SCIENCE AND TECHNOLOGY

IN

WORLD BANK OPERATIONS

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TECHNOLOGY AND SCIENCE IN WORLD BANK OPERATIONS

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FOREWORD

Because science and technology have important consequences for economic development, the World Bank is helping its developing member countries increase their technological capabilities and is supporting a variety of technological innovations. It is also developing new approaches to national technology policy and advising governments on sectoral technology policy. In the generation and design of projects financed by the Bank, the Bank helps borrowers consider alternative technologies and select those most suitable to local conditions. Science and technology are thus integral parts of World Bank operations.

The Bank intends to expand and strengthen its scientific and technological activities in the future. As a prelude to that process, it has sought to document its past and present activities. We believe that this report, which is a result of that effort, may be of interest outside the Bank.

The report describes a broad range of technological issues. It discusses these first generally and then sector-by-sector to permit selective reading by people interested only in one sector. Inquiries about the report should be addressed to Mr. Charles Weiss, Jr., Science and Technology Adviser.

Warren C. Baum
Vice President, Projects Staff
This report describes the science and technology components of World Bank operations. It was prepared as part of the documentation for the Bank's contribution to the United Nations Conference on Science and Technology for Development (UNCSTED) held in Vienna, Austria, during August 1979. It is also intended to serve the broad purposes of (a) informing both generalists and specialists about the workings of a multilateral lending institution from the point of view of technology and (b) providing a factual basis for those interested in policies and programs related to applying science and technology to meet development objectives. The data and other information in this report are current through June 1979, unless otherwise indicated.

The report was prepared by Paul S. Shapiro of the Bank's Science and Technology Unit. General guidance was provided by Charles Weiss, Jr., Science and Technology Adviser to the Bank. The cooperation and assistance of the sectoral department heads of the Central Projects Staff and of the various members of the CPS Projects Advisory Staff were essential to its preparation. Specific acknowledgments of major contributions by them and other individuals for each sector are made at the beginning of the pertinent chapter. The contributions of dozens of other people—from the Bank's regional operations departments, Development Policy Staff, and Operations Evaluation Department and from the International Finance Corporation—are also gratefully acknowledged. Editorial assistance for some chapters was provided by D.W. Gottlieb and Associates. Helpful comments were provided by Herman G. van der Tak and V. Rajagopalan.
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<td>IDF</td>
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<td>PHN</td>
<td>Population, Health and Nutrition Department</td>
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<td>STU</td>
<td>Science and Technology Unit</td>
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<td>Transportation, Water and Telecommunications Department</td>
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ACKNOWLEDGEMENTS

This introduction was prepared by Paul S. Shapiro and Charles Weiss, Jr. Contributions were made by Warren C. Baum.
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INTRODUCTION

I. Overview

The International Bank for Reconstruction and Development (IBRD), generally known as the World Bank, is among other things an agent of technological development in the developing countries. 1/

The primary function of the Bank is to promote the economic growth and productivity of developing countries; it does this by financing investment projects of high priority. The focus on investment gives the Bank important strengths in dealing with science and technology. It has ready access to policy-makers and maintains a continuing dialogue with them on a variety of development issues. Its experienced, multidisciplinary staff works on projects in all parts of the world and can bring to bear on any one project relevant experiences gained in other countries. The focus on projects reinforces a strong orientation toward practical results and facilitates and encourages the integration of technology with all other aspects of a development project. That focus also enables the Bank to deal with all stages of innovation: from the identification of a need through research, development, and pilot implementation of a new idea to full-scale implementation. Moreover, the Bank's practice of investing only in projects of high development priority means that Bank-financed projects provide an opportunity for local technologists to be directly involved in the mainstream of economic activity, rather than be "on the outside looking in," as too often is the case.

The Bank has four basic technological objectives:

(1) To ensure that the most appropriate technologies are used in the projects it finances. These technologies must be appropriate to the objectives of the project; to the broader development objectives and aspirations of the country; to the local social, cultural, economic, and environmental situation; to available local raw and semi-finished materials; to the local and grass-roots capacity to plan, operate, and manage; and, if this is a principal project objective, to creating opportunities for productive employment and to alleviating poverty. The appropriateness of technology to specific factor endowments and local conditions will ensure efficiency in the allocation of resources.

(2) To promote the development of technological capacity in developing countries. That capacity is defined as the capacity to plan, assess, choose, acquire, adapt, implement, manage, operate, and generate technology. It requires a pool of

1/ The terms "World Bank" and "Bank," as used in this report, refer to the IBRD and the International Development Association (IDA). The term "World Bank Group," used in Chapter 10, also includes the International Finance Corporation (IFC). IDA and IFC are affiliates of the IBRD; IDA has the same staff as the IBRD, while IFC is separately organized.
trained individuals. It includes a capacity for training, engineering, pre-investment studies, sector planning, and scientific and technological research. It implies the integration of research efforts with production and policy-making and the focusing of that research on the problems of poverty and the need for productive employment. The development of this capacity will foster the operational efficiency of production units.

(3) To promote the generation, diffusion, and application of innovative technologies needed to solve development problems, especially those of the poor.

(4) To promote the adoption by developing countries of national policies that can foster local technological capacity and lead to the use of technologies suited to local conditions, especially to the needs of the poor.

The Bank is in a position to render a substantial service to developing countries in working to achieve these four objectives.

II. The Lending Program of the World Bank

In fiscal year (FY) 1979 the IBRD and IDA made 142 loans and 105 credits totaling US$10.0 billion to governments, public enterprises, or private enterprises with government guarantees; of this total, the International Development Association extended credits amounting to US$3.0 billion. 2/ The assistance represented about 35 percent of the total project costs. These costs include contributions by co-financiers and the borrowing entities. The International Finance Corporation made 48 investments in private enterprises in developing countries. Those investments, in the form of equity or loans, amounted to US$425 million. The IFC does not require government guarantees.

Goods and works financed by the Bank are normally procured through international competitive bidding, open to suppliers and contractors in all of the Bank’s member countries (plus Switzerland). Locally manufactured goods are allowed a 15 percent margin of preference or the applicable tariff, whichever is less. Local contractors in poorer countries are allowed a 7.5 percent margin of preference. Consulting services are subject to a different set of policies, which explicitly encourage the development of local capacity. These are discussed below.

2/ The Bank Group’s fiscal year runs from July 1 to June 30. IDA charges no interest, only a 3/4 percent annual service charge. Its credits are repayable over fifty years after ten years of grace. In the text that follows, the term "Bank lending" refers to IBRD loans and IDA credits, unless otherwise noted.
In addition to finance, the Bank offers borrowers disinterested technical advice from its experienced professional staff. This assistance—the bulk of which comes during the conception, preparation, and implementation of projects—is a regular part of the professional work of the Bank's staff. Although most of the technology financed by the Bank is not proprietary, the Bank assists its borrowers in negotiating equitable terms for the purchase or licensing of technology. This activity will increase as the Bank becomes more active in petroleum lending, a sector in which proprietary technology plays a major role.

The Bank has close working relationships with other organizations of the United Nations system. It has entered into formal cooperative agreements with FAO, UNESCO, WHO, and UNIDO, agreements under which the partner agency helps to identify and prepare projects in fields of its specialization for ultimate Bank financing. The Bank works on an ad hoc basis with other multilateral organizations: for example, UNICEF in education and water supply and ILO on technological education and labor-intensive technology.

Until the early 1970s, the Bank's principal concern was with the rate of economic growth, rather than the extent to which the poor share in such growth. That approach has been replaced by a more balanced strategy that combines accelerated growth with a direct attack on poverty through programs to raise the productivity and living standards of the poor.

Accordingly, the emphasis of Bank lending has increasingly been on the development of the poor and least-developed countries in Asia, Africa, and Latin America. Sectoral emphasis is shifting from industry and basic infrastructure to a more comprehensive program aimed at growth, the provision of basic services, and a better distribution of income. Although infrastructure continues to be important, lending has been introduced or greatly expanded for education, nutrition, population, agriculture and rural development, urban sites and services, and water supply and sanitation. Even in the sectors of traditional emphasis, a similar evolution can be traced: power projects now are more concerned with environmental issues and a structure of tariffs that promotes economical use and mass consumption; road projects with the need for feeder roads to open up new areas, adequate systems of maintenance, and appropriate technology for construction; development finance companies with lending for small-scale enterprises. Greater attention in project design in all sectors is given to employment, income distribution, environmental impact, training local personnel, developing local resources and institutions, and overcoming social and cultural constraints.

At the risk of oversimplification, a comparison of a "typical" loan of the 1950s with a "typical" loan of the mid-1970s illustrates this evolution. The loan of the 1950s would have been for power generation in a middle-income developing country. In a sense, it would be an "enclave" project, using proven large-scale technology designed and supervised by foreign consultants, executed by foreign contractors and suppliers, and managed with the help of expatriates. The technical and financial viability
of the project would have been analyzed, as would its organization and management, but little attention would have been paid to its setting within the energy sector, to the ways of distributing power, or to the impact of the level and structure of tariffs on electricity consumption.

The loan of the 1970s would be for rural development in a low-income developing country. It would provide an integrated package of goods and services to raise the productivity and living standards of the farmers—a package of extension, credit, marketing, storage, infrastructure, and research. Local institutions would be strengthened or established. Local staff would be used as much as possible, with the help of extensive training programs. Low-cost design and appropriate technology would be emphasized, giving greater opportunities for local contractors and sources of supply. A built-in system of monitoring and evaluation would help to adjust the project as it went forward and to draw lessons for future projects. In addition, attention would be paid to cost recovery from the beneficiaries so that the project would be replicable.

III. Using the Most Appropriate Technology in Projects

A. Requirements for the Selection and Introduction of Technology

Most of the scientific and technological activities covered in this report—the support of agricultural and industrial research and extension, the research on appropriate technology, the testing and large-scale implementation of innovative technology, and the assistance to the consulting industry—have been undertaken since 1970 in response to problems and opportunities in specific countries or sectors, especially those arising from the Bank's efforts to help the poor. This pragmatic approach has had the advantage of ensuring that the technological activities supported by the Bank are linked to practical needs and integrated with the mainstream of production in developing countries.

A critical factor in such linkage and integration is the capacity of local people and institutions: the capacity to define objectives, to plan and analyze alternative approaches, to implement policies and projects, to mobilize suitable technology from whatever source in order to reach their goals, and to set in motion the processes of evaluating past experience, of research and training, of education, and of institution building so that future needs will be foreseen and met.

Because of its policy commitment to devote a substantial portion of its lending to projects that directly benefit the poorest people in developing countries, the Bank tries to ensure that if a technology is chosen from among those used to solve a particular problem in the developed countries, it is not overly expensive or otherwise unsuited to solving the same type of problem in a developing country.
The crux of the Bank's recent focus on poverty has been the design of projects that increase the productivity and the income of the poor and provide them with essential services. These projects must be replicable: that is, they must be sufficiently simple administratively and sufficiently inexpensive or self-financing to be reproduced elsewhere. This requirement leads directly to the need for technologies that use little capital and scarce skills and that make full use of abundant labor. The Bank, therefore, has pioneered in the large-scale application of low-cost technologies, such as the sites and services approach to minimum housing, and has carried out techno-economic and engineering studies in such fields as low-cost sanitation and labor-intensive construction of civil works.

B. Techniques and Criteria of Project Preparation and Appraisal

The Bank's techniques for preparing and appraising projects are intended to ensure that the technology used is tailored to the social, economic, cultural, and environmental needs of a specific situation. Project preparation is the responsibility of the borrower. It involves feasibility studies of alternatives, comparisons of their respective costs and benefits, and detailed investigations of the more promising alternatives to reach the most satisfactory solution. What is needed is not necessarily the most advanced technological solution, but the solution most appropriate to the country's endowment of resources and stage of development. Innovative technologies new to an area may be given pilot tests before being applied on a large scale.

Preparation of a project for World Bank financing must incorporate consideration of the full range of technical, economic, financial, and institutional conditions necessary to achieve the project's objectives. For example, a resettlement project might require studies based on remote-sensing data to identify arable land, transport corridors, and the population in the area proposed for resettlement. Verification on the ground would be followed by more detailed investigation of soils and water resources; by determination of the appropriate cropping pattern on the basis of available resources and research; by selection of the technical package necessary for increasing crop yields; and by economic and sociological studies of the people being settled to determine appropriate systems of land tenure, extension services, marketing, project management, and other institutional arrangements. Government policies with respect to the cost of inputs and the price of farm products would be studied, as would the level and methods of cost recovery and their effect on the financial position of the beneficiaries, the project entity, and the government.

As an example of such policy changes, the Bank urges its borrowers to adopt design standards that will permit the use of capital-saving technologies when they are appropriate, especially in such sectors as housing, education, transportation, and water supply. In some of these sectors,
however, many countries tend to overemphasize capital works and neglect maintenance. This leads to the adoption of high engineering standards, which militate against the use of labor-intensive technology during construction and maintenance. The Bank discourages such practices.

