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9. ABSTRACT

The subjects considered in the course of the symposium and therefore in these volumes were construction, transportation, housing, water resources and nutrition--all highly relevant to concerns of the developing countries and all subjects of current interest at MIT. The four volumes of this report contain most of the papers that were commissioned to formulate questions and issues. Volume 1 contains the following papers and list of participants:

Introduction and Background, J.P. Ruina

Panel Reports

The U.S. Foreign Assistance Program: Past, Present and Future, Curtis Farrar

Technology Utilization in Developing Countries: an Economic Overview, Richard S. Eckaus

Summaries of Papers

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PROCEEDINGS OF THE M.I.T. SYMPOSIUM ON STRATEGIES FOR A.I.D. PROGRAMS IN SELECTED AREAS OF SCIENCE AND TECHNOLOGY

J. P. Ruina (ed.)

VOLUME 1: SUMMARY

April 1974

Massachusetts Institute of Technology
Cambridge, Massachusetts USA

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INTRODUCTION AND BACKGROUND

J.P. Ruina
Professor of Electrical Engineering, MIT

The Technology Adaptation Program at MIT sponsored a symposium in April of 1974 to consider strategies in the utilization of science and technology in development. The Agency for International Development provided financial and substantive support in the planning and execution of the symposium. The aims of the symposium were to examine areas of science and technology that might merit more attention in the future as well as to consider the scope, balance, and perspective of the Office of Science and Technology (TA/OST) of AID within the context of the current needs and conditions of developing nations. In order to foster the interchange of more than superficial ideas about gaps, opportunities and needs for change, we intentionally limited the number of participants but tried to keep the topics as broad and comprehensive as possible. Indeed we worried that we might end up with only one person who could deal intelligently and comprehensively with each topic. But our fears proved unjustified--maybe we were just lucky but we choose to believe that the relevance and breadth of discussion at the meeting were attributable to the wise choice of participants and discussion leaders, who brought to bear an unusual combination of knowledge and experience. The participants included U.S. academics, U.S. A.I.D. officials and representatives from developing nations with diverse technical interests, posing some initial communications problems; however, as the meetings progressed, the strong common concerns about development dominated the spirit of the discussions.

The site of the meeting was Endicott House, an MIT conference center about one-half hour drive from the MIT campus, so that the participants were a bit removed physically but yet a part of the MIT environment.

The subjects considered in the course of the symposium and therefore in these volumes were construction, transportation, housing, water resources and nutrition--all highly relevant to concerns of the developing countries and all subjects of current interest at MIT. The four volumes of this report contain most of the papers that were commissioned to formulate questions and issues. The papers certainly convey the substance but they cannot communicate the quality of the productive informal

interchange among the participants. My impression is that virtually all of the participants felt that their perspectives on problems of developing countries were enriched in the course of the meetings.

After presentation of the prepared papers, panels met on the afternoon and evening of the 25th of April to discuss each of the following five program areas of AID's Office of Science and Technology,

I. Science and Technology Policy

II. University Orientation Strategy

III. Strengthening Industrial Institutions

IV. Natural Resource Use and Conservation

V. Strategy for Reducing Public Investment Costs

The panel reports appear in this summary volume. In addition, the five program panel chairmen convened a Master Panel to consider and correlate the reports of the program panels, and to present their views on the five program areas of TA/OST and other AID programs of science and technology.

It is impossible to summarize the specific contributions of all of the participants. Those who prepared formal papers are represented in the text of these volumes. There are four other participants whose comments I would like to note here.

In his welcoming comments Provost Walter Rosenblith of MIT stressed the continuity of the problems that the symposium was confronting. He pointed out that these problems have been recognized for a long time and that MIT itself has been engaged with the relationship of science and technology to development almost from its founding in the mid-1800's. Now the task becomes one of determining the new boundary conditions so that one can make the contributions of science and technology appropriate and adaptive, taking into account what we know of individuals, institutions, traditions and socio-economic conditions in each country.

In his after dinner remarks Dr. Robert Charpie, President of the Cabot Corporation, an engineer with a long and active interest in technology and public affairs, voiced serious concern about the limited impact of U.S. foreign aid programs on the progress of developing countries.

He encapsulated the main problems, as he sees them, into three main aspects: money, people and time.

Money: There is too much spent by the U.S. in its total foreign assistance program in the form of loans and too little in the form of technical assistance. The U S. has been too timid in supporting the idea that sustained analytical effort can contribute to the solution of problems, and too willing to believe that by spending larger sums of money we will get better results. Good technology combined with good people will produce success a high percentage of the time, but not always. You cannot always be sure you are working on the right problem, and not everyone will agree as to what constitutes success. The stress put on successful outcomes produces a fear of failure and hence leads to large loans instead of support of sustained research.

People: Neither the universities nor the government have been able to evolve a satisfactory career path for people who want to devote themselves to technical assistance to developing countries, or for people in private industries wanting to do such work under the government's umbrella. At present people are not available for extended period of time because they are not assured of satisfactory careers when they return to their parent institutions. Technical assistance must not be a secondary activity to those involved in the field.

Time: A tragic error is that we have allowed the notion to be perpetuated that the time frame necessary to solve the hard problems of development is the same as that necessary for hard technical problems, such as developing a bomb or landing on the moon. Development problems are much harder and it takes one or more generations to discern any appreciable changes but still governments persist in appropriating funds that on the short side are for one year and on the long side are for five years. However, the problems will not yield to this time span and the result is that short term projects end up as so much "noise" in the long term progress of a country.

The fourth problem mentioned by Dr. Charpie, and the one that he thought probably the most pervasive, is that of political overlay. Powerful political biases tend to determine how much should be spent on what problem in which country, and these biases have a stronger influence on choice than all other considerations. Since the political environment changes faster than our ability to solve problems, the

initiation of work now that will remain relevant in a future political context becomes a critical aspect of choice.

Given solutions to the money, people and time problems, the political problems would still exist to frustrate participants, since although they appear no harder than in the past there are no signs that they will lessen.

Dr. Amir Khan, speaking from his extensive experience as Director of the Agricultural Engineering Department of the International Rice Research Institute (IRRI) of the Philippines pointed out the importance of carefully selecting the target population for which any specific technology is to be developed. For example, IRRI found that farm machines designed and developed to take careful account of the precise size of the farms which were to use the machinery were most successful. He also pointed out the need for close coordination with the local equipment manufacturers since all designs, no matter how clever, must be feasible for local manufacture. He cautioned that local manufacturers have little available capital for testing unfamiliar manufacturing processes so that the introduction of new processes must be gradual.

Dr. Mokthar Latiri, Dean at the Ecole Nationale D'Ingenieurs de Tunis, was particularly poignant in pointing out the difference between transferring universal scientific knowledge and the transfer of technology. Developing countries need technology and skills transferred with basic concern for their unique local, social, economic and physical conditions. There will inevitably be resistance to experts from developed countries who seem patronizing and who prescribe solutions rather than working to accomodate their expertize to the cultural realities of the developing country.

The report is divided into four volumes--the first is a summary volume, but includes two papers of a general nature that were presented at the first evening of the conference. The other three volumes include specific papers that were presented at the conference and they are grouped on the basis of their size and relatedness.

The conference owes a debt to several people who worked to get it all together: Henry Arnold, the Director of the Office of Science and Technology at AID, who conceived the idea for the meeting and provided continuous counsel and guidance and who is responsible for follow-up

efforts; Dan Margolies, now an independent consultant, provided the benefit of his wisdom and long experience. while Stelios Arghyros, with his fresh Ph.D. from MIT, sparked the process with youthful enthusiasm and healthy skepticism. Miss Frances Stefan of MIT managed the administrative arrangements skillfully with charm and with good nature. Colin Warren, a graduate student at MIT interested in the problems of developing nations,was not present at the conference itself, but has done a masterful job of capturing its essence in his rendering of some of the material of this report.

The conference was an important learning experience for me, and I wish to thank personally all of the participants. Hopefully it will advance "the state of the art" in applying science and technology to development.

PANEL REPORTS

I. Science and Technology Policy

II. University Orientation Strategy

III. Strengthening Industrial Institutions

IV. Natural Resource Use and Conservation

V. Strategy for Reducing Public Investment Costs

PANEL 1. SCIENCE AND TECHNOLOGY POLICY[1]

Objective: To assess the general scope, balance and perspective of TA/OST's program in the area of science and technology policy.

