Paul B.W. Gollong, New York City
Neil S. Grigg, Water Resources Research Institute, University of North Carolina
John C. Guyon and Robert C. Hallissey, Southern Illinois University at Carbondale
Harold Hamilton, St. Louis Labor Council, AFL-CIO
Klaus Heiss, American Institute of Aeronautics and Astronautics
George Herbert, Research Triangle Institute
Donald J. Howard, Mobil Oil Company
Irene M. Hulicka, State University College at Buffalo
Leah Janus, Overseas Education Fund of the League of Women Voters
R. Curtis Johnson, University of Colorado
Jo Jones, Sierra Club of Georgia
Lawrence R. Kegan, Population Crisis Committee
R. Lynn Kelley, Webster College
Yun Kim, Population Research Laboratory, Utah State University
William R. Kimel, American Nuclear Society
M.E. Knabe, International Executive Service Corps
James H. Kratzer, Childrens Hospital, San Francisco

Howard G. Kurtz, War Control Planners, Inc.
Eugene C. LaFond, International Union of Geodesy and Geophysics
Susan Lees, Hunter College
Jean-Robert Leguey-Feilleux, United Nations Association of Greater St. Louis
Carol Leimas, American Association of University Women
J.V. Leonard and Herbert A. Crosby, University of Missouri at Rolla
Ronald Lipton, Department of Appropriate Technology, State of California
Betty A. Little, Education Division, Passaic River Coalition
Evodio Llevada, Florida International University
Edmund Lusas, Food Protein R&D Center, Texas A&M University
Morton Malin, Institute for Scientific Information
J.O. Maloney, University of Kansas
Thomas J. Maloney, Southern Illinois University
Kenneth Manning, COMSAT General, Inc.
H. F. Massey, American Society of Agronomy
Clair N. McRostie, Gustavus Adolphus College
E. Gerald Meyer, University of Wyoming
Eugene Mihaly, Mihaly Associates
George E. Miller, M.D., University of Illinois Medical Center, Chicago
Michael J. Moravcsik, University of Oregon
Robert P. Morgan, Washington University
F. David Mulcahy, Polytechnic Institute of New York
William W. Nash, Jr., Georgia State University
Howard K. Nason, Industrial Research Institute Research Corporation
Buford L. Nichols, M.D., Baylor College of Medicine
Mary Cushing Niles, Friends Committee on National Legislation
Patrick J. O'Farrell and Lester Trachtman, African-American Labor Center
Emilio Pagoulatos, University of Missouri at St. Louis
Ann Palm, Berkeley, California
William Parrott, Black Vanguard Associates
Louis J. Pignataro, Polytechnic Institute of New York
J. Roger Porter, American Society for Microbiology
Scott Porter, United Nations Association of San Francisco
Juan de Dios Pozo-Olano, Reston, Virginia
C.R. Price, J.M. Huber Corporation
Bruce Q. Rado, Department of Natural Resources, State of Georgia
David R. Reyes-Guerra, Engineers' Council for Professional Development
David W. Ridgway, University of California at Berkeley
Carly Rogers, Sierra Club of New York
Kurt Salziner, New York Academy of Sciences

Henry M. Schaerf, Washington University
George Schillinger, Polytechnic Institute of New York
David Schlessinger, American Society for Microbiology
Eugene B. Schultz, Jr., Principia College
Benjamin A. Sharman, International Association of Machinists and Aerospace Workers
Sydell Shayer, League of Women Voters of Missouri
Raymond Sherwin, Sierra Club of California
Paul Silverman, RCA Global Communications, Inc.
Dick Smith, Purdue University
Howard W. Smith, University of Kansas
Robert Smylie, United Presbyterian Church
Jane A. Starling and William Bethel, University of Missouri and St. Louis University
Fred Stokeld, U.S. Chamber of Commerce
Guenther Stotzky, New York City
Frank Stucki, ITI Corporation
H. Harry Szmant, University of Detroit
Margaret Thomas and Vincent Tucker, Washington University
Richard Thorsen, Polytechnic Institute of New York
Pir Toor, Lockheed Corporation
T. Paul Torda, American Society of Mechanical Engineers
John D. Upham, Monsanto Company
Edward Vickery, Southeast Consortium for International Development
Robert von Pagenhardt, Monterey Higher Education Association
Thomas W. Wagner, Environmental Research Institute of Michigan
T. Kelley White, Purdue University
Anne Whittington, Stanford University
Herman S. Wigodsky, M.D., University of Texas at San Antonio
Bobby G. Wixson and J. Derald Morgan, University of Missouri at Rolla
R. Osborne Wright, St. Louis, Missouri
George Young, Experiment in International Living
Sherilynn Young, Applied Systems R&D, Inc.



☆ U. S. GOVERNMENT PRINTING OFFICE : 1978 O - 266-912