Once the proposed project has taken shape and studies are completed, the project is appraised. An appraisal is as close to an overall assessment of the impact of the proposed project (including an assessment of the impact of the technology) as the state of the art and the rather stringent constraints of staff and time will allow. The appraisal procedure of the World Bank is designed to produce a thoughtful answer to the question: All things considered, is this a sound use of the country's resources?

The Bank systematically reviews the environmental consequences of a development project and requires that appropriate action be taken to avoid or mitigate major adverse effects. In this endeavor the entire range of environmental issues is addressed, including those of renewable resources and their proper management. To date, it has always been possible to reach agreement on warranted environmental measures with the borrower or member country.

The Bank has, however, been guided by certain basic principles. It will not finance those projects which compromise the public's health and safety significantly, cause severe or irreversible environmental deterioration, or displace people without adequate provisions for resettlement. Some environmental issues require a regional approach. River basins, watersheds, or even "airsheds," for example, are ecologically delimited areas which may lie astride political boundaries. Projects likely to have a significant effect on the environment in a neighboring country are not approved for financing without the express consent of that country; nor are any projects violating any international environmental agreements.

The Bank tries to pay attention early in the project cycle to the local circumstances that encourage or impede the participation of women in the project and to the extent to which women will benefit from or may be adversely affected by the project. The Bank attempts to learn from the projects it finances what the potential effects of technological changes are on women and to incorporate that knowledge in the design and appraisal criteria of later projects.

IV. Developing Technological Capacity

A major obstacle to the application of science and technology to development is the limited technological capacity in some developing countries. This capacity includes not only education and research, but also a capacity to conceive, plan, design, implement, manage, and operate projects, to monitor and evaluate them, and to feed the lessons of experience back into
current and future projects. Bank support for the building of indigenous technological capacity therefore includes support to technological institutions, such as universities, laboratories, consulting firms, and research and extension services. It also includes efforts to build institutions in the productive sector that can choose and manage technology.

A. Research and Extension

Through FY79, the Bank financed 25 projects totaling US$577 million for the establishment or improvement of agricultural research and extension institutions on a nationwide scale and has financed some 250 research components of agricultural and rural development projects—for example, developing and testing crop varieties best suited to specific locations. In large countries, such as Brazil and India, these institutions have been established at state and regional levels.

The Bank has financed eight projects and project components in seven countries having components totaling US$83 million for upgrading industrial technology at the enterprise level. This support for industrial innovation has taken a variety of forms. Emphasis, when practicable, is on funding specific technological improvements at the enterprise level ranging from improvements in product design, quality, and quality control to development of new export products based on indigenous technology. These efforts have been financed in two ways: through direct government support to specific projects in the productive sector, and through special loan funds administered by development banks. The most ambitious of these projects is in Korea, where the government, the development banks, private sector electronics firms, and the Korean Institute of Electronics Technology are collaborating to bring Korean industry to the frontier of several areas of sophisticated electronics design and manufacture.

B. Education and Training in Science and Technology

The Bank has helped to finance the construction or improvement of some 1,000 technical and agricultural schools and 100 faculties or universities, mainly for science, engineering, agriculture, and teacher training. About 1,700 general secondary schools and 300 teacher training colleges have been provided with science or technical facilities. Some 300,000 student places have been provided in institutions for technical and agricultural education. In the general secondary schools some 350,000 students a year may take science courses; in the teacher training colleges, perhaps 90,000. During FY63-79, the Bank lent US$2.7 billion for 192 education projects that had an aggregate project cost of US$5.1 billion. More than two-thirds of this amount was for scientific and technological education.

The qualitative improvement of scientific and technological education has been an important objective of Bank-financed education projects. There have been improvements, but the gap in performance between students in developed and most developing countries remains fairly wide. Strong additional
efforts will be required to bridge it. The improvement has often been hampered by a shortage of teachers qualified in science and technology, by the procurement of inappropriate equipment, and by insufficient funding for materials and the maintenance of workshops and laboratories. Many workshops and laboratories continue to be underused, despite appropriate curricula and facilities. The Bank provides technical assistance for analyzing sectoral manpower needs and developing training methods to meet them; it advises on both international and local facilities that can be used for training.

Bank lending to developing countries in traditional engineering-intensive sectors, such as power, mining, highways, irrigation, and telecommunications, includes a substantial transfer of operating and managerial technology. The Bank also supports development of the more sophisticated scientific and technological skills through loans in the education sector. In addition, it helps to develop the capacity for sector and project planning.

The Bank is increasingly focusing its attention on the need to transfer technological know-how through specific training components in noneducation projects. The training of sufficient numbers of workers in skills appropriate to the operation and maintenance of project facilities has come to be known as project-related training. In FY79 the Bank financed project-related training in 152 non-education projects (mostly in projects for agriculture and infrastructure) at a total cost of US$140 million. This training, which generally is carried out on the job, makes an important contribution to the ultimate success of a project and therefore has a high rate of economic return.

In addition to the Bank's assistance to the development of technological capacity through its projects, the Bank's Economic Development Institute (EDI) gives short courses to middle-level and senior-level officials of developing countries. They study problems of development planning and management and learn methods for designing, appraising, and implementing projects in most of the sectors and subsectors for which the Bank lends. About two-thirds of EDI's courses are now conducted overseas in cooperation with local and regional institutions. The curricula are increasingly being tailored to the problems of preparing and implementing projects in specific countries and regions, including the choice, acquisition, implementation, management, and operation of technology. Some EDI courses include training in negotiations with transnational enterprises.

C. Local Consulting and Engineering Capability

The Bank encourages the use of qualified consultants from either a borrowing country or other developing countries, alone or in association with firms from the more developed countries. The use of local consultants is an important way to build local capacity for the planning, design, implementation, and operation of projects. From the point of view of the project, the
use of local consultants or those from other developing countries may offer the advantages of lower costs, closer cultural affinity, and better understanding of local conditions. The final decision about appointing consultants belongs to the borrower, who selects and hires them subject only to the Bank's judgment that they are qualified and that their terms of reference and the conditions of their contract are satisfactory. Although the Bank encourages the solicitation of proposals from consultants of different nationalities, no international competition is required.

In an effort to strengthen the local consulting industry in the developing countries, the Bank has initiated surveys of local consulting services in a range of countries. Such a survey has been completed in Indonesia, and a preliminary survey has been carried out in Brazil. On the basis of the survey in Indonesia, the Bank is designing a special project, likely to be financed by the UNDP, to support the consulting industry in that country. The Bank expects to undertake surveys in other countries, with the possibility that further projects to support a consulting industry will emerge from these.

The project in Indonesia, which is based on a program of assistance by the Dutch bilateral-aid organization, is likely to serve as a model. It involves an approach that would provide services both to the government and to the consulting industry. The services to government would include advice on and assistance with policies and procedures, as well as some training of government officers. Those to industry would primarily involve technical assistance and training. In addition, data would be collected on the consulting services available, and assistance would be given to joint ventures and to Indonesian consultants in promoting the export of their services.

The Bank has found that joint ventures between foreign and local consulting firms are becoming the rule rather than the exception. Almost as a matter of course, a foreign firm will enter into an agreement with a local firm when doing business locally. The Bank considers such joint ventures to be an excellent mechanism for transferring technology and developing local technological capabilities. In the projects it finances, the Bank tries to encourage workable training programs and provisions for the transfer of technology within joint ventures, while ensuring that all parties realize this will cost money and possibly time.

The technical assistance the Bank provides to developing countries for sector planning, project pre-investment studies, and institution building is another mechanism for developing local technological capabilities. For example, in acting as an executing agency for the UNDP, the Bank is providing such assistance for the preparation of master plans for water resources in Egypt, Guinea, and the Senegal River Basin and for a study of energy policy and a program of technology development in Korea.
D. Institution Building in Government and the Private Sector

The impact of any particular technology depends heavily on the social and institutional structures on which it is superimposed. For this reason, there are many situations in which an intervention focused purely on technology—whether indigenous or foreign and whether new, adapted, or transferred—is likely to be doomed from the start. If a desired innovation is to be effected, the introduction of hardware must be accompanied by and integrated with a package of policy and institutional changes.

In its projects, the Bank pays careful attention to institution building, which is one of the Bank's principal vehicles for developing technological capacity. This term is interpreted in its broadest sense to cover not only the project entity, its organization, management, staffing, policies, and procedures, but also the array of government policies that condition the environment in which the project entity operates and the way it uses technology. 3/ Institution building perhaps is the most difficult aspect of a project, in part because its success depends so much on understanding the cultural environment. The Bank has come to recognize the need for a continuing re-examination of institutional arrangements, an openness to new ideas, and a willingness to adopt a long-term approach that may apply to several projects. In an effort to overcome the difficulties of understanding the local cultural environment, the Bank is increasingly using anthropologists and sociologists in its project work and is encouraging its borrowers to do likewise.

The bulk of the technological capacity developed by the Bank's institution building efforts is concerned with increasing the ability to choose, acquire, manage, and operate technology well known elsewhere, even though that technology may be new to the particular country and require adaptation to its conditions. The capacity the Bank seeks to promote in this way covers a broad range of skills: those for project planning, sector planning, pre-investment, detailed engineering, and construction supervision; those for relatively simple operations, such as improved cultivation practices or improved maintenance of highways; those for sophisticated management, such as managing interconnected power systems or launching technology-intensive electronics products on world markets.

In other cases, the Bank's institution building efforts are concerned with developing an indigenous capacity to conceive, plan, and design projects—and in that context to choose, acquire, implement, and manage

3/ The project entity occasionally is a scientific or technological institution, such as a laboratory or a university, but usually is an operating institution in one of the sectors in which the Bank lends: for example, a development bank; a highway, power, irrigation, or municipal water authority; an integrated rural development project unit; a maternal and child health service; or a public enterprise manufacturing steel, fertilizer, or cement.
technology. In Brazil, for example, a series of projects for ports, highways, and railroads was defined as the result of a transport survey that the Bank initiated and supported with the UNDP and the United States Agency for International Development. Loans to finance those projects involved a decade of collaboration between Bank staff, outside experts, and Brazilian engineers and planners. The federal agencies now are much stronger, and the Brazilian consulting and contracting industries now are internationally competitive. In addition to financing, the Bank contributed to Brazilian highway development in three main areas: the economic planning of highways, the development of bidding and contracting procedures, and the development of modern design standards. The Bank also played a major role in developing the highway engineering profession, both in government and in private industry.

V. Promoting Technological Innovation

The technology of the developed countries usually cannot be directly transferred to developing countries, where very different conditions prevail. Technology in industry, agriculture, and other sectors must be adapted to local conditions and technological capacities. Moreover, the requirement that technology improve the productivity of the poor or provide them with essential services at a cost within the resource constraints of the country has made it necessary for the Bank to seek technology that is different from that in common use in developed countries. Because technological innovation may flow from indigenous technological capacity or from external sources, Bank-financed projects promote innovation from both sources. The Bank’s support of indigenous capacity was described in the preceding section.

The Bank uses a variety of mechanisms to promote technological innovation in the sectors in which it is active.

A. Pilot Projects and Scale-Up

The Bank must frequently confront the problems of enlarging the scale of an innovation so that it can benefit large numbers of people. The gap between a successful pilot project and full-scale application of a new idea often poses a major obstacle to the application of science and technology. The Bank is in a good position to help bridge that gap.

The training and visit system of agricultural extension, for example, supports the use of a systematic approach to conveying technological information to the farmer—especially the small farmer. That information is applicable to his situation and in a form he can understand. The system provides for the training and regular supervision of village-level extension workers. They in turn provide farmers with specific and timely advice originating from specialists working in research institutions or elsewhere. When the system has been used over a sustained period, the productivity of small farms has markedly increased.
The training and visit system was developed in pilot projects in Turkey and has now been applied in full-scale projects in six states in India and elsewhere. Another example of the successful expansion of a pilot project is in Mexico, where trials with legume pastures and mineral supplements in both temperate and tropical areas have led to marked increases in national production of low-cost meat.

The Bank has also initiated pilot exercises in several countries to provide an insight into promoting the use of innovative technologies, such as more efficient woodburning stoves, in rural energy programs. These programs require individual and collective commitment at the village level, and the scattered pilot experiences will help incorporate localized inputs for wider application.

In Mali and Burundi, surveys of the use of fuelwood and other alternative energy sources are being organized as a preliminary to possible pilot projects in this field. Sociocultural studies will complement the surveys to determine ways of mobilizing local participation in efforts to develop and use more efficient woodburning stoves and charcoal kilns in rural areas. In the Indian state of Uttar Pradesh, village forest committees will participate, together with personnel from the Planning, Research, and Action Institute, in a pilot project to adapt, demonstrate, and use more efficient stoves in about 1,000 villages.