As a point of departure for the Panel, representatives from Cornell University and the National Academy of Sciences, and John Montgomery of Harvard University described briefly their respective AID-sponsored activities in the sector of science and technology policy.

Recommendations:

After animated discussions, the Panel reached the following conclusions:

(1) Since the United States itself has not adopted a formal science and technology policy, the role of AID in assisting developing countries to strengthen their science and technology policies is difficult to define. Moreover, the problem of developing a technology policy as distinguished from a science policy raises a number of complex questions. (Science and technology policies were discussed collectively, recognizing their relationships as well as their differences.)

(2) There is a need for an in depth study of the generic character of science and technology policy formulation for individual developing countries, and the institutional framework through which it takes place. The academic approach of Cornell and the "joint workshop" and related techniques of the National Academy of Sciences were found to be useful approaches which should avoid advocacy of U.S. solutions to local problems. However, greater emphasis should be placed on good engineering and the need for interaction with the industrial sector.

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[1] Panel participants:
Chairman: J. Herbert Hollomon
Rapporteur: William H. Littlewood
Members: Frank Ahimaz, Pierre Aigrain, Stelios Arghyros, Julian Engle, Carl Fritz, Mario Edgardo Ibacache, Daniel F. Margolies.

(3) Further, the Panel suggested that AID consider the following research study areas;

a. How can we distinguish between the institutional qualities of "success" and "failure" in applications of science and technology to development needs, in terms of the ability of the science and technology community to participate in the planning process and its linkages to operating agencies, i.e. the decision orders and linkage structure?

b. What effect does participation by economic planners and science and technology policy-makers in their respective policy-making efforts have in terms of their subsequent perceptions of "priorities" and "feasibility" issues?

c. What are the side-effects of the contracting procedures by which the science and technology bodies undertake problem-solving for clients, and how can they be controlled?

d. How can we identify the contributions science and technology can make to the vertical structure and operations of developmental sectors?

e. How can AID work more effectively in cooperation with the science and technology policies of the international development banks such as the IBRD?

f. AID should look for ways of strengthening its own science policy, namely by improving the institutional framework within AID in order to better apply AID's capabilities in science and technology in the design and implementation of AID field operations.

PANEL II. UNIVERSITY ORIENTATION STRATEGY[1]

Objectives: To consider the need for re-orientation of LDC university objectives towards more intensive application of science and technology to national goals, and the extent to which U.S. universities could play a role in this re-orientation.

Issues:

(1) Encourage and implement effective orientation of LDC university science and engineering programs to development needs.

a. Mismatch between national needs and traditional university structure and approach to education.

b. A fundamental question of educational goals: the definition of academic excellence; scholar vs. practitioner.

c. Identification of needs and the creation of responses.

(2) Enhance the commitment of U.S. university science and engineering programs to LDC development needs.

a. Historically, the commitment has been based on the evolution of the personal commitment of individuals.

b. Personal commitment stretched out over long time periods with very little institutional or government support.

c. Inherent problem of the conflict between peer recognition and LDC development needs.

Recommendations:

AREAS IN NEED OF STUDY

(1) Questions of scale inherent in LDC science and technology university programs.

a. Cost of science and technology programs.

b. Inclusion of a research component in educational programs.

c. Redundancy of efforts

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1 Panel participants:
Chairman: Edmund T. Cranch
Rapporteur: Robert H. Goeckermann
Members: Nathan H. Cook, Eugene R. Chamberlain, H. C. Ladenheim, Mokthar Latiri

(2) Questions of centralization vs. dispersion.

a. Cost of dispersion

b. Quality consequences of dispersion

(3) Questions of linking educational programs with other technology development institutions.

AREAS WHICH MAY MERIT ADDITIONAL ATTENTION

(4) Creation of summer seminar bringing together LDC staff with U.S. educators.

a. Time continuity important

b. LDC staff access to U.S. programs and engineering practice.

c. Follow-on relationships established with teaching staff.

(5) Pilot program between selected LDC and U.S. institutions in priority subjects.

a. Focus programs in high priority subjects

b. Include practitioner component

c. Include technology selection component

(6) Pilot use of jointly prepared educational technology units.

a. Need to bridge the continuing information gap; this problem exists from both sides

b. Need to overcome the time constant of career educators and their own training.

PANEL III. STRENGTHENING INDUSTRIAL INSTITUTIONS[1]

Objective:

The panel took as a given premise that strengthening industrial institutions is a useful objective for the AID Office of Science and Technology. Though there was no discussion of the validity of this objective, the point that institutional development is a part of the larger problem of industrialization was made by the panel several times in the discussion of other issues.

Initially, the panel expanded upon the issues suggested in the strategy paper. The list proposed for discussion included:

(1) How can the normally high risk factors associated with industrial R, D & E be minimized in LDC situations to encourage local industry use of technology?

(2) Can multi-national corporations (MNC's) play an active role in the development of Industrial Research Institutions (IRI's) and in the utilization of their services?

(3) Are there ways in which the present energy problem can be the basis of increased useful application of technology in LDC's?

(4) What should the role of information networks be in the transfer of industrial technology?

(5) What can be done to convey the importance of timely decision making to LDC government and industrial officers?

(6) What should the AID/OST role be in promoting the interest of LDC governments in the development of small scale industry?

(7) Given the importance of agricultural development and the rural poor in AID efforts, what can be done to develop small industry in the rural areas?

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1 Panel participants:
Chairman: Norman Dahl
Rapporteur: Clinton Stone
Members: Stanley Backer, James Blackledge, Charles Dennison, Peter Griffith, Ross Hammond, Amir Khan, Hugh Miller.

Recommendations:

(1) Minimization of RD & E Risks

The panel noted that direct technical assistance to industry is excluded from OST objectives and therefore that the reduction of risks associated with specific industrial development projects is not appropriate. Rather, the panel felt that it should address the posture and functions of IRI's with respect to project risk. One view expressed by some members of the panel was that efforts in the areas of measurement, analysis and testing were inherently less risky and that IRI's should emphasize these activities until industrial confidence in the institute was established. Other panel members suggested that this was under-utilization of available skills and pointed out the potential danger of the institutes lapsing into strictly a "testing" mode. The panel agreed that a dual approach was the preferred strategy. The institutes should regard service functions as a necessary and useful role in establishing industry confidence but they should use available or "bootlegged" time to develop both the technical and economic understanding of in-house project ideas to the point where many of the uncertainties have been removed or quantified before seeking industrial support. While this does not guarantee that financial backing for the proposal will be forthcoming, it does help to promote the problem solving image to industry.

(2) Role of the Multi-national Corporations

The panel emphasized the scale on which MNC's undertake training and the development of local sources of materials and components to accomplish their objectives pointing out that if a fraction of that effort were devoted to the development of more generalized technical skills, it would have a major impact. While examples of MNC attempts to involve local institutions in industrial problems (without success) were cited, it was generally agreed that the majority of MNC's have not been sensitive to the long range advantages which could accrue from paying special attention to the development of the technical and managerial skills of indigenous institutions. Although past attempts to engage MNC interest in the development process have not been rewarding the panel recom-

mended that OST develop an inventory of institutional capabilities on a country by country basis together with a brief description of OST institutional development programs where applicable , the reasoning being that MNC's were largely unaware of these potential resources. Such an inventory could provide the basis for continuing attempts to elicit MNC support and participation in strengthening LDC institutions.

(3) The Influence of Energy Shortages

The major changes that have taken place in the price and availability of fossil fuels and also therefore in energy intensive goods will have a profound effect on AID's ability to meet its stated priority objectives and on the ability of LDC's to achieve continued development. The panel recognizes that the problem has many political aspects and that the country specific difficulties which have arisen or which will arise as a result of altered energy availability will have many dimensions. Further, the panel realizes that the scope of the problems greatly exceeds the resources presently available to OST but in view of the large technical component of any significant changes in the generation, use or distribution of energy, the panel strongly urges OST to support research and development on energy problems unique to LDC's. This activity should draw upon U.S. R & D to the maximum extent possible recognizing the differences in scale and acceptable costs likely to be encountered in developing countries.