B. Research Financed by the Bank's Administrative Budget 4/

The Bank, in collaboration with research institutes and consulting firms in industrialized and developing countries, has developed and is testing efficient labor-intensive techniques to reduce the cost of rural road construction and concurrently to provide employment in areas where jobs and capital are so scarce that wages are less than US$2.50 a day. This civil works study, partly financed by the Bank's administrative budget, examined the feasibility of alternative technologies using different combinations of labor and equipment for civil construction. The study developed and demonstrated technologies which improve the productivity of labor and create employment.

If the need for adequate and convenient supplies of safe water for drinking, washing, and sanitation is to be met in the near future, new technologies will be required to reduce investment costs. A Bank research project in sanitation has shown that there are feasible alternatives between pit privies on the one hand and complete water-borne sewerage systems on the other, such as aqua privies, cartage systems, and septic tanks.

The Bank has reviewed the literature and carried out case studies of the use of radio for education in school, for formal education out of school, for nonformal education, and for distance teaching. The study concluded that the potential of radio for development communication generally remains untapped.

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4/ For brief descriptions of such research see World Bank Research Program, Abstracts of Current Studies, October 1979.
The experience in too many developing countries is that the technological community, even in the relatively unusual case when it becomes fully involved in the productive sector, is concerned almost exclusively with the problems of strategic industries or modern manufacturing. Results of a Bank study of the choice between domestically produced and imported textile-weaving machinery in Korea confirm that substantial scope for capital/labor substitution exists in textile weaving in Korea, depending on the degree of automation. Another Bank-supported research project has found that there is substantial scope for capital/labor substitution in mechanical engineering activities.

C. The Bank as Executing Agency for Projects Financed by the UNDP

UNDP global demonstration projects are useful in introducing new and promising technological innovations and have been a means of testing innovations under difficult and varied conditions. The Bank has been active as an executing agency for some of these projects. A recent example is a global demonstration program for solar-powered irrigation, a program which over the next three years will test devices using solar-thermal power and solar photovoltaic power on small-scale irrigation systems in India, Sudan, Upper Volta, and the Philippines. Another global demonstration program for low-cost water and sanitation will design and implement prototype projects in several countries to demonstrate the technical and economic feasibility of solutions identified through the Bank's research project on appropriate technology for water supply and sanitation in developing countries. On the country level, the Bank is executing a UNDP-financed study of technology development in Korea. The purpose of the study is to map out the long-term directions for the development of Korean industries and to identify the necessary tools and institutional arrangements.

D. New Technology in Project Planning and Implementation

Development planning requires knowledge of the identity, state, and location of natural resources in a given area, but many countries are not equipped to gather or use such knowledge. In recent years there have been major advances in the technologies available for carrying out natural resource inventories and for evaluating the potential of resources. One of these advances—remote sensing, especially by satellites (LANDSAT)—is faster and much less expensive than the methods previously used. It also provides synoptic and temporal data which would otherwise be impossible to obtain. The Bank uses remote-sensing systems in project identification and aids developing countries in their use of such systems in project preparation and implementation. The Bank also assists in the organization or establishment of remote-sensing agencies that use the full range of techniques for such applications as regional planning, evaluating soil and water resources, assessing agricultural and livestock potential, and exploiting minerals and forests.

E. Large-Scale Financing of Research

The Bank provides the chairman, the secretariat, and about 10 percent of the funds mobilized by the Consultative Group on International Agricultural Research (CGIAR), which helps to finance thirteen internationally governed
institutes or programs for agricultural research. These institutes and programs have more than 5,000 staff, including some 450 senior scientists; their budgets in 1979 totaled US$98 million including support for the new International Food Policy Research Institute, with headquarters yet to be determined and the International Service for National Agricultural Research (ISNAR), with headquarters in the Netherlands.

The Bank has applied the financial mechanism developed for the support of agricultural research by the CGIAR to other areas of priority in developing countries. It is a co-sponsor, with WHO and the UNDP, and serves as fiscal agent of the Special Programme for Research and Training in Tropical Diseases. The program has two principal objectives: to develop and apply effective, low-cost methods to control six tropical diseases - malaria, schistosomiasis, filariasis, leishmaniasis, trypanosomiasis, and leprosy; and to train scientists and technicians and to strengthen research institutions in the countries affected by the diseases, thus increasing the capability of these countries to deal with the problem. The Bank also is leading a research effort to develop improved methods for combating the many causes of diarrhea, methods that include vaccines for short-term protection of travelers and chemotherapy for inhibiting the effect of toxins which initiate fluid loss. In addition, the Bank administers and contributes to the Onchocerciasis Fund, which finances a program to control river blindness in the Volta River Basin of Western Africa. This debilitating, fly-borne disease afflicts large numbers of people in that region.

The Bank, the Rockefeller Foundation, and the UNDP, which has the lead role, have developed a proposal for an integrated global program to defend the market competitiveness of cotton and the incomes of cotton producers. Cotton is the most important nonfood crop grown in developing countries; low-income developing countries produce more than two-fifths of the world's supply. The program would have the following elements: agricultural research to increase yields, improve quality, and reduce production costs; industrial research to give cotton desirable end-use properties, such as permanent-press, and make it more compatible with high-speed textile machinery; technical assistance to mills in developed and developing countries to facilitate the transfer of newly developed cotton technologies; and marketing and promotion to strengthen the image of cotton as a desirable fabric and to promote its new features. The proposal calls for the establishment of an intergovernmental organization, to be called Cotton Development International, that would be funded in part by countries producing and consuming cotton and in part by aid donors and would complement the efforts of existing organizations to assist cotton. A number of aid donors have indicated their willingness to contribute to the new organization if it comes into being. The proposal was presented to governments after six years of preparatory work. If their reaction is favorable, preparations will be made for a founders' meeting to establish the new organization.

A major general problem that remains is to devise or strengthen mechanisms for linking international research to national research. Such efforts already are under way. The Special Programme for Research and Training in Tropical Diseases stresses the building of local competence and its
involvement in an internationally coordinated program of research. The CGIAR has established ISNAR to operate under its auspices and to assist in strengthening the capacity of developing countries to plan and carry out agricultural research. ISNAR is meant to complement the work of FAO, private organizations, and bilateral and multilateral agencies.

VI. Promoting Policies for Technology

National policies in areas not explicitly oriented to the development of technology and technological capability may profoundly influence the application of science and technology to development. If economic policies prevent competition, firms will pass up opportunities for the use of known technology to improve quality and will have limited interest in risky but politically profitable innovations. If financial authorities overvalue local currency, enterprises will have an incentive to import equipment and raw materials in place of locally available supplies and will neglect local sources of technology and the building of local capacity. If government marketing boards pay too little for agricultural products of higher quality, processors of those products will not only be unreceptive to new technology but even neglect to maintain their existing equipment. If banks and other credit institutions are unwilling to extend credit to small farmers, those farmers will continue to face severely restricted technological options.

If governments do not give high priority to the provision of safe water to poor people, the agency charged with this responsibility will neither attract good managers nor provide proper working conditions for its engineering staff. If, moreover, the decision is made to provide a high level of service to relatively few people, rather than to maximize the number of people served, that agency will not adopt design criteria suitable for providing water to the poor.

Alternative paths of development based on new and more appropriate technology can evolve only as the result of consistent and long-term application of a different development strategy and set of global incentives. It then becomes a critical goal of technology policy to design national policies and institutions that can guide the evolution of technology in use into appropriate directions and to ensure local mastery of that technology. Reaching this goal requires an intimate knowledge of the effects of social, market, and administrative forces on technology. It implies a close integration of technology policy with broad development policy and a critical change in emphasis from the traditional concern of technology policy-makers with research programs, scientific infrastructure, and manpower development.

The Bank promotes this integration through its country economic and sector work. It carries out—or assists the more advanced developing countries in carrying out—country and sector studies intended to provide essential background on strategic policies and issues that critically influence the technology used in projects.
A typical World Bank study in agriculture and rural development, for example, gathers data on and analyzes a number of factors that impinge on the type of technology used in rural areas: the distribution of rural income; the land tenure system; the distribution of farms by size; the availability and cost of different types of credit to farmers; the rural labor market, including patterns of migration and possibilities for nonfarm employment; and the organization of the system for marketing agricultural inputs and outputs, including processing, storage, and transport.

Through its country economic work and its sector work in industry, the Bank has encouraged governments to change policies that may have led to distorted prices, subsidized capital equipment, overvalued exchange rates, subsidized interest rates, and discriminatory access to credit. It also has encouraged governments to change regularly measures that may have promoted undue capital intensity in investments and inhibited the ability of small enterprises to function.

The Bank considers requests from member countries for financing sectoral or cross-sectoral projects in science and technology. It assists in the preparation of such proposals, including those for broad studies of sectoral and cross-sectoral technology policy, and appraises them in the light of their contribution to the building of indigenous technological capacity in areas where this will make an immediate or long-range contribution to development. In Spain, for example, the Bank is supporting research, development, and engineering to improve Spanish industrial technology through local efforts in product and process development.

VII. Structure of this Report

This introduction has given an overview of how the Bank operates as an agent of technological development. The following ten chapters describe in detail the uses of technology in each of the sectors for which the Bank lends: Agriculture and Rural Development, Urban Development, Education, Population, Health, Water, Telecommunications, Transportation, Energy, and Industry.

The format for each chapter reflects Bank work in that sector, but generally deals with four topics. 5/ The first is the Bank's approach to the sector, which is necessary for understanding the technology used in that sector. This topic covers the main reasons for supporting the sector, particular problems being addressed, and the Bank's role in dealing with them; critical points in sector and project work and what the Bank does to overcome them; and the nature of Bank lending, including a history of borrowers, trends in the number and size of loans, lending in FY79, and projections for future lending.

5/ Most chapters are organized by treating each of these topics in turn. In chapters 2, 8, 9, and 10 these topics are dealt with under each major subsector of lending.
The second is a general description of the science and technology used in the sector, trends, and major recent breakthroughs; possible alternative technologies and attempts at adaptation and innovation in Bank-supported projects; criteria used in selecting suitable technologies for Bank-financed projects, and pilot and engineering studies and any project-related research that the Bank supports.

Third, each chapter describes attempts to build local capabilities to use and develop technology—e.g., technical assistance using foreign and local engineering and management consultants; training in management, engineering and production or project-related skills; use and development of local contractors and suppliers; and use of and projected-related ties to local universities and technological or research institutes.

Fourth, each chapter gives an account of the technological lessons the Bank has learned from its operations in the sector (or for each subsector within the sector). In some subsectors (e.g., petroleum, coal, renewable energy sources in the energy sector, and small enterprises in the industrial sector) Bank lending experience does not yet provide a basis for reporting on such lessons.

These elements constitute the scientific and technological aspects of Bank work. The balance between science and technology in Bank operations differs by sector; the title of each chapter is meant in part to reflect the nature of the science and technology activities supported in that sector. These differences are also reflected in the detail with which various scientific and technological activities are described in each chapter.
1. TECHNOLOGY AND SCIENCE IN AGRICULTURE AND RURAL DEVELOPMENT
ACKNOWLEDGMENTS

This chapter was written by Paul Shapiro (Science and Technology Unit) with substantial assistance from the Bank's Agriculture and Rural Development staff. In particular, Graham Donaldson provided guidance on the overall structure of the paper; the following advisers provided information for the subsector indicated: Frederick Hotes (irrigation and drainage), Donald Pickering (annual crops), Brian Gray (perennial crops), and William Spall (agricultural credit); James Fransen provided valuable advice on the section on research and extension; and Judith Graves helped to obtain information in a number of subsectors. Bernard Woods of the Training Unit of the Bank's Education Department advised in detail on the section on training and education. Other contributors were Montague Yudelman, Daniel Benor, and James Goering.
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A. Bank Policy on Lending in Agriculture and Rural Development

1. Bank Rural Development Strategy 1/

A major objective of the Bank in agriculture and rural development is to improve the welfare of the rural poor, especially small farmers, by increasing their productivity and income. Typically, small farmers inhabit holdings of less than 5 hectares and often less than 1 hectare in size. They are the largest group of poor people in developing countries, constituting approximately one-third of the total population.

The Bank is the largest single external source of development funds for agriculture in developing countries. In FY79, the Bank lent US$2.5 billion for 83 projects. Nearly 21 million persons, of whom two-thirds are rural poor, are expected to directly benefit from these projects; another 20 million people should benefit indirectly.

The primary responsibility for rural development rests with the governments of those developing countries with significant populations of the rural poor. The Bank assists member developing countries by advising on national policies and programs for rural development primarily through its country economic and sector work and project-related activities. Governments are encouraged to design policies that affect both the prices of goods and services within the agricultural sector and between agriculture and other sectors and to provide the small farmer with the incentive to try new technologies. Governments may also need to adjust fiscal policies so that the taxes placed on the rural poor are not regressive and so rural areas receive an equitable proportion of the country’s public expenditures.