(4) Information Networks

The panel discussed a number of approaches to the question of the role of information in technology transfer. It was pointed out that industrial technology relies heavily on "know-how" as well as the judicious use of available materials and components. The role of person to person contact was emphasized in achieving useful exchange of this class of knowledge. Another view was that the increasing sophistication of technical expertise in LDC's should permit a less personal approach to information flow noting that the expense and U.S. policy of reducing direct involvement required an altered approach. Mention was made of the role of catalogues and "sector" handbooks in U.S. practice with the suggestion that

regions or multi-country groups might analyze and compile information relevant to a particular industry or technical area of priority interest. After continued discussion the panel concluded that OST should assist LDC institutions in acquiring information management and analysis skills so that all the steps of acquiring, screening and assembling printed information can be carried out on a local or regional basis. This would be an effective complement to UNIDO information dissemination activities. It was also suggested that OST increase its support of LDC "Donor" expert exchange with LDC recipients to preserve the necessary person to person transfer of "know-how".

(5) Timely Decision Making

The panel stressed the importance of decision making and timeliness in the execution of technical projects noting with despair the lack of understanding on the part of those officers and officials responsible for such decisions. The panel had limited time to discuss this point and confined its remarks to pointing up the concepts of the time value of money, the opportunity costs and their particular relevance to science and technology. The possibility of using case studies as the basis for training officials was suggested as a means of institutional change.

(6) Promotion of Government Interest in Small Scale Industry

The consideration of multi-national corporations, summarized earlier, expanded to include the possible interaction between agricultural development programs and efforts to establish small industry in rural areas. The panel regards this class of industrial development as being particularly important. These industries often have greater potential for income redistribution than urban industrialization and can provide services and goods to improve the rural existence which might otherwise be unavailable or more expensive if produced at urban locations. The panel suggested that agricultural programs with the primary objective of increasing crop yield, decreasing infestation, improving the utilization of fertilizers, etc. could be a very useful vehicle for stimulating small rural industries with small program cost incre-

ments. Prior or parallel developments in mechanization, containerization, wast utilization, etc. as relevant could be the basis for combined activities. The panel suggested that an informational package similar to that described in (2) above might be the starting point for further discussions with AID Bureaus or other development agencies.

PANEL IV. NATURAL RESOURCE USE AND CONSERVATION[1]

Objectives:

Given time limitations, the Panel restricted itself to reviewing TA/OST's perspective and general programming approach with respect to each of the three components of the natural resources area of concentration set forth in the AID Policy Determination for Science and Technology, namely: (1) development of faster, cheaper and more effective techniques for identifying and appraising natural resources; (2) improved techniques for multiple-use planning and management of land and associated resources; and (3) technologies and methodologies for protecting the environment including pollution abatement and control. In general, the Panel felt that these are all areas in which AID can play a useful role, and that they collectively provide a rather well-defined program format. However, TA/OST is encouraged to convene a group of experts for a day or two to undertake a detailed examination of the three areas in an effort to identify the most promising high-payoff targets and to further sharpen and delimit the boundaries of the areas.

Recommendations:

With respect to the development and application of techniques for resource assessment, the Panel urges that attention be focused on the renewable resources. The evaluation of the agricultural potential of marginal lands is a heretofore neglected area in which the introduction of new technologies can have a significant impact. While obviously potentially important to the economics of the developing countries, nonetheless the development of techniques for mineral resource inventories and appraisal should probably be left to the private sector and the stimulation of market forces. AID's role in the mineral resource area might best be confined to providing guidance to the countries on true value and best use of the resources that might be identified.

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1 Panel participants:
Chairman: William W. Seifert
Rapporteur: Bill L. Long
Members: Richard Bender, Ian Burton, Omer J. Kelley, David C. Major, William H. North.

In the area of new techniques for multiple-use planning and management, emphasis should be placed on social decision-making, and on identifying and assessing alternative strategies for the use of land and associated natural resources. Improved management of underground water resources to ensure their sustained yield is a high priority need and will require new techniques for reservoir appraisal, better data collection and analysis, and sensitization of developing country officials.

The environmental protection component of the program should continue to receive attention. Given the sensitivity of environmental issues in many countries coupled with the image of the U.S. as the world's biggest polluter, TA/OST initiatives should be carefully selected and pursued--with the focus probably continuing to be on training plus the dissemination of information in response to specific developing country requests.

The Panel also noted that the world energy situation which is causing, among others, rapid depletion of local wood resources, is presenting the developing countries with a set of critical problems which do not appear to be receiving adequate attention by AID. Further, the U.S. energy program as presently designed will probably not provide, without additional stimulation and direction, direct fallout for the developing countries. These observations deserve urgent examination, and it is therefore recommended that a group of experts be convened by TA/OST to help determine whether there is a useful role for AID to play in this field, and if so, to define the magnitude of resources and the type of program strategy thatAID will require to ensure a meaningful impact. The required effort may have to be much larger than the current total OST program to be effective.

Finally, the Panel considered the question of whether TA/OST should establish a permanent group of outside experts to advise it on natural resource programming, and was unanimous in recommending against this approach and in favor of greater reliance on the use of small ad hoc panels.

PANEL V. STRATEGY FOR REDUCING PUBLIC INVESTMENT COSTS

Objective:

Within the framework of AID's "Guidance Statement of Selected Aspects of Science and Technology", Policy Determination 51 of January 12, 1973, the Office of Science and Technology is assigned a policy guidance and technical leadership role in the concentration area, "Reducing Public Investment Costs." The long range objective within this area is to identify technological innovations that can greatly reduce the costs of economic infrastructure activities that are heavy users of LDC public funds in order to improve LDC technological choice in implementation of such activities and thus release public resources that could be applied to other development needs. Particular attention will be given to those technological innovations which will contribute to employment and income distribution objectives of AID which relate directly to improving the quality of life for the poorest segments of the population.

Important milestones within the next five years are the implementation and completion of individual research and related experimental and demonstration projects designed to explore the opportunities for LDC technological innovation within such activities as public works, housing, transportation, communications and energy development. Each project will be oriented toward identifying the techno-economic factors relevant to improving technological choice by decision makers in LDCs at different levels of national development among alternative decisions in these fields. Consideration will be given in the selection and internal design of projects to employment and income distribution objectives, the impact of technological change on social systems, and improvement of the quality of life for the mass of the population.

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[1] Panel participants:
Chairman: Fred Moavenzadeh
Rapporteur: Merrill Conitz
Members: Richard Eckaus, Lester Gordon, L. Odier, Paul Roberts, Ian D. Terner, Louis B. Taylor

Recommendations:

Future Plans: As the experimental investigations in the above area are completed, the results will be evaluated to isolate the most promising areas for future efforts in dealing with the problems of reducing public investment costs. This evaluation will provide a selection of alternatives which will form the foundation for investment strategies of the future. The criteria for the selection among these alternatives include the need for a balanced approach to technical assistance efforts, the most efficient use of AID's limited resources, and the need to accommodate external pressures such as the energy crisis and regional disasters. In implementing the suggested alternatives, attention will be paid to the capability of the local government to administer the solutions, and to the possibility of developing better management techniques for budgeting, financing, contracting, licensing and quality control of public work projects.

Research Programs: The following is the list of the research programs recommended for each of the five areas of housing, public works, transportation, communications and energy. These programs are listed in order or priority in each area.

(1) Housing

a. Residential support systems such as water and waste

b. Land and land tenure policies

c. Credit and credit distribution systems particularly to families with marginal incomes

d. Use of indigenous building materials

e. Coherent set of building elements and fireproof cladding materials

(2) Public Works

a. Reexamination of the existing western public works systems in terms of their appropriateness for use in developing countries

b. Development of totally new technologies responsive to smaller scale initiatives

c. Development of optimum labor and capital mix in construction including considerations for design, maintenance, and operating expenses.

d. Development of appropriate maintenance technology and management.

e. Accounting for maintenance resources in international financing

f. Improvement of the utilization of local materials

(3) Transportation

a. Utilization of existing research findings in demonstrative cases

b. Evaluation of simple mass transit systems such as car pooling and bus lines

c. Review of exising low volume transportation technologies including off road vehicles

d. Development of total transport systems which account for design, construction, maintenance and operation

e. Integration of transport planning with plannings of other social systems

(4) Communication

The recommended research programs in this area are essentially the same as in transportation with the following addition: Evaluation of economic benefits of telecommunication systems.

(5) Energy

a. Review of existing esoteric technologies for energy generation within the context of newly developed energy crises.

b. Survey of possible micro-scale hydroelectric projects which could tap the vast hydroelectric potential available in most developing countries

c. Consideration of integrating methane and other energy generating potential of solid waste with treatment technology

d. Development of solar systems as energy source with particular interest in low efficiency systems

THE U.S. FOREIGN ASSISTANCE PROGRAM: PAST, PRESENT AND FUTURE

Curtis Farrar
Deputy Director, Bureau of Technical Assistance
Agency for International Development

The title given to my brief remarks this evening is misleading. Hard-bitten bureaucrats, even when they also are economists, are reluctant to project the past and present too far into the future; so instead, I will limit my comments to some of the major events and trends in international development with which we in AID are starting to deal now in preparation for the future.

One thing is clear. In spite of a good deal of rhetoric from time to time suggesting otherwise, the political justification for a United States foreign aid program is very much with us and will continue to be with us in the future. It is represented at the moment most substantially by the AID program in Southeast Asia--particularly in Vietnam, and will probably be represented in some fashion in the Middle East. I think it is fair to say that the need for programs of this type remains an overriding consideration on the shape of the total program and a very important reason that it continue. This can be illustrated in recent experience by the talk that the Secretary of State gave at the United Nations General Assembly. It was an important political statement, but also a developmental statement. From the point of view of AID and the people interested in development, it was a strong and personal move by the Secretary toward active concern for the needs of the developing countries and toward possible changes in United States policy and attitudes to help them meet their needs.

One cannot talk about the future of the AID program without saying something about the energy crisis which was the reason for Secretary Kissinger's speech at the United Nations General Assembly. The first thing that AID people say about the energy crisis is that it obviously is too big to be dealt with by the foreign assistance program even when one considers only the impact of the rise in petroleum prices on the developing countries. You are certainly aware that the impact varies, depending on the country. Our analysis so far shows that there are about twenty-five developing countries which are having short-run difficulties because of low initial foreign exchange reserves or because they have no exports benefitting from rising prices. At the moment the solution to this short-run crisis is not at hand. If one considers these countries alone, excluding other countries which, while affected, can obtain relief from non-concessionary foreign sources, the amount of money we are talking about for this year and part of next is about three billion dollars--not the staggering sums that have been mentioned in some of the reports that have been published, but quite clearly a problem that needs to be resolved in the international context. It needs to be resolved in part by the countries that are benefitting from the rise in petroleum prices; and from such international bodies as the IMF. AID's role in the solution is not yet clear. If one tries to look beyond the next few months on this issue, the concern we in AID and the United States Government have for capital transfers to developing countries must continue. As you know, we have been shifting the responsibility for capital transfers to other donors and multilateral agencies. expect that this shift will have to slow down to some extent. And the pattern of such transfers will be different in many ways from what it would have been had the break in petroleum prices not occurred.

Let me turn now to an area related to the energy problem--that of world food production. Some way must be found in the reasonably near future to reduce the present extraordinary vulnerability which results from the low level of world food stocks. This issue, of course, is to be a principle concern of the World Food Conference to be held in November, 1974, where the United States Government will play a very important part. (AID's role will be just one element in the wider U.S. Government involvement.) If one assumes that the stocks can be built up and vulnerability to disaster reduced in the short run, the problem becomes one that has been central to the AID program for some time how to increase food production in the developing countries themselves. We hope very much that the World Food Conference will devote a good deal of attention to that problem and give renewed vigor and energy to efforts to solve it. It is certainly clear that in the long run it is not the total supply of food in the world that counts, but rather whether poor people in various countries can earn enough or grow enough to have adequate diets. That means working on production by poor people in the developing countries.

Now, if one were to try to discern something about the future of the AID program by looking at our discussions with Congress over the next few months, I think you would detect two lines of emphasis and perhaps a certain lack of bridge between them. Here I am going to be talking almost exclusively about development assistance, leaving out programs justified primarily on political grounds.

One of these lines of emphasis is based on a perception that the developing countries really have new problems--problems that have never been solved before anywhere. Therefore, the solution should be to mobilize technology, develop problem-solving capacity, focus it on these problems and provide the new technical

solutions which, like the short-stemmed grains of the green revolution, will be adopted with relative ease. We have the models of the international agricultural research centers such as IRRI and CIMMYT to follow. This is also a fairly easy approach in the sense that it raises no important political questions, no questions of intervention. So it offers a very attractive line of work and one that holds great promise.

The other emphasis is based on the perceptions that the green revolution and other progress over the last decade or two has not reached the very poor in the poorer countries; that the gap between the rich and the poor is increasing; that various groups may be being harmed by the development process. For example, women may be being deprived of their traditional economic roles without being given another role to fulfill. Part of this perception is that certain countries (Taiwan is the usual example cited) have been able to make great progress in overall economic growth and combine that with good distribution of the benefits in a fashion that cannot be explained, at least not wholly, by technological breakthroughs or new technology. The judgment is that no matter how aid donors and development planners expect the benefits of their programs to be distributed, the society's institutional framework will frequently prove strong enough to re-arrange the benefits in accordance with its norms. My response to this is that an aid program must seek to re-arrange institutions; must work directly with the rural poor; must look at rural infrastructure such as credit and marketing structures and land ownership; and must focus not so much on technology as on the gap between available technology and the planned beneficiaries out at the end of the line. This is a messy problem, not a clean one like technology, because it implies intervention. It implies making judgments about other people's societies and, even worse, we do not know how to do it. We have some examples of successful rural development efforts, usually rather limited in area, but we do not really have any very convincing examples of what AID organizationally can do to bring the process about.

I expect that within AID and other development organizations there will be some rather stern confrontations between these two points of view in the coming years. Both points are represented in the report of the House Foreign Affairs Committee, but the stress seems to be on programs directed toward the poor, rather than on technological solutions. People who look at the technical focus sometimes brush aside too easily the policy aspects and the secondary institutional problems. People who look primarily at the poor seem to assume the technical and economic answers are there, and just need to be organized properly in order to work.

I suppose that our job as AID administrators, and yours as people who are involved in one way or another in supporting or working with development programs, is to try to build the middle ground between these views or to build some kind of complete and workable system that embraces both perceptions. One of the program implications, for AID at least, is to sponsor activities which have a direct impact on target groups. For instance, if we can encourage the replacement of ordinary corn with high lysine corn, the people who eat corn will have more protein in their diets without having to change their eating habits. The same kind of approach could probably be taken with sorghum. If we can find a way to administer a very rudimentary health delivery system that reaches 85% of the population in a relatively poor country instead of the 15% such programs now reach, then people will benefit directly without much else changing. However, there are only a limited number of possibilities like these.

Whether we are talking primarily about technology or about institutional change, it is going to be increasingly difficult for AID to do anything substantial outside of the three areas of concentration specified in our legislation. You will recall that these are food and nutrition, population and health, and education. There is a clear move in this year's program to increase activity in those areas and reduce it in other fields, particularly

large capital projects. I venture to say that this trend will continue, with the added restriction that programs which have a very immediate impact on large numbers of poor people will be given priority. It seems to me, for example, that transportation and housing, the subjects on your agenda, may have some tough sledding.

Some aspects of science and technology will receive considerable attention. The need for research and development work on LDC fertilizer needs which Secretary Kissinger mentioned at the UN is an example. Fertilizer is, of course, an extraordinarily important commodity. The annual figure for world fertilizer expenditures is now $30 billion and a rapid rise is expected; although only $8 or $9 billion is spent by the developing countries. Yet in the United States, of fertilizer that is put on the ground, about 45% of the nitrogen and only 25% of the phosphorus show up as actual increased plant growth, suggesting that substantial increases in the efficiency of chemical fertilizers may be possible. The U.S. has proposed development of a fertilizer center which would concern itself with the range of questions involved in better utilization of chemical fertilizers. Eventually it may be part of a broader plant nutrition institute which would go beyond these questions and look at how nitrogen is fixed biologically; at the whole chemical and physical system of plants, soils, fertilizer and atmosphere; and perhaps also at the use of waste as a source of nitrogen. I would expect that as problems drop at us with the suddenness with which the fertilizer one has, other efforts of that kind will be mounted.

I think there are going to be many questions asked of the scientific community, including many that will be very difficult to answer. An example might be to tell us how to take weather into account in our planning for the next twenty years. I have a tentative answer to that one, which is that there is probably going to be more variation, and that means more bad weather, in the next two decades than there was in the last two. We do not know why, and asking that question usually starts a conversation that goes on for weeks. But, if weather is to be taken into account, and it

must be, it will be necessary to look back more than three decades into the past to estimate expected variations. I do not know how good an answer that is but I raise it to illustrate the kind of question that is likely to come up.