The institutions that developing countries use in implementing rural development policies and programs are an important factor in achieving the established goals. Success in large measure depends on decentralizing responsibility to regional and local levels. Thus, the development of national, regional, and local institutions that can effectively administer rural development programs is a major objective of Bank-supported projects. In addition, the Bank considers the degree of participation by beneficiaries in project design and implementation when making its project support decisions.

1/ The Bank has published several policy papers relating to the Agriculture and Rural Development Sector, including Rural Development (February 1975), Land Reform (May 1975), Agricultural Credit (May 1975), Agricultural Land Settlement (January 1978), Rural Enterprise and Nonfarm Employment (January 1978), and Forestry (February 1978). See also the chapter on "Farm Technology and Agricultural Research," by Graham Donaldson, in Charles Weiss and Nicolas Jequier (eds.), Technology, Finance and Development (forthcoming).
Increasing the productivity of small farms is a complex and difficult problem and standard solutions are usually inappropriate. Therefore, the Bank has been changing the nature of the projects it funds in this sector. Whereas the Bank's agriculture projects traditionally concentrated on a single aspect of farm production—e.g., irrigation, livestock, or credit for particular crops—the Bank's "new style" agriculture and rural development projects usually contain more than one component. A component may relate to irrigation and drainage, livestock, fisheries, forestry, perennial crops, annual crops, agro-industries, or area development. These projects may support non-farm activities as well, including rural roads, education, electricity, water supply, nutrition, population, and health.

The emphasis on "new style" projects affects every aspect of the Bank's work in this sector. Dialogues with governments on policies, programs, and institutional development reflect the complexity of the approaches needed to raise small farm productivity. The identification of projects may require information (such as the nature of the climate, water, and land resources; the size, ownership, and yield of farm holdings; and existing institutions and infrastructure in a potential project area) that has not been collected previously. It may be difficult to estimate the economic benefits or to quantify the social benefits during appraisal. Finally, implementation may not follow precisely the predicted development paths; projects must allow for modifications based on experience both in the project and elsewhere.

The Bank's approach to rural development requires careful attention at every stage to the technologies that will be used. In the course of project cycle activities, Bank staff discuss with governments the technologies that have proven effective elsewhere and that might be adapted to conditions in a specific developing country. Throughout the project cycle the Bank considers alternative technologies for meeting a project's objectives. The conditions under which small farmers live and work, their traditional practices and values, and the ways in which they organize for common purposes all affect the choice and adaptation of technologies for use in Bank-supported projects.

Improved technology—including both physical inputs ("hardware") and the institutional supports necessary for their effective use ("software")—is an essential element in increasing small farm productivity and agricultural production generally. The hardware may range from improved seed and fertilizer to modern dairy equipment at a central location. Since the Bank normally supports only the use of proven technologies, research is needed to ensure that tested approaches are available for use in Bank-financed projects. Thus, the Bank finances such research at the international, national, and local levels.

The Bank frequently attempts to strengthen local institutions that can provide both hardware and software services by providing for training, technical assistance, and institutional development in the projects it finances.
The Bank cooperates in this sector with other international agencies. It has, for example, a cooperative program with the Food and Agriculture Organization (FAO) for the preparation of agriculture and rural development projects and, through the Consultative Group on International Agricultural Research (CGIAR), is coordinating a program of international agricultural research.

2. **Agricultural Credit**

Credit is frequently a key element in the modernization of agriculture. Not only can credit remove financial constraints, but it may accelerate the adoption of new technologies. The Bank regards the provision of appropriate agricultural credit as usually a necessary (if insufficient) condition for increasing farm productivity and incomes in many project situations. However, credit is still unavailable from institutions (as opposed to borrowing from money-lenders) to a large proportion of small farmers in developing countries—as much as 90 percent in some cases. Since the early 1970s, the Bank has increased its lending for the direct benefit of small farmers and provision of credit has amounted to more than half of sector operations. In FY79, for example, the Bank lent more than US$1.0 billion for agricultural credit components.

Bank agricultural credit loans provide financial support to overall development packages that the Bank selects and appraises. The choice of specific technology (equipment, technique, or other technology), however, is normally left to the financial intermediary and the borrowing small farmer. For example, a Bank loan may specify that credit is to be provided for minor irrigation and land leveling. Whether the land leveling is done by bullocks or graders and whether the irrigation is provided by tubewells or dugwells will depend on the physical conditions in the area, the farmer's preferences, and the credit available from the financial intermediary. While the Bank may not be directly involved in this decision, it will attempt to ensure that acceptable technical "packages" are available.

The Bank's largest agricultural credit operations have been for livestock production in Latin America and irrigation in Asia. Now, the Bank is increasingly supporting the provision of credit for multi-sector projects. A Bank-assisted agricultural credit project in Afghanistan, for example, has eight components. Three of these are: (1) providing for farm mechanization where double and triple cropping is possible but seasonal labor and power shortages exist; (2) improving irrigation through both shallow and deep wells with associated pumping equipment; and (3) establishing on-farm development by improving vineyards, orchards, poultry, dairy, livestock, apiculture, foodgrains, and cotton growing.

2/ This subsector is singled out because it is a mechanism used in many loans to provide support for other subsectors.

3/ For a description of Bank industrial credit operations see chapter 10.
The Bank usually finances credit by lending to government-supported agricultural credit banks, which in turn re-lend to farmers. To increase the availability of credit to small farmers, the Bank encourages borrowers to: use more commercial banks; have financial intermediaries soften the collateral requirements so downpayments can be geared to the small farmer's ability to contribute to investment costs; and reach greater numbers of small farmers through improved branch coverage and group borrowing.

The Bank supports the provision of technical assistance for building credit institutions. A project may, for example, include provisions for specialized staff (e.g., agricultural credit supervisors, economists, and accountants; office machinery, a computer, or other necessary equipment; and study of accounting systems). In addition, assistance in understanding auditing requirements, solving special problems, drawing up manuals, and developing criteria for management of accounting and other systems may be provided. Although the staff of an agricultural credit institution may include technical specialists in productive areas of great lending (e.g., livestock), it often lacks a detailed knowledge of the local conditions that affect the technology choice. The extension agent, therefore, is usually needed to provide advice on appropriate technologies for credit use.

Finally, the Bank attempts to build institutional capacity through training. In India, for example, the Bank is assisting a national agricultural credit system through the Agricultural Refinance and Development Corporation. There, large numbers of senior, middle-level, and junior staff members of the participating State Land Development Bank systems have been trained. The training program has aided lending institutions in accepting farm productive capacity as a basis for lending. Previously, depending on property for collateral was the predominant approach. In addition, the training has resulted in an improved capability to formulate and appraise subprojects.

B. Subsectoral Approaches to the Use of Science and Technology

There are still some single-component, Bank-supported agriculture and rural development projects (e.g., irrigation or grain storage within agro-industries), but most projects draw from several subsectors (and in some cases from subsectors outside of agriculture and rural development) when trying to increase farm productivity.

The technologies used in a particular subsector are designed to optimize productivity under the prevailing conditions without introducing unacceptable risks to either the individual farmer or the project as a whole. The Bank's increasing experience in the various subsectors gives it a wide array of technologies for use in designing projects to meet this objective. The Bank may support the introduction of compatible combinations of farming different crops, raising livestock, and carrying on a cottage enterprise on one farm plot in a given project area, while under different project conditions, it can finance the introduction of a single physical input and the supports necessary for its use.
1. **Irrigation and Drainage**

Irrigation and drainage has been the largest area of Bank lending for agriculture and rural development. Prior to the mid-1960s, Bank lending in this subsector was primarily for the construction of dams and major canal systems. The Bank now finances complete systems which typically include: a source of water from pumping or storage; a conveyance system or ditch network involving secondary, tertiary, and even quarternary canals; onfarm facilities for using the water and shaping the land to receive the water; a means of delivering the water to the crops; and a drainage system. It also finances the completion and (increasingly) rehabilitation of parts of these systems.

In the Indian state of Haryana, for example, where limited availability of irrigation water is the major constraint on increased crop production, a Bank-financed project is supporting the modernization of canals, the lining of watercourses (which distribute water from the institutionally-managed irrigation system, through communally-owned field channels, down to individually-owned farm plots), and the construction of tubewells to allow public use of groundwater storage. In addition, it will provide improved markets, roads, and drinking water supplies.

Major irrigation and drainage projects are often planned and designed by joint ventures of foreign and local firms, frequently providing significant training opportunities for local agriculturists, economists, hydrologists, and engineers. In assessing proposed physical works the Bank sets no single standard, but rather reviews each project in the light of the prevailing topographic, climatic, economic, agronomic and social circumstances, and the applicable and available technologies and materials. The Bank encourages the use of labor-intensive methods of construction and discourages the use of capital-intensive systems for irrigation when economically justifiable.

Locally suitable technologies that have been used in Bank-financed projects include gravity irrigation with and without storage, river pumping plants, and low cost or specially designed control gates, canal linings, tubewells, and sprinkler systems. In certain saline areas, such as Pakistan and Egypt, where drainage projects have been vital and land expensive, the Bank has encouraged the use of underground plastic drainage tile. The Bank has also encouraged the experimental development of solar pumps for irrigation use in India and has funded the use of glass-reinforced plastic and timber flumes for tertiary canals in Malaysia. The plastic-timber flumes are lighter in weight and permit more rapid installation than either concrete and metal flumes or the construction of lined or unlined ditches, since excavation is not necessary and seepage and weed growth are minimized.

2. **Livestock**

The Bank’s support of livestock development is tailored to the needs of each major geographic region. Considerations include the nature of the land, climate, and technical resources as well as political and cultural constraints. Until the early 1970s, about 70 percent of Bank lending for
livestock went to Latin America, mainly in support of large-scale ranching operations. More recently Bank lending has targeted more on the livestock needs of the smallholder, both in Latin America and elsewhere.

In certain areas, marked increases in land and livestock productivity have been achieved through the direct transfer of proven technologies from parts of the world with similar climatic and soil conditions. In Uruguay, Argentina, Spain, and Ireland, for example, Bank-financed projects supported the adoption of legume pastures, fertilizers and management techniques that have been extensively used in temperate regions of Australia and in New Zealand. Similarly, other legumes, without fertilizer application, have been adopted in some tropical countries including Thailand, Colombia, and Madagascar.

When direct transfer of technology is not possible, the Bank supports applied research and demonstration efforts. In Mexico, trials with legume pastures and mineral supplementation in both temperate and tropical areas led to marked increases in national production of low-cost meat.

Bank-financed efforts to assist small farmers differ by region; they generally focus on improving and increasing existing stock, diversifying land and animal uses, and providing processing and marketing system. In much of Latin America, for example, the Bank has assisted small farmers in the adoption of dual purpose dairy-beef production. This provides a more constant income than beef production alone. In Western Africa, the need for aiding pastoralists was heightened by the Sahelian drought. However, the experience in most other parts of the world has been that attempts to settle nomadic peoples have resulted in high livestock mortality. A Bank-financed project in Senegal is based on current efforts in Eastern Africa. In Senegal, groups of related families which adopt prescribed husbandry practices (especially for limiting livestock numbers) are allotted grazing and water rights for a specific area and are provided with a range of facilities and necessary services. In this and similar projects the Bank is increasingly using social scientists to determine both the appropriate organizational structure and the socio-cultural considerations which can lead to increased livestock productivity.

In Asia, the Bank has been encouraging the use of cattle (and buffalo) both as draft animals on small mixed farms and as a source of cash income through dairying and meat production. In India, for example, local milk production has grown through the formation of 28 major cooperative dairy unions that operate under the National Dairy Development Board. These cooperatives include about 1 million member families; 30 percent are landless agricultural laborers who supplement their wage earnings by caring for one or two cows in their village area. A Bank-financed project in India is supporting the use of modern technology to develop the national dairy industry through provision of milk collection, processing, and marketing facilities and by supplying technical services for improving the quality and husbandry of cattle and buffalo in selected areas.
Providing suitable technology to the small farmer is a major factor in increasing livestock productivity. In Western Africa, for example, smallholders have been found to quickly adopt new techniques in animal husbandry for the propagation of work oxen and livestock fattening. Extension systems exist in many parts of Asia that can provide information on the various technologies. In Latin America, by contrast, the greatest hindrance to the adoption of improved livestock practices by smallholders may be the lack of effective extension services.

3. Fisheries

Prior to 1971, Bank-financed projects supported fishery development by providing for the purchase of commercial fishing vessels and the improvement of port facilities. Since 1971, the Bank has increasingly sought to aid small fishermen through fishery components of rural development, irrigation, and other projects.

The Bank continues to develop, and modify as necessary, its approach to the support of small-scale fisheries activities. Technical improvements in equipment have included the introduction of fiberglass canoes, synthetic nets, and outboard motors, and the use of ice to preserve the catch. However, fisheries projects also require extension services, technical assistance, processing and market systems, and other infrastructure supports similar to those required by land-based agriculture. Management and training are also important.