That kind of answer, of course, has significant implications for the size of food reserves the world needs to maintain. It has significant implications for how countries go about agricultural sector planning, and also for those who are engaged in trying to plan packages of technology that have low risk and hence can be adopted more easily by poor people.

I think you will also see AID trying to move a good deal faster to apply the results of its research and development activities to field programs. An example of the kind of think we are considering is the sorghum program. Perhaps some of you have noticed that scientists at Purdue University found some strains of sorghum in Ethiopia which have two or three times as much available protein as the normal varieties. A program is being designed to breed these characteristics into varieties which are also desirable for other reasons such as productivity and protection against pests. We are considering what might be done simultaneously to identify areas where such sorghums can be grown and to build the institutional structure that would be needed to support the new varieties, so that the normal gap between the time when an improved seed is available and the time when it is put into widespread use is substantially reduced. There may not be many other instances as dramatic as that one, or involving perhaps that degree of risk , but I think that in general AID will be trying to speed up the rather slow process of getting research results out into the field and into actual use.

Before I close there are two other points of a different kind that I would like to make. One is that there is going to be considerable discussion of, and possibly greater reliance on, the private sector. The private sector in our terminology, of course, includes universities, private voluntary organizations and co-ops and similar associations, as well as private business and industry. We have not really solved the problem of how to involve private

business and industry most effectively in development programs, but that one is clearly being set for us by the AID Administrator, Dan Parker.

The other point is the question of the transfer of technology to developing countries, including rich developing countries. I know that to many of you, as to some of us, the AID philosophy of "phase-out" has provoked frustration because it frequently means that a country stops getting U.S. aid just at the point where it can rapidly use increasing amounts of technology. As yet there has not been developed a satisfactory mechanism for insuring the continuity of support from the technical side, after the need for concessional financing ends. I am not suggesting that we are going to solve this problem quickly, because we do still live with the sense of impropriety about expending our resources on the "graduates", even though they may have many very poor people within them, when there are so many countries still sorely in need of concessional aid. On the other hand there are clearly going to be several so-called aid graduates in the near future--countries with which we have had long and successful AID relationships, and there are also the countries that are becoming oil rich and that clearly want to use our technology to a very large extent. The United States Government is going to have to organize itself to do a much better job in this area than it has in the past. There are a number of initiatives being taken. At the moment the Technical Assistance Bureau includes a small office that does provide American technical assistance on a reimbursable basis to countries which can afford to buy it, or which do not receive concessional aid. Whether it will be possible for AID to take the lead in this area of technology transfer, given the Congressional mandate to direct our attention to the poor, is an open question. We clearly have strong advantages in knowing something about the business, perhaps more about it than other parts of the United States Government. On the other hand, some of our strongest supporters feel it is not something AID should spend its time on. This is an issue to which we will be giving considerable thought and about

which we perhaps will be consulting with many of you in the future.

If there is any conclusion to this talk I guess it is that no matter how many important single purposes are put forward for an aid program, it seems to me that development assistance is going to remain multipurpose to the end and it would be unwise to think of it in any other fashion.

TECHNOLOGY UTILIZATION IN DEVELOPING COUNTRIES: AN ECONOMIC OVERVIEW

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I. Introduction

Opinions about the utilization of technology in the less developed countries of the world have changed a good deal in the past ten years and for the most part for the better. There has been a growing awareness that the issues are not narrow ones, that there are technological choices to be made and that the issues involved in the choice are neither narrowly technical nor obvious in their broad import for the path of development of any country.

In the past policy makers in developing countries have often acted as if they thought of technology utilization and the choice of appropriate technologies as matters about which, for the most part, only scientists and engineers had to be concerned. Such policy makers, if they thought about technological issues at all, frequently had relatively simple and direct ideas such as: "We don't want anything old-fashioned. We want the most modern technology." Or, in contrast, a Gandhian conception of technology has been held in some places and times, that has taken the form: "We want to preserve traditional handicrafts."

Development economists, when they have thought about technology, have usually tended to think in the relatively simplistic terms of conventional economic theory. This means that they have customarily assumed that everything which needed to be known about technology was already known to everyone. This is the assumption of "perfect information," commonly found in economic theorizing.

The conventional descriptions of technology by economists have been at two extremes. It has been assumed either that there is an infinite number of alternative ways of using productive factors - and everyone knew all about every one of them; or, it has been assumed that there was only one way of producing anything, and again, everyone knew it.

The assumption with which many engineers approached the issues of the choice of technology for developing countries has, perhaps, been equally simplistic. Specifically, a common, though not universal, attitude of engineers has been: "Leave it all to us. We know what the best practice is in the country in which we have been working. And that is also the best practice in whatever new country we happen to be in."

Scientists, when they have briefly considered technological questions, have often been as unrealistic as policy makers, economists and engineers. New, fundamental scientific discoveries have been announced as solving some major problems of economic development--when all that has been achieved is a successful laboratory experiment. And the painful processes of bridging the gap between laboratory and production have been impeded by being glossed over.

The increasing attention given in recent years to issues of technology utilization in developing countries has several intellectual sources. One continual source of attention might be called the "science fiction" paradigm. Scientific revolutions have been promised which would eliminate hunger--as in the Green Revolution--or solve all the energy problems or control population as with the development of the pill--or eliminate malnutrition with a concentrated pellet of fishmeal. This kind of thinking in development is usually pure escapism. The laws of thermodynamics promise us that we aren't going to get something for nothing. Yet it is reasonable to expect that there will be technical changes which

increase resource productivity. Those which utilize present basic knowledge are likely to be gradual; other changes may be true revolutions. Some advances, such as those of the Green Revolution, will relax the constraints of land availability but only by making greater demands for other resources, in this case, fertilizer and water.

Another, more profound intellectual source of the increased interest in technological choice and utilization is the growing awareness that some of the views which have been held by policy makers, economists and engineers have been naive. It would be nice to be able to report that the changes in intellectual outlook were the result of intellectual re-examination and analysis. But, to a considerable extent, it has been the pressure of events which is responsible. The economic development of the poor countries of the world over the last twenty-five years has, with some important exceptions, been quite remarkable. Nonetheless, it has not been as fast as projected, or as fast as necessary, or of a character to prevent the problems of open unemployment from increasing. Nor has development resulted in a better distribution of personal income. These shortfalls in the achievement of development goals have with some injustice--and some justice, perhaps--been blamed on "wrong" choices of technology. While it would undoubtedly be erroneous to "blame" technological choices for all development shortfalls, there is widespread belief, based on abundant evidence, that mistakes have been made. Unfortunately our knowledge is still so limited that it is not yet clear how better utilization of technology can make a difference in development problems. But simply identifying the critical issues more clearly creates a hope that they may be resolved in the future.

Three tasks will be taken up in this paper. First there will be a review of the range and economic impact of decisions about the choice of technology. Secondly the special features of the technological choice problem in the less developed countries will be identified somewhat more specifically. Much of this discussion will be treading old ground. However, in addition to reviewing some of the economics which has by now become commonplace, an argument will be made about optimal technical choices which is still not generally appreciated. Next, some comments will be made on current speculation about the possible discovery of more appropriate technologies for the less developed countries.

II. The Impact and Range of the Technological Utilization Decisions

The technological choices made in the developing countries regularly seem to have a dramatic quality which they do not have in advanced countries. That is rightly so for the effect of the choices <u>are</u> more dramatic--just as stone buildings stand out in a city of reed huts. The technologies introduced in developing countries are frequently profoundly different than those of the past. New products and new methods represent sharp technological breaks with traditional techniques and have profound and obvious social as well as economic consequences.

By comparison in the advanced countries most new technologies are marginal changes or changes of a well known kind introduced in societies much more accustomed to change. Even so it has been argued that the cultures and social structures of the advanced countries are not yet really adapted to the rapid and accelerating rate of change which technological advance is forcing on them. How much more shattering then is the impact of new technologies on the societies of the less developed countries in which change is still a novel experience in many sectors and areas.

Perhaps it is not necessary to emphasize the range of the technological choice and utilization issues. No single symposium can cover all the relevant topics. Various aspects of civil engineering predominate among the topics to be covered in this set of meetings. That is not unusual though it is unusual to have it so well represented. Food technology, one of the most commonplace of manufacturing processes, is a set of processes which have been among the most neglected. So its representation is unusual. Thus, the agenda of this symposium does suggest the great range of the technological choice issues.

Customarily, when technological utilization issues are considered, manufacturing processes come to mind most readily. One of the most common development ideologies has emphasized the importance of investing in heavy industry as the high road to development. Even if this approach is followed, it is appropriate to look for the technologies which are most appropriate to the countries' resources and objectives.

Another development policy theme which has been a guideline for many countries has been import substitution. This has led to a concentration of investment in consumer goods industries in order to displace foreign goods with domestic production.

Agriculture is now recognized to be one of the most significant sectors in the development process. By comparison, not too many years ago it was common to think of agriculture as the residual sector, supplying foods and fibres and labor and changing slowly, if at all, under the secondary impact of changes elsewhere. After famines and food shortages have made the point dramatically, there is a new appreciation of the central role of agricultural development in overall development in most countries. The Green Revolution was often promoted as as set of scientific and technological miracles which would eliminate food shortages in many areas and make it possible to concentrate

again on industrial development. It hasn't worked out that way, so far at least, and food shortages and famine scares have a new urgency. This certainly does not mean that it is necessary to rely on traditional agriculture. Rather it exemplifies the importance of careful assessments of the costs and potential of new technologies.

In all the manufacturing sectors there are recurring controversies over appropriate technologies. Every two or three years someone discovers used machinery and there is a spate of speculation about the potentiality of development by its intensive use--as if all less developed countries could industrialize on that basis. And, as regularly, someone will recommend the production and use of new equipment but with the designs of twenty, fifty or a hundred years ago because they would be more "appropriate." Perhaps these suggestions should be taken seriously. Perhaps they would provide a better utilization of technology then is currently achieved. Yet, to my knowledge, there has seldom, if ever, been any intense study of such alternatives in the manufacturing sector though there are strong opinions.

The technological utilization issues are naturally thought of in connection with civil engineering projects such as transport, in power generation and in agriculture and manufacturing, though they are certainly not confined to these areas. Health services, communications, education and information processing, for example, absorb substantial amounts of investment resources in developing areas. Clearly there are many alternative technologies in use in these sectors; often sharply contrasting ones exist side by side. We do not know the characteristics of the alternatives in any detail and do not understand well the implications for efficiency and growth of what we do know.

III. The Special Problems in the Choice of Technology in Less Developed Countries

Every country has a wide range of technical choices to make. The special problems of the less developed countries in making these choices arise from the characteristics of the resources which are available to them and the nature of their objectives. In order to clarify these problems it is necessary to do a little economic analysis. However, the little economics which is necessary is almost intuitively obvious so that it should not be an obstacle to progress.

Two important factual observations are required. One, the types of resources which are available in the less developed countries are typically somewhat different from those available in the more advanced countries. Second, making rough comparisons among resources, it is typically found that the proportions in which they are available are quite different in the less developed as compared to the advanced countries. These simple facts are profound ones in their significance for the choice of technology in those countries and deserve a brief elaboration.

The different resources of the less developed countries are, in part, those which have to do with their special geography and geology. The less developed countries are sometimes tropical, which is not the case for many of the relatively advanced countries. Often the arable land is a small part of the total land area. Rainfall may be relatively sparse. In some countries of Africa there are insect infestations which limit the herding and use of animals. They may have tropical forests but not hardwoods, copper but not oil, and so on.

In addition to differences in the kind and quality of the resources, there are great differences in relative availability of productive resources in the less developed countries. In some countries, typically those of Asia, there are relatively high population densities on agricultural land, sometimes approaching the population densities in some cities in the U.S. In others

of the less developed countries, especially those in Latin America and Africa, the agricultural population densities are not so great. In all of the less developed countries one notices, relatively speaking,much less capitol equipment being used in a wide range of types of production. This relative capital scarcity is observed in agriculture where one also finds less of fertilizers and pesticides employed. But relative capital scarcity is characteristic of the industrial sectors and transport and other services as well. It should be emphasized that, in the sense used here, "capital" scarcity means scarcity of real productive equipment--tools, machinery and plants and buildings.

Capital scarcity is one of the dominating features of the less developed countries and, therefore, it must be one of the dominating concerns of anybody concerned with them. This capital scarcity is so great a problem that it can dominate the choice of technology issues and sometimes influence them in ways that are somewhat unexpected.

After reviewing briefly these stark facts of poverty as related to technical choice, it should be emphasized that the developing countries are not identical. The differences between the "typical country" characteristics in Asia, Latin America and Africa are obviously profound ones. Yet, it takes only a slight familiarity with the circumstances to recognize that there is hardly a single "typical" feature of all the countries on any of the continents--except perhaps their differences from the more developed countries of Europe and North America.

What are the implications for technological choice of the differences in relative factor availability? How should these choices be made in order to do as well as possible in terms of each country's development? To a good first approximation the rule to follow in making technological choices is to design technologies or to choose technologies so that, on the margin,

the contribution of capital and labor and every other productive resource is each equalized in each of its uses. The definition of "appropriate technologies for development" is that they are technologies which equalize the productivity of capital, on the margin, in every use of capital. They also equalize the productivity of land, on the margin, in every use of land and equalize the productivity of labor, on the margin, in every use of labor.

What is meant by equalizing on the margin? Imagine a function which expresses outputs in terms of inputs. Now differentiate this function with respect to each one of the resource inputs. Set each differential equal to zero and you get a set of expressions each of which says that, for each input, the derivatives of output with respect to that input must be equal. That is the meaning of equalizing, "on the margin." The rule is not too easy to express in words but it is an obvious one mathematically.

If there are any doubts about the rule, consider the consequences of violating it. Would it make sense to use a great deal of capital equipment in one line of production, so that an additional piece of capital equipment would hardly pay for itself, and at the same time, use very little capital equipment in another type of production where its return is high. Should some sectors be inundated with capital while other sectors are starved? It is almost a matter of common sense not to have such an imbalance. If there were such, it would be clear that outputs could be increased by redistributing the capital more equally among sectors. Just keep shifting capital until a shift in every direction would have the same potential pay-off and that would mean equalizing returns on the margin. That's the rule for making optimal technological choices. If that rule is applied then the resulting resource combinations which define technologies are the ones which are most appropriate for development in the sense that output and income would be maximized with the available resources.

If this little bit of economics is combined with the previous factual descriptions of the less developed countries, a clearer picture is obtained of the problems of adapting to less developed countries the technologies created in the advanced countries. Suppose technological choices are being made in more or less optimal ways in advanced countries. That implies that in the advanced countries the technologies being designed and being adopted are those which combine productive resources in proportions which are suitable for the proportions in which productive resources are available in advanced countries. Yet less developed countries not only have different types of resources but have resources available in different proportions. And that means that the technologies which are best for the less developed countries are different from those which are best in advanced countries.

The argument can be taken one step beyond the first approximation. Under some circumstances the technology which is most appropriate for long term growth is not the technology which maximizes current output. This argument can be made plausible in the following manner. Remember that in many of the less developed countries one of the greatest problems is that of capital scarcity. In order to remedy this problem it is necessary to accumulate capital. To do that requires domestic savings or foreign capital or both. Suppose, following the previous argument, it is proposed to adopt for a particular kind of production process a technology which is very labor intensive in a country which seems to have a lot of labor. To go to an extreme, suppose it is possible to find a technology which uses only labor. In that case the income which is generated by the project would be labor income plus some profits, which can be assumed for the moment to be negligible. Suppose also that all the labor income is consumed. Then the project would add to

current consumption but would add nothing to savings. Therefore, the project would contribute nothing toward solving the development problem of capital scarcity. It has added to current output and current consumption and that is worthwhile. But it hasn't added to savings, and, thus, it hasn't added to investment at all. So, if the object is to maximize growth, the use of a very labor intensive technology, which does not indirectly generate saving is a mistake. In this case the appropriate technology may be more capital intensive, yielding a greater share of income to capital and profits--either private or government--and more saving. However, if the objective is a mixture of future growth and current consumption, it is possible that a still more appropriate technology would have been a technology which would have generated somewhat lesser savings and also some more current consumption.