To increase fish supplies for local consumption and to reduce the dependence of fishermen on seasonal availability of a catch for food and cash income, the Bank has also supported aquaculture project components (e.g., the cultivation of oysters, shrimp, and other species in selected sections of ocean bed). A technical package for land-based fish farming has also been developed. This includes the fertilization of selected ponds, the introduction of a genus such as the *Tilapia*, which is hardy and reproduces rapidly, and the use of supplemental feeding with bran and other waste products.

4. Forestry

Prior to 1976, the Bank's forestry projects were largely directed toward industrial forestry and were based on large-scale, integrated forest industry complexes. Since then, emphasis has shifted towards rural development needs and environmental protection.

Joint agro-forestry projects have been designed to meet both the developmental and environmental needs of participating countries. For example, food crops can be grown alongside immature trees, or cattle can be grazed

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beside more mature trees. A Bank-financed project in the Philippines includes a multi-purpose fast-growing tree called "Ipil-Ipil" (Leucaena). At 1-3 years, the tree can provide fodder for livestock, at 4-6 years it can supply wood for fence posts and fuelwood, and after 10 years timber and charcoal can be produced.

Currently, over 90 percent of wood consumption in developing countries is accounted for by fuelwood. Increases in fossil fuel prices have made conservation of this alternative fuel source even more essential. However, several factors inhibit conservation and reforestation efforts. These include a lack of space, shortage of water, limited control over grazing, other conflicting uses of the areas to be reforested, and difficulties in establishing locally suitable packages of technology, management, and extension services. The Bank is helping to fund project components using such approaches to fuelwood production as: supporting reforestation on private lands by local self-help groups; financing nurseries to supply seedlings; establishing fuelwood plantations on government lands; and combining plantations with self-help operations. These project components have also demonstrated the value of conservation through such means as improved wood-burning stoves and simple wood preservation systems in buildings.

5. Perennial Crops

Bank-financed perennial crop projects commonly involve such crops as tropical oil palm, cocoa, coffee, and tea. The Bank has also funded projects which include fruit trees such as mangoes, avocados, and apples (in India), less widely harvested tropical crops such as cashews and cinchona, and some perennials, such as spices, which are grown in semi-arid regions. In the Kandy gardens of Sri Lanka, for example, the Bank has been supporting a stable form of agriculture (known locally as "mixed forest gardens") that was developed on the steep slopes of the area. In an effort to reduce dependence on tea production, diversified gardens have been created of nutmeg, clove, pepper, coconut, coffee, and other perennials that provide cash income and subsistence, do not require much cultivation, and are ecologically sound in that they retain the soil and replenish its nutrients.

The technologies involved in tree crop production are generally well known because of extensive research and testing by both governments and private corporations. Increased smallholder productivity requires more extension and training programs and efforts to provide simple instruction have in fact existed for many years, often pre-dating their use for general crop production. Research efforts now focus on simplifying and reducing the number of techniques to be performed by the smallholder.

Recent technological developments that are or may be used in Bank projects include oil palm and coconut trees with a small annual height increment to facilitate harvesting; coconut dwarf hybrids with yields far in excess of traditional varieties; a low-volume insecticide sprayer that is light enough to be powered by flashlight batteries; a puncture tool for easy tapping of rubber trees; and a budding tool for cocoa plants that greatly simplifies the grafting process. The Bank's role has been to provide support for the large-scale application of such research and development results.
6. Annual Crops

Bank-financed projects primarily support the production of staple grains—sorghum, millet, maize, and rice—among the tropical rainfed (as opposed to irrigated) annual crops. However, fiber crops (principally cotton), grain legumes (cowpeas, chickpeas, groundnuts—also when used as an oil seed crop), and root crops (cassava, yams, sweet potato, taro) are also grown. Frequently, Bank-financed projects include provision for development of a variety of rainfed annuals to promote appropriate cropping sequences and thereby provide small farmers with sustainable food and cash incomes. In Northeast Brazil, for example, corn, beans, and cassava are grown concurrently.

In supporting annual crop projects the Bank seeks to reduce the risk to the small farmer. These projects typically use only well-tried approaches. New seeds and techniques are developed by the international research centers sponsored by CGIAR, but they require testing under conditions similar to those of the developing country in which they would be used. Even the most attractive technical packages must be adapted to local climate, soil, and sociological conditions before they can be applied in Bank projects. This process leads to positive results. Nigerian farmers found that new short season maize, developed as adjuncts to sorghum and cotton projects, fit well into the cropping pattern, were highly productive, and were acceptable to local consumers as a food crop.

Bank-financed projects provide various mechanisms for assuring that needed technical advice and inputs such as low-cost protective seed dressings reach the farmer. In addition, they frequently provide farmers with credit or cash income so they can purchase such inputs and a delivery system for getting them to the farmer.

7. Agro-Industries

Agro-industries integrate the farm sector with the processing or industrial sector in a given country. Bank-financed agro-industrial projects include those for seed production, crop processing, meat and dairy development, and storage and marketing facilities which are adjuncts of agricultural development programs.

Agro-industrial projects frequently use relatively advanced technology, since perishability and hygiene are critical elements in the handling of fruits, vegetables, and livestock. Strict quality control must be applied when preparing these commodities for export, for which most projects include at least some provision. In addition, many of these projects are medium or large in scale, to permit purchase of necessary equipment, adequate management and technical staff, and operation at a low enough per unit cost.

A Bank-financed project component in Brazil is designed to enable several dozen entrepreneurs and cooperatives—mainly private—to increase their processing capacity for cattle, pigs, and poultry and to meet domestic and international sanitary conditions. The project component supports the construction of new plants and the rehabilitation of existing facilities for slaughtering, processing, and packing the meat.
In some projects it has been possible to support the use of smaller facilities; examples include fruit packing, where economies of scale are not important, and livestock slaughtering, where high transport costs offset the advantages of large-scale operations. A Bank-supported development bank in Bangladesh has financed small-scale agro-industrial enterprises.

Grain storage is an increasingly important part of Bank agro-industrial lending. Bank-financed grain storage projects have traditionally been implemented through large cement or steel silos with facilities for drying and chemical fumigation. Recently, however, small steel storage bins have been introduced into several rural development projects, and other innovative forms such as plastered rattan containers are being considered for use at the farm and village level.

8. Area Development

Area development can involve the application of technology from all other agricultural subsectors as well as from transport, public utilities, health, education, small-scale industry, and many other non-agricultural subsectors.

In preparing area development projects, the Bank expects the borrower to analyze in detail the physical resources, the people involved, and the technology needed for implementing the project. Before large populations are moved in a settlement project, for example, as was done in a Bank-supported project in Indonesia, satellite imagery may be used to demarcate relocation areas, surveys of the population may be conducted to determine their needs and capabilities, and alternative schemes for habitation and productive work may be systematically studied.

The Bank also considers environmental factors in the design of area development projects. Such factors include both the prevention of destruction of natural resources and the redress of existing damage. Nearly all African rangelands projects, for example, are designed to prevent overgrazing and destruction of rangeland resources. The Bank also considers the potential danger from the use of pesticides and includes trial use in the projects it supports before financing widespread application.

A measure to coordinate the diverse activities is frequently one of the unique features of area development projects. In Bank-financed projects, such coordination has traditionally been institutionalized through the creation of an executing agency which assumes responsibility for all the necessary administrative functions in the project area. In Malawi, for example, the Lilongwe project used a single project management unit for very intensive development of the area with large expatriate input. This model has since been used in three Bank-supported projects in Northern Nigeria.

In more and more areas of developing countries, separate line agencies charged with such administrative responsibilities as road construction and water supply now exist. As a result, newer Bank-supported
area development projects increasingly have the possibility of using existing agencies to carry out specific functions, while a central coordinating mechanism disburses project funds. The coordinating mechanism can be a single specified agency or a committee of line agencies headed by a strong political figure.

Two principal approaches are being used in Bank-financed projects in such areas. The "comprehensive integrated" approach is used both in the Bank-supported PIDER project in Mexico and in Colombia. It involves a project agency which coordinates the many subsectors but does not execute project activity. The "minimum package" approach provides one or more specific technical inputs to large numbers of farmers, along with credit, extension, and other services. Using this approach, a Bank-supported project has provided improved seed varieties to a half million farmers in Korea and, in Ethiopia, a Bank-supported project is educating up to a million small farmers about the benefits of using fertilizer.

C. Research and Extension

The Bank supports research and extension activities as a means of ensuring (1) that tested technologies are available for use in Bank-supported and other projects in a country and (2) that the countries implementing these projects have the institutional means for putting these technologies to productive use. Where there is little existing knowledge to guide the adaptation of technologies to local conditions, some Bank-financed projects become, in a sense, field-scale demonstrations that add to the store of knowledge from which other projects will be designed.

The Bank financed in FY79 approximately US$331 million in agricultural research and extension activities at the international, national and local levels in order to increase farm productivity. Almost every project in some way makes use of the results of these efforts. Monitoring and evaluation are often used as management tools to lower the risks associated with innovation and as means for providing additional knowledge. In FY79, nine out of ten Bank-financed agriculture and rural development projects included monitoring and evaluation components.

The Bank finances research and extension activities through the following mechanisms.

1. Research Components of Agriculture and Rural Development Projects

These research components establish the basis for increasing agricultural output by strengthening the indigenous capability to generate, diffuse, and adapt information needed at the farm level. The projects frequently include monitoring and evaluation units that help guide and orient the research.

7/ This figure includes the Bank contribution to CGIAR. It is difficult to identify exact amounts for research and extension, since projects differ widely in both the nature and definition of their activities.
program toward the needs of the smallholder. In FY79, the Bank supported research components in about half of 83 agriculture and rural development projects. Cumulatively, the Bank has aided developing member countries in this way in more than 250 projects in some 70 countries.

2. National or Regional Agricultural Research and Extension Projects

The Bank funds projects of research, extension, and combinations of research and extension intended to increase agricultural (especially small farm) productivity in member developing countries. The primary objective is to improve the management capabilities and the technical skills of agencies responsible for providing these services to farmers. The need for these projects is usually identified during agricultural sector missions, from country economic studies, or as a result of problems identified in existing projects. The Bank now has about a dozen of these projects which are being or are near to being implemented and approximately the same number in earlier stages of preparation.

Research projects (and those projects which are predominantly research but include some extension) are mostly carried out by national agencies with programs decentralized to important agro-ecological regions. These projects generally include one or more of three kinds of activities as they apply to the specific conditions within such regions: (i) area development and farming systems; (ii) national programs of commodity research; and (iii) factor or disciplinary research dealing with such issues as soil and water management, pest control, and social and economic characteristics of the farm population.

A Bank-financed agricultural research project in Brazil is typical. At the request of the new Brazilian Agricultural Research Corporation, the Bank, with the assistance of several of the international agricultural research centers, helped formulate a national research policy and design a project of national and regional research programs that focuses on commodities which are basic food crops or valuable export or import substitution crops. The project provides for a program of research to accelerate the production of nine commodities (rice, maize/sorghum, cassava, cotton, beans, rubber, dairy cattle, beef, and mutton) in three regions through the improvement and/or construction, development, and staffing of 25 agricultural research centers. The project also includes an extensive technical assistance program for staff training and consultant services. One research station, for example, conducts natural resource reconnaissance and soil studies using mapping and remote sensing capabilities provided by another agency; ten on-going experiments covering geomorphology, climatology, and flora and fauna, plus studies of infrastructure, land use, population movements, and development policy; and work on water resources, plant physiology, entomology, and farming systems by expatriate (in the absence of local) technicians.

Through the "training and visit" system of agricultural extension, the Bank has supported the use of a systematic approach to conveying technological information to the farmer—especially the small farmer—that is
applicable to his situation in a form he can understand. The Bank now supports projects in six Indian states that use this system. More than 20 million farm families have been reached. When this system has been used over a sustained period, marked increases in small farm productivity have resulted. The system provides for the training and regular supervision of village level extension workers. They, in turn, provide farmers with very specific timely advice originating with subject matter specialists working in research institutions or elsewhere. Efforts are now being made in India to link the state agricultural universities' research programs with the state extension services. Extension projects, including those with some research, usually have been carried out at the state level in large countries rather than on a national basis. In most cases, the research is in the form of demonstrations.

3. Support for Science-Based Technology

The Bank, through its education and research lending, has financed over a dozen projects to expand and improve the research programs and facilities, upgrade the teaching staff, and create or improve undergraduate and graduate programs at agricultural universities—all essential to the use of science-based technology in agriculture. Most of these projects have been in Asia and Africa.

The Bank's first such loan in 1964 was in support of the University of the Philippines' College of Agriculture at Los Banos, which is adjacent to the CGIAR International Rice Research Institute. The Bank and others supported a major construction and equipment program to permit expansion and broadening of its facilities, following establishment by the Rockefeller and Ford Foundations. In two more recent loans to the Philippines, the Bank is supporting the University's College of Forestry, College of Veterinary Medicine, and Department of Animal Science; the development of three regional colleges of agriculture; and other aspects of the national agricultural education system.