The moral of the story is that in choosing the best technology, there are not likely to be any simple rules which can be followed. It is true that labor abundant countries should push in the direction of labor intensive technology. Yet the "most appropriate" technology depends both on the resources available <u>and</u> the goals of development. Unfortunately, life is complicated. In essence it is necessary to do a cost-benefit analysis for each possible kind of technology. The cost-benefit analysis must specify clearly what the goals of the project are. If the over-riding goal is employment, that will lead in one direction. If the goals are current consumption, that might lead in another direction. If the objective is to increase savings in order to increase investment, that might well lead in quite a different direction.

IV. The Prospects for the Development of More Appropriate Technologies

The next step is to turn away from painful economics and to consider the current concern for technological utilization and the science utilization in developing countries. It is such a popular subject now that it is worrisome. Its popularity is indicated by this kind of symposium. The OECD is also concentrating on this subject. The National Academy of Sciences has a committee on appropriate technology. And various development centers in this country are investigating it. All this attention is a little worrisome in part because the development field is so susceptible to fads and fashion.

At the beginnings of the general concern with helping the poor nations of the world to improve their conditions, the first development policy was technical assistance, Point Four of President Truman's 1948 presidential inaugural address. This might be called the "cheap tricks" era of development policy. The popular conception was one in which the United States was to send some American agronomists and engineers to the less developed countries. These technicians, with their superior knowledge, would correct the mistakes being made as the result of ignorance and tradition. They would plant the seeds an inch deeper or an inch higher, and harvest a day earlier or a day later, and drop the nets into the sea ten feet deeper or five feet higher and speed up or slow down the machines. And this type of advice based on superior technical "know-how" was expected to solve most of the problems of development. Well, it didn't work, of course. There are very few such easy tricks in the world.

From the "cheap tricks" stage we went to the capital assistance era. That was the period in which the development policy emphasis was on providing more capital. Perhaps it didn't matter too much how that capital was used; plans could be made to direct its overall allocation among sectors. As for technical choice issues, presumably the engineers were taking care of that. Well, great things were accomplished but not all the problems were resolved and some appear to have been aggravated.

We have gone through several other fads and fashions. There have been technological change and education fashions which are still popular. This is the "population year" and the "nutrition year"--the new fashions.

Is the concern with appropriate technologies and science in the developing countries going to be just one more fad and fashion. To a very considerable extent, as mentioned above, it has been generated by some of the failures which have been observed in the development experience of the less developed countries, in particular the increasing unemployment which has often emerged. The blame for this increasing unemployment has usually been put on technology. It has been argued that the wrong kind of technological choices have been made; "inappropriate" technologies have been used. The blame for these wrong choices of technology have been ascribed to various sources; conspiracy on the part of the multi-national corporations, an endemic problem of capitalism, or simply myopia on the part of the engineers who are designing projects. A number of obvious solutions have been proposed.

Are there appropriate technologies, more appropriate technologies, than those which have been used in the developing countries? If they are there, where have they been hiding? Certainly some people have been looking for them. Maybe they haven't looked for them hard enough or in the right places. Or, perhaps, the wrong technologies have been used deliberately. Yet, before jumping to these conclusions, it should be noted that there are often good reasons for using technologies which appear, at first glance, to be quite inappropriate. For example, a United States' steel engineer evaluating the technology used in a Russian steel plant in India once commented that it looked rather old-fashioned. He claimed it was a technology which had been developed in the United States in the 1920's and sent to the Soviet Union in a plant which was put up in the Soviet Union by the U.S. engineers at that time. According to the U.S. engineer, it has been built over and over again in the Soviet Union so all the "bugs" had been eliminated. The U.S. engineer said he wouldn't design an old-fashioned plant like that.

However, there's something to be said for a plant in which all the technical problems have been resolved. Such a plant can usually come into production quickly. By comparison, the plant which the United States engineers were designing had a new technology, perhaps even a capital-saving technology. But it was a technology which would have required the solution of new problems to achieve capacity operation. That would usually involve delays and delay in achieving operation at full capacity is itself a heavy cost. This story doesn't prove anything but it does indicate again some difficulties in deciding on what is "appropriate."

Old technologies are not always more relevant to the less developed countries than new technologies as has often been argued. The usual reasoning is that the old technologies had been developed in a time when labor was more abundant and capital was more scarce. And these conditions, characteristic of the advanced countries twenty, fifty, a hundred years ago, are more comparable to the characteristics of the less developed countries today than are new technological developments. These, it has been argued, have been primarily labor-saving.

However, this argument must be examined carefully and careful comparisons must be made with measurements rather than assumed. In general technological change seems not to have been characterized by simple labor-saving development. The measurement of the characteristics of technological change is a difficult undertaking, but to the extent that some results have been achieved at all, technical change appears to have been as capital-saving as it has been labor-saving. That is, technological change seems to have occurred in a way which has reduced requirements for both labor and capital. A technical change which does that is as appropriate for a less developed country as it is for an advanced country. If technical change has been both labor-saving and capital-saving, then old technologies are not more "appropriate" for less developed countries than new technologies. The new technologies which are neutral in their saving on resource inputs are superior on all counts to old technologies.

An implication of the argument that there should be a concerted search for technologies more appropriate to the less developed countries is that nature is malleable. It has been assumed that, if it is desired to move in the direction of technologies which are more appropriate for the developing countries than those which are used in the advanced countries,

then it is possible to do so. However, the assumption may not be warranted. It is conceivable that nature is not so malleable. There is no guarantee that nature is symmetric in this particular respect and that it always will be possible to find new, efficient labor-saving methods. There may turn out to be a bias in nature against more labor intensive technologies. Perhaps there won't be any wonderful new ways of producing steel or textiles, etc., which are labor-saving as compared to those which are now available.

Another possibility--and an interesting hypothesis--is that in order to find more appropriate technologies for the less developed countries it will be necessary to make new product designs. New types of products may have to be created to perform the same functions as old products. For example, it is difficult to imagine an efficient but highly labor intensive way of rolling sheet steel. But, perhaps, it might be possible to redesign some sheet steel products in order to use a cast steel and labor intensive foundry method in place of forging and stamping methods. Recently Professor Fred Moavenzadeh of M.I.T. has emphasized the possibility of adopting more appropriate road construction technologies by redesigning the kinds of highways which are built in less developed countries.

There are many things to do and one can't really get very far by speculating on what might be. In order to make progress in finding or creating more appropriate technologies for developing countries it is necessary to do careful research. That research must start with science and engineering. However, it must be emphasized that the generation of technical alternatives is only the beginning. It is also absolutely essential to investigate the economics of implementing alternative techniques and the other social consequences as well.

SUMMARIES OF PAPERS

Volume 2: Housing, Transportation and Water Resources

"Incremental Infrastructure", Richard Bender

Incremental construction is identified as a major tool in the attack on the world housing problem. This technique takes a variety of forms: self-help, mutual aid, and the work of small construction organizations. They use industrially produced tools and materials but are not centralized or industrialized methods. While three techniques have proven effective in the production of dwellings, their use has been restricted by the lack of parallel technologies for infrastructure: incremental service and support systems.

This paper sketches the background of this problem. It then looks at the forces behind recent technological developments, suggests alternate directions and strategies which can be used to achieve them. Centralized and linear forms are contrasted with others which are dispersed and incremental. Capital intensive and labor intensive technologies are explored and examples of water, waste-water, and energy systems are illustrated. The use of "Trickle-Down" and "Direct Action" are discussed as is the relationship between this problem as it appears in developing and developed economies.

"Self-Help Infrastructure: Applications of irregular, small-scale, incremental systems for residential utilities", I. Donald Terner, Anne Aylward, Byung-Ho Oh, and Abby Rashid.

Millions of residents of the rapidly growing urban areas of developing countries live without adequate water and sanitary services. The rates of disease and death among such households are staggering and the ability of the residents to contribute

productively to the society and economy of which they are a part is substantially reduced by the conditions under which they live. It is estimated that 65% of the urban population of developing countries do not receive piped water in their homes; that about 41% have no access to piped water at all with reasonable distances. An even greater percentage are receiving inadequate waste disposal service. Among the residents of the rapidly expanding areas of spontaneous settlement--commonly known as squatter settlements--the percentage of households receiving water and sanitary service is far lower.

As the cities continue to grow the environmental conditions of their residential areas will continue to worsen. The reversal of this trend must be considered a national and international priority if the residents of these areas are to be able to participate fully and productively in society and in the national economy and if the high level of disease and death among this population is to be reduced.