Some Bank-financed agricultural research and extension projects also support agricultural universities. For example, a Bank-supported project provided fellowships to strengthen the faculty and funds to operate two commodity-oriented research stations and one substation at Assam Agricultural University in India. The Bank in addition supports agricultural training institutes at the post-secondary level (see chapter 3).

4. Funding of International Agricultural Research

As mentioned in the introduction to this report, the Bank provides the chairman, secretariat, and about ten percent of the funding for the Consultative Group on International Agricultural Research (CGIAR). 6/ Formed

6/ The CGIAR is not, strictly speaking, a "project financed by the World Bank," but is rather one of the very few examples of grant financing by the Bank of a technological activity. (A few others are under consideration.) It is included in this report to provide a full picture of the scientific and technological activities of the Bank in the agriculture and rural development sector.
in 1971, CGIAR is co-sponsored with the Bank by FAO and UNDP and now has 36 member countries and organizations. It consists of 13 internationally governed agricultural research institutes or programs with over 5,000 staff, including some 450 senior scientists, and a budget in 1979 of US$98 million.

CGIAR activities aim to meet the need for special international research and training efforts in critical aspects of food production that are inadequately covered by existing research facilities. A strong outreach program seeks to strengthen the capabilities of national programs, without which the international centers cannot be effective. The centers have now extended their work beyond the original biological research concerns and are examining the economic and social aspects of crops and farming systems improvement. The work in the 1960s of the centers which concentrate on the improvement of rice and of wheat and maize contributed substantially to the "Green Revolution"—the development and adoption of high-yielding wheat, maize, and rice varieties throughout the developing countries.

The CGIAR institutes and programs are:

(1) the International Center for Tropical Agriculture (CIAT) in Colombia, which has programs in both plant and animal sciences related to the humid, lowland tropics of the Western Hemisphere;

(2) the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, which is breeding varieties with higher yield potentials and yield stability under conditions of pest or disease attack, drought or low soil fertility (previously developed wheat varieties now cover over 20 million hectares worldwide);

(3) the International Potato Center in Peru (CIP), which is aimed at increasing the adaptability and improving the performance of this crop in both the low and high altitude tropics;

(4) the International Center for Agricultural Research in the Dry Areas (ICARDA), being established at three sites in the Middle East, which will be concerned with crop improvement (barley, durum wheat, broad beans, lentils, and chickpeas), soil and water management, and farming systems;

(5) the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, created to genetically improve selected cereals (sorghum and millet) and grain legumes (chickpea, pigeon pea, and groundnut), and to develop farming systems for the semi-arid tropics;

(6) the International Livestock Center for Africa (ILCA) with headquarters in Ethiopia, which emphasizes social and economic research on livestock production in tropical Africa;

(7) the International Laboratory for Research on Animal Diseases (ILRAD) in Kenya, which is mandated to develop control measures for two major animal diseases—trypanosomiasis and East Coast Fever;
the International Institute of Tropical Agriculture (IITA) in Nigeria, which breeds cereals (maize and rice), cassava, and grain legumes (soybean and cowpea), and develops technology for soil management;

the International Rice Research Institute (IRRI) in the Philippines, which has bred varieties that reduce the growing season from 160 to 100 days and in other ways increase yield and which is now breeding varieties of rice more tolerant of pests and diseases and developing more intensive land use measures;

the West Africa Rice Development Association (WARDA) with headquarters in Liberia, of which CGIAR supports the research program for coordinated rice trials;

the International Board for Plant Genetic Resources (Genes Board) with headquarters in Rome, which is intended to collect, conserve, and utilize plant germ plasm;

the International Service for National Agricultural Service (ISNAR) with headquarters in the Netherlands, which is to provide assistance to developing countries to plan, organize, and manage research more effectively; and

the International Food Policy Research Institute (IFPRI) with headquarters yet to be determined, which is to provide analysis and determine actions and policies that could affect a continued increase in the quantity and quality of food supplies.

5. **Bank Research on Socio-Economic Aspects of Agricultural Technology**

Bank studies examined the effects of the large-scale introduction of tractors to farms in Pakistan and India under Bank-supported projects. In Pakistan it was found that the average size of farms increased, as did the proportion of farms growing each crop. This resulted in high financial and economic rates of return, but the amount of labor used per cultivated acre decreased and some tenant farmers were displaced. The study concluded that providing smaller tractors and creating the option of loans for the purchase of imported tractors for farmers with less than 25 acres of land might have benefited a greater number of people.

A Bank study of rural development in Northeast Brazil concluded that the use of traditional farming methods in the region is rational given the present land tenure system and the excess of farm labor. The research indicated that attempts to introduce new technology may be hampered by the landlords’ unwillingness to have their tenants become less dependent and the tenants’ unwillingness to accept risks that could result in financial independence. In addition, it was concluded that efforts to introduce new technologies must deal with existing organizations—e.g., farm credit and marketing cooperatives. The results of this study are expected to be useful in designing effective rural development strategies in other regions.
The Bank sponsored baseline surveys in the Yemen Arab Republic and Ethiopia and a follow-up study in Madagascar to quantify the contribution of Bank-financed feeder-road projects to the economic and social development of subsistence-oriented local economies. The studies looked at transportation income distribution, and consumption effects of the project on different subgroups of the local population (farmers, traders, salaried employees, and craftsmen). The follow-up study in Madagascar found that the road itself was a marginal investment because of long construction time and high construction costs. Reduction in transport costs, however, made marketing of rice possible and produced a sharp rise in income, and the existence of equitable land tenure conditions ensured that income increases were shared by the majority of family farmers in the area.

These studies are typical of research by Bank staff, consultants and associates, financed from the Bank's research budget, 7/ which directly or indirectly bear on the selection of technologies to be used in the design and implementation of Bank-supported agriculture and rural development projects.

D. Training and Education

The changes in the purpose and size of the Bank's lending program for agriculture and rural development have had profound effects on the nature of the training and education needs in this sector. Previously most Bank-financed projects outside the education lending sector contained limited training components and the components which were included often received low priority in project implementation. In contrast, in FY79, the Bank included specific project-related training components in 63 of the agriculture and rural development projects it financed, lending a total of US$59 million for this purpose. Moreover, Bank-financed education projects include agricultural education and training components which support both basic and secondary education in rural areas, as well as agricultural training schools and university faculties.

Nearly all of the older and much of the more recent training components in agriculture and rural development projects have been project-related. That is, they are generally aimed at improving the management of human resources within the project organization, improving the skills of existing workers in the project and providing the workers with improved career development opportunities. The training methods have included study at universities or agricultural centers at home or abroad (usually supported by fellowships); and on-the-job training programs with resident experts, usually from developed countries, who advise local counterparts in the project organization or occupy line positions for which local staff later compete as replacements.

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The greater emphasis in recent projects on increased agricultural productivity for the poorest farmers has produced a need to provide technical skills to large number of people. In part, this increases the need for trained workers at the local level; to a much greater degree, however, it has led the Bank to seek means by which projects can have a direct impact on the skills of project beneficiaries—i.e., the small farmers themselves, their families, and others among the rural poor. Thus, bank-financed agriculture and rural development projects try to impart four kinds of skills: living skills, agricultural production skills, production skills related to non-agricultural jobs, and management skills.

1. **Living Skills**

Based on experience to date, the Bank believes that one of the most important contributions it can make to long-term agricultural productivity of the rural poor is to change the attitudes of large numbers of farm families toward their environment. For example, the combination of rising populations and poor cultural practices is causing severe soil erosion in many developing countries. Farmers need to develop an understanding of the causes of and the skills necessary for erosion control, forest preservation, and pasture management. Similarly, an ability to control livestock pests and diseases, to improve personal hygiene and communal sanitation, and to obtain adequate nutrition are skills necessary to the survival of rural populations. And, the accelerating change in the conditions and needs of rural life in most parts of the developing world makes the need all the more urgent.

However, the short-term needs of farmers for a livelihood must be balanced with the long-term capacity for increased agricultural productivity. To deal with this problem, the Bank is giving more attention to training needs in national agricultural sector studies (e.g., in Nepal, Bangladesh, and Lesotho). These efforts, which are still in the early stages of preparation, are intended to approach agricultural manpower requirements and training programs on a national level.

2. **Agricultural Production Skills**

The adoption of even one simple technique or input can often dramatically increase the productivity of the poorest farmer. Yet, many poor farmers are averse to the suggested changes, fearing the loss of their crop if new techniques fail. In addition, many poor farmers do not have access to institutional credit and must either borrow from moneylenders at as much as 100 percent annual interest or use existing savings to purchase the new inputs; they would risk losing all resources in a bad season or if new inputs are not applied correctly.

Therefore, the principles being emphasized when designing projects include: greater participation by farmers in determining which inputs they receive and how they receive them, strengthening of local research and extension services so the information and inputs provided are appropriate to the specific conditions in the area, and provision for additional sources of income (e.g., by training farm families to carry on cottage industries or subsidy farm enterprises such as fish farming, fruit production, or stall-feeding of livestock).
3. Production Skills Related to Non-Agricultural Jobs

The earliest project-related training in Bank-financed agriculture and rural development projects was intended to develop capabilities within institutions responsible for project implementation. Emphasis was placed on developing expertise within participating banks and other agricultural credit institutions; but some training for irrigation projects was also supported. As rural development efforts proceeded, training was included for the staff of rural extension agencies. This was sometimes directed toward the development of a specific crop within a given region. In both cases, an organization usually existed that could be the focus of training efforts. Most recently, the Bank has begun financing the training of skilled and semi-skilled workers in non-agricultural trades (e.g., welding, carpentry, plumbing, and equipment maintenance) and services (i.e., marketing, input supply, administration of cooperatives, etc.). Virtually all Bank-financed agriculture and rural development projects now contain provisions for such training to some degree, as do some agricultural education components of Bank-financed education projects in the case of artisan skills.

4. Management Skills

The local capacity to conceive, develop, and carry out agriculture and rural development projects is one of the most critical factors in the long-term success of the Bank’s rural development strategy. As the number of workers in Bank-financed projects increases, management and supervisory skills become more important. In many developing countries, existing skill levels and institutions to develop and upgrade them are very limited. Lack of leadership, limited career opportunities in rural areas, and low prestige and pay all contribute to a lack of motivation for acquiring such skills.

The Bank is trying to apply sound approaches to training and management in the projects it finances, especially those derived from world-wide experience gained in industrial settings. Experience suggests the need to treat whole organizations, so each level understands what is being done, and to institute long-term efforts which permit continuous training or periodic re-training. Doing this requires developing training skills among managers and supervisors, frequently setting up separate training units in the organization, and at times creating the capability to develop training materials. As an indicator of future trends, the Bank has appraised in one African country its first training project solely devoted to improving management practices in the agricultural sector.

Thus, development of local capabilities is one of the Bank’s principal development objectives. Its increased lending program for agriculture and rural development provides the opportunity for many developing countries to implement both more systematically and on a broader scale of training that will enable national, regional, and local agricultural personnel to improve their effectiveness and assist small farmers and their families to increase productivity.
E. Lessons Learned

1. Project Experience

The experiences gained through implementing the approximately 600 projects now under way are both positive and negative. Many were "pioneer" projects either involving activities new to the Bank or work with new agencies. Experience shows that there is often a need for considerable flexibility as circumstances change and as implementation reveals new possibilities or demonstrates the likelihood of failure. In many countries, experience with a first generation or pioneer project forms the basis for subsequent projects. Such experience may also form the basis for an expanded national program that goes forward without continuing Bank or other external support.

In the last few years it has become clearer which factors contribute most to the impact of specific projects. First and foremost, there is no substitute for government policies which combine (1) adequate incentives to farmers to produce, and (2) increases in the capabilities of rural operating agencies. Most projects are intended to provide a large number of individual producers with an opportunity to raise their output. Whether farmers take advantage of this opportunity has often been determined by external factors, such as the weather, international and national market price changes, or political change.

The experience with smallholder projects illustrates one of the several constraints on the expansion of Bank operations to address the problems of rural poverty. Tens of millions of small farmers produce very little in precisely those unfavorable conditions which currently available technologies cannot adequately overcome. Similarly, there are many hundreds of millions of people in the rural areas who either do not have access to land, or whose holdings are too small to sustain themselves and their families. These people can be reached through, for example, the creation of employment opportunities, both permanent and temporary. The Bank has financed more than one million temporary jobs through investment in raising production, land clearing projects, and public works programs. Nevertheless, experience serves to re-emphasize an important general lesson that the contribution to employment creation, either of the Bank specifically or of agricultural projects in general, is necessarily a limited one.

One other lesson of recent experience—perhaps the most important of all—is that poverty-oriented projects often need more time to be effective than conventional projects. In retrospect, this is not altogether surprising. Projects intended to help the poor may require several concurrent activities, often including (1) developing technology to suit small farmer capabilities and circumstances; (2) training and motivating extension staff; (3) training farmers and wider communities for full participation and self-management of institutions such as cooperatives; and (4) preventing discrimination against the poor and the pre-emption of benefits by the richer local leaders, who are sometimes more aggressive entrepreneurs.
2. Research and Extension

Building effective national agricultural research systems is a complex, time-consuming effort which requires a well-conceived national research plan and the commitment of technical and financial support over an extended period of time (10-15 years) by both governments and external donors. Research goals must be clearly articulated within a means-end framework to link to national development objectives, to guide research managers, and to provide a basis for evaluation. There is need to link research much more closely to production problems experienced by farmers. Involvement of producer groups in establishing research priorities increases the relevance of research results.

Failure or success of a country's technology generation effort is determined in large part by the competence and motivation of the research scientists and their support staffs. Adequate incentives, generally more attractive than those now prevailing, are essential. Attempts to economize on budgetary support in this respect may jeopardize the economic and social benefits from research. Training of research staff must be linked more closely to the task at hand. Overtraining in agricultural research projects may occur and is counterproductive when it reduces interest in practical research problems. There is a need for a balance among trained staff, including more diploma-level cadre to facilitate the testing and application of existing knowledge on farmers' fields.

Particular care must be taken in the design of projects with research components to ensure that these components generate useful research results that can be employed during the investment phase of the project. Research objectives and procedures must be clearly spelled out and linkages established between the research component and extension and between the components and the national research system. Equally important are assurances that the research activity will be supervised and implemented as effectively as the directly productive components. Given the usual time lag between research expenditure and results, projects of this nature could usefully include more than one phase. A first phase might focus on maintaining on-going work and on quick payoff, location-specific research to prepare for the directly productive second phase. Lending for agricultural research should be guided by sectoral standards pertaining to, e.g., physical infrastructure for research, training and remuneration of staff, and balance in numbers between support and professional staff.

The fundamental requirements of the "training and visit" system of agricultural extension are firm decisions to set priorities and concentrate efforts to ensure success right from the start. Such initial success generates growing enthusiasm for the system and the possibilities it offers of higher productivity in return for hard work done both by the extension agents and by the farmers themselves. The structure of the extension service should be flexible so that it may be introduced through modification and restructuring within an existing service rather than requiring a completely new organization.
Any fundamental reorganization of an agricultural extension service should, regardless of the scale of its initial introduction, be capable of being expanded to the entire state or nation. It should be possible to extend it to both irrigated and rainfed areas of production, and to all categories of farmers. Failure to recognize this need will result in the establishment of a favored group of producers—those in the project compared with those outside—and give rise to bitterness and resentment among the "have nots," which can only be harmful in the long term.

Finally, the system provides a service capable of raising productivity initially by introducing relatively unsophisticated techniques among farmers in developing countries and areas. As such farmers adopt more advanced methods of crop production and more diverse cropping systems, the extension service will need to increase its capabilities, advising on a wider range of crops and on much more sophisticated techniques. The system should have a built-in capacity for monitoring and self-evaluation so that it can be continuously modified and strengthened to meet the changing requirements of the farmers.
2. TECHNOLOGY AND URBAN DEVELOPMENT
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TECHNOLOGY AND URBAN DEVELOPMENT

Introduction

The need for supporting urban development projects for low income communities stems from several basic considerations: 1/ First, growth in urban population of developing countries is expected to exceed 4 percent per annum for the next two decades. In many cities, population growth will exceed 6 percent per annum. In a considerable number, population will double and urban area triple in less than a decade. To accommodate this growth by conventional permanent housing of even "minimum" cost standards would far exceed available resources. Currently, the supply of such housing is generally only a fraction of the increase in number of urban families. Put another way, except for the richer developing countries, most urban families cannot afford conventional housing unless subsidized on a scale that the public authorities could not possibly support beyond relatively small programs.

With no alternative, a growing proportion--often over a third--of the urban population lives in squatter settlements which, though overcrowded, unhygienic, and lacking in basic services, provide accommodation at prices that can be afforded. Such settlements represent a significant investment in housing stock built by self-help and without public investment, and often they can be upgraded with a minimum amount of relocation and modest investment. Better housing in terms of space and construction standards is generally of lesser priority to these poor urban families than better employment, education, water supply, health, etc.

The heart of the problem of urbanization lies in the rising numbers of the urban poor. 2/ If a city's population is growing at twice the national

1/ The Bank has published a number of sector papers related to urban development, including: Urbanization (June 1972), Sites and Services Projects (April 1974), Housing (May 1975), Urban Transport (May 1975), and staff working papers--e.g., No. 342, Johannes Linn, Policies for Equitable Growth of Cities in Developing Countries, July 1979. The Bank also sponsors an international newsletter, The Urban Edge.

2/ The Bank has adopted both "absolute" and "relative" poverty measures. Absolute poverty is calculated on the basis of a balanced minimum nutritional diet. The actual figures are calculated from the mix of food bought by the population at about the 20th percentile of income to fulfill this requirement; the cost is adjusted upward by a varying percentage for fulfilling other basic needs (e.g., housing and water). The relative poverty level is determined by the population group whose personal disposable income is one-third or less of the average income in the country. Different prices are used for calculating urban and rural poverty target groups. The larger of the target groups thus defined (i.e., those in absolute or relative poverty) is taken as the Bank's target group for operational purposes within a given country.
rate, the poor—in their illegal, unserviced squatter settlements, unemployed or underemployed in low productivity jobs—are typically growing at twice or three times the rate of the city's population as a whole. The Bank estimates that currently almost one-third of the urban dwellers in the developing countries lack the incomes and, therefore, the consumption sufficient to maintain a productive life. Over 250 million of them lack reasonable access to minimal nutrition, safe water, minimal sanitation, and basic education and shelter. The Bank also estimates that these numbers are growing by perhaps as much as between 15 and 18 million persons per year, and that unless much more is done to alter present trends, by the year 2000 over 600 million urban dwellers will be found living in these conditions. Appropriate national strategies to cope with this situation are generally lacking and overdue and must now be formulated as a matter of high priority.

The prospect of the supply of dwellings and urban services continuing to lag far behind the growth in urban population, with consequent further proliferation of slums and squatter settlements, intensified overcrowding, and deteriorating levels of services, is making reconsideration of current urban development policies mandatory.

The Bank has developed various approaches for meeting the needs of the urban poor and, while the approach is being continuously refined, the elements of the strategy are reasonably clear. In some instances, the strategy has involved the extension of the Bank's more traditional approaches in sectors such as water supply, power, transportation, sanitation, and education by specifically designing projects so that these services reach the lower income groups. The provision of many of these services is of critical importance to low-income groups who can usually undertake the provision of shelter itself, but who cannot provide the complementary services.

The sector-by-sector approach by itself, however, has had certain weaknesses which have required the development of more comprehensive and integrated approaches of shelter provision in order to strengthen the impact of these services on low-income groups. Most of these services, when taken by themselves, have an important role in the provision of shelter, but their impact is considerably enhanced when they are provided in a complementary manner. Provision of water alone, for example, will have a minimal effect on health unless complementary measures are taken to improve human waste disposal. Removal of stagnant waters and dangers of periodic flooding through drainage projects will have limited usefulness unless there is a system of solid waste removal to prevent the clogging of drains. To bring these services together requires a considerable degree of planning and integration of investments in urban services that is by and large lacking in most urban areas. These services are usually fragmented among different agencies and different levels of government and the coordination of investment is at best haphazard.

In addition to the problems of coordination, the purely sectoral approach has the disadvantage that it does not lend itself to addressing the critical problem of land tenure. All too often the lack of legal tenure is
a barrier which prevents public service agencies from delivering services to low-income groups. But more important is the fact that without the granting of secure tenure the necessary complementary investments will not be made by the private sector or individual households.

Thus, to overcome some of these problems, the Bank has developed what is termed an integrated approach to urban development to complement and support the sector-by-sector approach. These projects have as their focus specific communities and try to ensure the delivery of a complementary package of services that meets the priorities of those communities. At the same time, they are trying to improve the management capacity of cities so that the coordination of investment programs is greater and that greater priority is given to such issues as land tenure.

To improve the provision of shelter and related services, the major thrust of the Bank’s program has been the financing of slum improvement or upgrading projects in existing settlements and sites and services projects for the development of new settlements. The key feature of these projects has been the planning and provision of urban land (including tenure arrangements), public services, and private investments, together with improved employment opportunities. The Bank also finances separate urban transport projects.

The Bank’s entire approach to dealing with urban development problems is in a sense innovative and different from what is being done in many developing countries. For this reason, this chapter will first give a broad description of Bank-financed urban projects. In some parts of the approach to dealing with comprehensive urban planning that is characteristic of Bank-financed projects, there are specific technological considerations; these will be described in more detail.

About one-third of the Bank’s total lending is now urban-related in the sense that the projects directly affect non-farm jobs or provision of urban services. During the period FY73-79, the Bank lent US$1.1 billion for 42 specifically urban projects with a total cost of US$2.5 billion. In FY79 alone, the Bank lent US$310 million for 8 such projects costing in total US$761 million.

I. Serviced Sites and Slum Upgrading Projects

Bank financing can only provide a marginal contribution to the total of investment in urban dwellings and services required in developing countries. It follows that for a significant impact to be made, projects must be capable of repetition on a much wider scale without such assistance. This means that:

(a) the projects must provide a package of benefits that is widely accepted by potential occupants as well worth the charges made;
(b) such charges must be small, rentals or mortgage payments not exceeding a limited proportion, generally about 20 percent, of the income of occupants; and

(c) any costs not covered by the occupants must be within the capacity of the public authorities to bear on the scale of a large continuing program.

The replicability of urban projects, and thus their ability to reach all or most of the urban poor over time, depends to a large extent on how low standards and, therefore, costs are set, and on the extent to which costs are recovered from project beneficiaries.

The major achievement of Bank-financed projects is the drastic reduction of costs per plot compared with those of conventional public housing programs. This cost reduction has been possible because of reduced standards. Bank-financed projects generally do not involve the construction of a complete house, although some of the sites and services projects provide core structures ("wetcores")—i.e., minimum structures for sanitary facilities on the lot—or, for higher cost lots, minimal one-room structures ("core units"). Slum upgrading project components have not in general provided any structures, although loans for the purchase of materials have been made available in approximately half of them.

Other sources of cost savings in urban projects financed by the Bank have been the frequent adoption of communal water supply facilities, i.e., standposts, and of non-waterborne sewerage disposal systems; reduced lot size as compared with traditional land allocation systems; and road widths and surfacing that are appropriate to current needs but can be upgraded to meet future transport requirements. Standards and costs have generally been lowest in projects carried out in the lowest income countries (i.e., in most of Sub-Saharan Africa and parts of Asia). This difference is dictated by the extremely low levels of per capita incomes among the urban poor in these countries and reflects the sensitivity of project design to the different levels of ability and willingness to pay.

A. Self-Help and Mutual Help

In both sites and services and slum upgrading projects, self-help or mutual help methods have been applied to the construction of dwellings and some community facilities. These methods have in some cases also been employed in road formation and the laying of water and sewer pipes. To be effective, self-help requires technical as well as financial assistance to the poor families and the settlement communities.

Bank-financed projects provide technical assistance in the form of individuals or groups of individuals who work with local project units—e.g., sociologists, community workers, and others who not only help implement the technical aspects of construction but also assist beneficiaries in applying for housing and obtaining title. In India, by and large, self-help has been a tradition for a long time and many such individuals are available locally; in Egypt, in contrast, they must come from outside the country, but local people quickly pick up the necessary skills and continue on their own.
All sites and services and slum upgrading projects supported by the Bank have aimed at the maximum use of self-help. However, in most circumstances, there are aspects of the construction process (plumbing, for example) for which self-help is inappropriate, so that some direct construction is required for efficiency. In most sites and services projects, the distribution network cannot be conceived as ending at the property line; it extends to the toilet and washstand, or the utility bloc. As it is possible to economize on these installations by providing them for two to four houses at one time, there is frequently a case for constructing a wet wall or "party wall" at the same time. This principle may also apply in cases where two-storey row housing leads to a more economic use of land. In most instances, the construction of the two common walls would have to be organized.

Some tasks, in addition, cannot be performed as efficiently through self-help as on a contracting basis. Even in the Botswana project, with minimal service standards, aqua privies could be installed by a contractor at significantly lower cost than by each family individually. In the Republic of Korea project, construction of the foundation and floor, which included ducts for the heating system, was beyond the technical capacity of the families which were to occupy the sites. This construction component was, therefore, incorporated in the project.