The limited resources directed toward improving squatter conditions have been used nearly exclusively for the construction of housing. It is increasingly clear that the creation of dwelling units is not a serious technical problem. An energetic and determined population has creatively adapted traditional homebuilding techniques to the demands and materials of the urban environment--houses do get built. But in almost all cases this production is constrained and the finished dwelling threatened by an inability to provide an adequate level of urban infrastructure. All too often, these houses are built in areas deprived of the most basic urban services.

The provision of urban infrastructure has been assumed to be the responsibility of large collectivities--municipal, regional, or national governments or quasi public bodies established by these governments. These large collectivities have failed at a massive scale to provide adquate service for urban residents. This failure has been particularly

acute in the case of the poorest urban households; policies have shown a systematic bias against the millions of inhabitants of spontaneously settled squatter areas.

The complexity of conventional water/waste system technology has defied the attempts of individual household and communities to provide service for themselves. Although squatters have successfully provided a variety of other community services and facilities for themselves, successful efforts to install water and waste systems have been infrequent.

Traditional responses to this problem, ranging from the elimination of squatters to decentralized response by individual households are described in this paper. Practical arguments are presented for and against implementing self-help schemes, including a discussion of the diseconomies of scale inherent in the conventional technology. The policy implications of self-help are discussed and a range of elements which must be considered in technology choice are presented.

The conclusion drawn from these arguments is that action in the provision of water and waste services must include a broad range of solutions. The lack of activity, both government-initiated and self-help, in the past has been in part the result of the demands of the conventional technology. This paper suggests that it is appropriate and necessary to develop a range of decentralized solutions to the infrastructure needs of the rapidly growing urban areas of developing countries. Given the situation of government default it is particularly important to focus on systems which can be iniciated, installed and maintained by an individual household or community with minimal external support.

"Roads and highway transportation in developing countries," L. Odier.

The aim of this paper is to draw attention to the special aspects of highway transportation problems in developing countries as compared with industrialized nations. Statistics for 20 countries substantiate

the comparisons. Factors affecting the design and construction of highways in developing countries which lead to solutions substantially different to those of industrialized nations are: traffic composition (private car/truck), traffic density, climate, materials availability and lack of money. Consideration is gven to the organization of transportation and the economic effect of government regulations. The economic roles of various classes of roads are described; benefits available from highway improvement include reduced operating costs and creation of production capacity through opening up previously inaccessible regions. Non-economic effects are noted. The need to integrate highway construction plans with other projects in a development plan is emphasized.

"Urban Transportation problems in developing countries: The role of technology", George W. Wilson

Based on seven propositions as to probable future trends in urbanization and transportation in developing countries, the response of local and national governments to the growing urban transportation problems is hypothesized, starting with a request for a large scale study by a foreign consulting firm and ending with non-implementation of its conclusions. The consequences of such inaction are sketched. Automotive and transit technology will not greatly improve the situation, the most effective approaches being non-technical in nature. A list of ten possible organizational modifications is presented and the likelihood of their implementation is discussed.

"Comments on the transportation papers", Louis Berger

The costly nature of developed country approaches to the urban transportation problem, as compared to the incomes of people in the less developed nations is emphasized. Feeder road construction in rural areas is an important area which would benefit from research leading to low cost methods of protecting dirt roads against the weather. The costs and benefits of driving low volume dirt roads into isolated areas are discussed in connection with Brazil's Transamazonas and North Perimetral roads.

"Technology utilization in water resource development and management", Ian Burton.

The technology that has been successful in providing safe, low cost and abundant water in developed countries has not been transferred to developing countries with the same degree of success. In these countries only 70% of the urban population and 12% of the rural population are adequately served with safe water; WHO plans for the period 1970-1980 aim at doubling this latter percentage. Although lack of sufficient funds to implement the necessary improvements is often cited as a major obstacle to more rapid progress, this view is predicated on the use of costly conventional technology. However, tight budgets often prevent experimentation with new ideas. Criteria for the selection of appropriate technology are developed, concentrating on incremental improvements that can be organized and executed at the community level. R & D activities on developing such technology should be carried out in the developing countries, possibly in institutions modeled on the existing International Agricultural Research and Training Centers.

Other water resource areas touched upon are irrigation and flood control.

"Evolution of modeling in water resources planning", Frank E. Perkins.

Three issues concerning the use of mathematical models embodying multi-objective investment criteria in water resources planning are discussed: the historical evolution of the use of such models; their proper role in water resources planning; and their relevance to the concerns of less developed countries. The historical aspects of modeling are viewed in terms of methodology, problems modeled and the role and acceptance of models. The value of mathematical models

lies in their ability to force the planner to ask the relevant questions and seek the quantitative information they provide for use in the decision-making process. However, models are not replacements for human skills and experience is required in selecting and applying a model to a particular situation.

The complexity of problems facing the developing countries, the desire of these countries to attain technical parity with developed nations, and continued U.S. export of water resources planning technology will probably lead to increased use of mathematical models in developing nations. Two pitfalls endangering this approach are defined: The misallocation of limited human resources for planning and the use of models to legitimize rather than analyze proposed courses of action.

Volume 3: Construction

"The Construction Industry in the Developing Countries", Fred Moavenzadeh

The construction industry is responsible for the generation of constructed physical facilities which play a critical and highly visible role in the process of development in many regions of the world. Its output constitutes a major fraction of GDP, and it employs between 5 and 15% of the labor force in most developing nations.

In most developing countries, the government is the largest client of the industry, in addition to being its regulator and material supplier. The labor-intensive nature of the construction industry coupled with the fact that most developing countries have some indigenous industry in this area makes the construction industry an attractive area for creation of jobs, conservation of foreign currency, and a training medium for transformation from agricultural-based employment to that of manufacturing.

The possibility of introducing a various mix of labor and capital technologies and the use of staging strategies in major public work construction offer an excellent opportunity for transfer and adaptation of technology.

Volume 4: Food Technology

"Some reflections on conditions of transfer of modern food technologies", Aaron M. Altschul.

The problem considered is that of at least maintaining the protein content of diets under conditions of expanding population. Three food and nutrition models are presented all of which reduce or eliminate the need for animal protein in a diet, and their application to a country in danger of famine and country experiencing economic progress is discussed. The chances for a successful transfer of food technology being greater in the latter situation. The education of leaders in the opportunities offered by new technologies is critical in this transfer, as are the attitudes of those in affluent countries towards the foods they produce.

"Production of food and feed by fermentation", Arthur E. Humphrey.

Single cell protein (SCP) is an important new source of food and feed protein that does not depend on agricultural and climatic conditions and grows quickly compared to more conventional sources of protein, animal and vegetable. A variety of substrates can be used for SCP production and the possibility of using agricultural by-products for this purpose makes them attractive to developing countries. Present uncertain conditions in world food markets inhibit the formulation of generalizations on the economic feasibility of the various SCP production processes. Processes that are viable on a commercial scale are described, including the use of oil, city refuse and agricultural wastes. Village level technology is in the developmental stage and has yet to be proven against the economies of scale available in large plants. Consumer acceptance of SCP is being studied and the problems appear to have solutions.

"Food technology and food fabrication", ChoKyun Rha.

Adequate food supply is unquestionably the most urgent problem facing low income developing countries. The fundamental solution to this crucial problem lies not in the temporary distribution of agricultural commodities, but rather transfer of essential technology, properly modified and adapted, for these nations.

First, it is necessary to determine and have a detailed analysis and definition of the "foods" that are needed for the target group. This must consider not only nutritional but all other qualities related to food including form, flavor, taste and textural qualities, and other factors relating to custom, habit, and emotion.

For raw material, indigenous resources available should be utilized whenever possible. These may be underutilized and/or unconventional sources readily available such as oil meal, gluten by-product from starch processing or zooplankton. The raw material resources should be studied for their long term availability and nutritional, functional and other acceptibility characteristics. Based on this study, the most desirable material for the "food" production should be selected.

Using the selected raw material as a basic or major ingredient, "food" may be structured into a desirable form by fabrication. Modification and adaptation of existing fabrication technology such as emulsification, thermosetting, extrusion and spinning can be accomplished effectively if sufficient understanding of the physical properties of the raw materials is attained. Careful selection of the optimum processing method and parameters is worthwhile since it would decrease the cost and increase the acceptability of the product.

Note: This paper was not available at the time the proceedings were sent to the printer.

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