The duration of the construction period affects the relation between direct construction and self-help. Sometimes self-help methods take too long to be utilized for project components which must be completed early. For the working poor, who form a significant proportion of very poor families, spare time to construct a dwelling may be extremely limited. Families often need protection from rain or cold while constructing or improving their dwellings. In either case, some shelter is usually required for the self-help process to get started. Additional special features, such as the need for earthquake-resistant design in Nicaragua and fire prevention in Indonesia, may require some degree of direct construction. A temporary shelter or small core unit may in some instances be required to convince families that development will in fact take place throughout the project area, enabling them eventually to benefit through neighborhood development from one another's efforts. Such partial construction is generally described as "core housing". It is built, as far as possible, of traditional materials. But, in some cases, more modern construction methods are required for structural reasons. Reinforced concrete, for example, was necessary to ensure resistance to earthquakes in the Nicaraguan project.

No consistent pattern has emerged in the use of mutual help, self-help, or small enterprise builders for consolidation. Variations clearly exist even between sites in the same city. Mandatory mutual help groups have been developed to a highly successful stage in site construction in El Salvador; most such groups are now being voluntarily extended to undertake dwelling construction. Mandatory systems, however, exclude some applicants because of the rigid work schedules. Voluntary groups on a smaller scale, particularly for foundation work, have developed with project unit support, the Nairobi Dandora serviced sites scheme providing a good example.
Self-help is generally concentrated on unskilled work, including such tasks as laying cement floors and preparing of soil cement blocks where, as in Dar-es-Salaam, conditions are appropriate. Local skilled labor is generally contracted for building walls and roofs, the family and neighbors supplying the unskilled assistant labor. The savings in cash outlays, corrected for loss of potential earnings during construction, has not yet been determined. Preliminary evidence suggests that the self-help element in dwelling construction, at least for the initial room, has been less, and paid labor has been more, than generally anticipated. In practice, the phasing of expenditure and the occupancy of the plot while building will probably prove at least as important as self-help in ensuring affordability.

The Bank recognizes the limits as well as the advantages of self-help and, therefore, supports assistance to small contractors and other small businessmen who are often the most efficient suppliers of the materials and services required. Such action often strengthens the private housing supply capability, and provides a promising possibility for extending the Bank’s traditional support for industry by stimulating the supply of materials for self-help construction.

B. Technological Considerations

Appropriate building standards can do much to create a safe and pleasant environment, for example, by ensuring adequate circulation of air, preventing structural failure, or limiting the likelihood of fires, floods, and similar hazards. However, if standards are set too high for existing income levels, either officially or by the architects and engineers responsible for a particular project, their primary effect will be to push down the living standards of the poor by reducing the amount of housing available at prices they can afford. The poor will then be driven to bribery to retain or construct "substandard" housing.

As a general rule (e.g., in Kenya, India, Thailand, and the Philippines), the type of construction used in Bank-financed projects is brick or concrete block. One or the other of these is usually the cheapest available local material. For example, in Calcutta and Thailand clay is in plentiful supply, while cement has to be imported (at least from out-of-state); in Kenya, the cost of burning brick is high compared with cement. So, by and large, the cheapest and best alternative is still to build with blocks or bricks. Roof construction also depends mainly on the locality, with corrugated sheet material usually used in preference to asbestos. In the really poor cities or countries, clay tiles are used on bamboo rafters.

Project target populations are usually unskilled and uneducated; they, therefore, find simple technologies (e.g., building with bricks) easier to adopt than more complex technologies such as prefabrication. Where experiments in prefabrication or partial use of panels to be bolted together have been tried, the system has usually been found to break down—either the steel required for reinforcement runs out or there is lack of quality control for the sand and other materials used or in the curing of the concrete.
Project beneficiaries tend to build internally with temporary materials (mud wattle on poles or fiber or palm matting) with a view to building more permanent structures either inside or outside later on. In most cases, when people are left a free hand, their style of architecture is probably more responsive to the inherent qualities of the building materials and the local climatic conditions than architect-designed schemes.

Usually there is a conflict between what is affordable by the poor and what is officially regarded as minimally acceptable. The Bank has been supporting experimentation with other materials, such as mixed soil-cement blocks and sun-dried bricks. In many cases local building codes have to be specially negotiated to allow minimum quality materials to be used in sites and services projects.

The Bank does not have fixed criteria for architecture and design, but it is beginning to develop some guidelines. For example, waste of building materials should be minimized. This can be achieved through proper orientation of buildings (so that solar protection devices are not required) and use of earth banks and stone or tile-pitching to save on vertical reinforced concrete retaining walls. Such general criteria must be applied with due consideration to local soil conditions, building techniques, climatic conditions, social behaviors, and attitudes toward density.

In terms of planning of buildings and layouts, Bank-financed projects are giving increased emphasis to local life styles. This has resulted in more local public participation in planning and implementation. While in the past layouts of plots were largely dictated by attempts at cost minimization (e.g., in the utilities and roads to be supplied), the solutions now used may be modified to take account both of social customs and their acceptability. Social behavior patterns are also reflected in the location within plots of the housing that will be constructed and the way in which it will be used.

The Bank encourages a greater amount of social analysis in early stages of project preparation to better understand the cultural backgrounds of the target populations that can influence house layout. For example, societies on urban fringe areas are in transition between rural and urban living habits. Since they often keep domestic animals (chickens, goats), the layout must allow for movement of these animals between the back and front of the plot. In some societies it is in bad taste to have the toilet or ablution area in front of the dwelling, so it has to be in back and the implications for plot layout are considerable. Cooking habits also dictate the layout, when space must be utilized for cooking outdoors, and the shape of rooms, when one is used as a kitchenette.

Space and building standards for schools, health clinics, and public buildings of different types are often excessively high. Urban projects financed by the Bank increasingly include these kinds of buildings and often the provision of these buildings is the responsibility of a single organization. This offers an opportunity to re-examine the building standards for a range of different structures in the light of the uses to which they will be put.
The Bank has had, through the development of urban projects, an impact on the many consulting firms that operate in both developed and developing countries in their use of intermediate technologies and the development of low-cost systems. There has been considerable transfer of this kind of expertise from Bank staff to consultants who then apply it in projects of other borrowers. Local consultants on a Bank-financed project in El Salvador, for example, have advised on low-cost housing and infrastructure in other projects financed by the Bank in Peru and Colombia. The Bank also encourages joint ventures of foreign and local consulting firms, both in design and training components of projects, to enable the greatest transfer and most suitable use of skills and technologies.

C. **Institution Building**

An extremely important objective of Bank-financed urban projects is to develop the institutions responsible for urban development and to mobilize local organizations that can assist in this process. As a result, about ten percent of Bank urban projects lending has been for technical assistance. In addition, Bank staff provide considerable technical assistance, both formally in the course of project work and informally by sending publications and other materials to officials with whom personal relationships have been formed. The Bank's Economic Development Institute (EDI) also gives an annual course on managing urban growth.

The nature of the technical assistance which Bank financing provides depends on the local situation, but the range of situations and assistance provided is very great. The familiar dilemma between creating new agencies and project units or adapting existing ones is particularly evident in urban projects. Initially, there often is no obvious focal point in national and local administrations for discussing the wide variety of aspects involved. The concepts and standards are still very new; they also challenge the thinking and status of technical and bureaucratic experts—particularly those in "low-cost" public housing and related institutions.

Special project units are often required for implementation because of the complexity of the services supplied, land acquisition and spatial problems, the often many thousands of families involved, and the need for on-site activities beyond physical construction. On the other hand, the need to coordinate the inputs of many agencies and the underlying objective to develop more appropriate national policies and programs for housing and urban development indicate that existing agencies should be adapted and that new ideas should be more broadly disseminated.

When a project team or project coordinating unit is set up, it is usually necessary to develop a nucleus of skilled people. Normally the people in a unit have to be trained locally, but specialized training overseas is provided. Sometimes consultants are employed to establish the unit and thereafter attached to it either for a short period or, when local expertise is in short supply, for the duration of the project to provide on-the-job training that may continue after the physical completion of the project. The objective, however, is to encourage subsequent projects that a unit will be able to develop itself for financing by the Bank, other external sources, or from local resources.
Since adequate local finance is essential to replication of urban projects, the Bank may seek a review of municipal organization and finance in a first or second project. This permits addressing the lack of local resources in subsequent projects. In India, Indonesia, Thailand, Kenya, and Lesotho, as a result, the Bank is encouraging the development of property valuation systems to expand local resource bases. In West Bengal, a central property valuation Board is being created which will ultimately replace over 200 local boards to ensure uniformity of valuation; Bank staff are advising on the law, and the organization and management of this Board.

The range of institution building efforts supported by the Bank is exemplified by work in Upper Volta, Egypt, Kenya, Brazil, and India.

In Ouagadougou, Upper Volta, the Bank is helping to organize a housing department to award mortgages and to collect money from beneficiaries. Even though the project unit is small, it has been necessary to bring in foreign consultants to supplement and retrain local experts.

In Egypt, a project development unit was set up within the central government's Ministry of Housing to coordinate the Bank-financed project and to develop future projects. Actual project execution, however, is to be provided by departments of the governorates of Cairo and the other cities involved, since they already have good facilities in terms of planning mechanisms, personnel, and equipment for urban development schemes.

In Kenya, the Ministry of Local Government, which is responsible for local authorities, has recognized that many local authorities were having difficulty fulfilling their responsibilities. So the approach taken by the Kenyans as part of a Bank-financed urban project was to reorganize the Ministry to respond to the local government's needs. This involves establishing a development wing in the Ministry to be responsible for planning and development of the local authorities and, as a later step, creating a pool of technical consultants consisting of Ministry staff, local hires, and foreign experts (financial advisors, engineers, planners, and valuers) so that wherever and whenever there is a local problem they can be sent to re-design and improve the local effort. Among the local institutions being used in Kenya are the Kenya Institute of Administration, which is helping with training, and various colleges of technology that have assisted with minor research studies--e.g., in traffic research--and by providing technical assistance to self-help efforts by project beneficiaries--e.g., in showing how to mix mortar and place bricks.

In Brazil, the Bank's primary objective is not financing the construction of low-cost housing for its own sake (even though the loan of US$265.7 million in FY79 is by far the largest single urban project loan to date), but to support the improvement of the National Housing Bank (BNH) and associated sectoral institutions in expediting the design and completion of low-cost housing in programs that were slow-moving. In order for BNH to effectively utilize its funds, the Bank-financed project will help develop the housing societies (builders) that borrow from BNH and improve BNH's capacity to develop these societies and provide funds expeditiously to potential homeowners.
With Bank encouragement, BNH will continue, expand, and complement under this project its ongoing technical assistance programs that include: (a) diagnoses of the housing deficits in project areas, (b) experiments in the use of soil cement bricks and blocks for low-income housing, (c) review of the adequacy of the municipal building code in Sao Paulo for low-income housing, (d) community development assistance to low-income housing companies, (e) evaluation of beneficiaries' response to low-income housing programs, (f) development of improved methodology and training techniques for design of low-income housing carried out by a group of specialists from six universities, and (g) management diagnoses of low-income housing companies carried out by a Brazilian organization.

Some of the Bank's most comprehensive urban institution building efforts to date are being carried out in cooperation with the federal and certain state governments in India. Working with three different forms of metropolitan authority and the many local authorities that make up the metropolitan areas of Bombay, Madras, and Calcutta, Bank-supported efforts are under way to resolve some of the more intractable problems of these three cities whose total population exceeds 20 million. In addition to assisting in the organization of the three metropolitan authorities, the Bank is involved in local government reorganization, local utilities reorganization, expansion and modernization of public transport systems, and in every form of locally provided service (for a description of the Calcutta project see the introduction to part II of this chapter). In each sector some form of institutional reorganization is occurring to provide expeditious and improved service delivery. In addition, regional planning, resource generation, and fiscal support systems are being developed by methods ranging from new legislation through design and installation of new systems and staff training.

D. Bank Economic Research and Project Monitoring

The objective of any responsible urban strategy must be to increase the capacity of towns and cities to absorb the newcomers. Absorption means providing productive employment and essential services at basic levels for these people. The Bank, therefore, has been studying the complementary relationships between urbanization and rural development, and the policy variables that are important for managing equitable growth are being explored. Special studies have been launched in a number of countries where urbanization and urban poverty problems are particularly severe.

This economic work, together with special studies of particular sectors or issues, is intended not only to provide guidance for project selection and design, but more importantly to provide a sound basis for policy dialogue within governments and between the Bank and its borrowers.

The Bank has been conducting research relating to urban development mainly in three areas. One is descriptive/analytic work related to urban poverty, including both measurement and conceptual aspects that are directly helpful in the formulation of appropriate programs and projects. The second is the creation of productive employment opportunities, involving the functioning of labor markets, an improved framework for economy-wide analysis
of policy options for employment creation, and project-related research on employment impacts—particularly of small and medium enterprises. The third is research to increase understanding of how cities function.

In this last area, a major study was made of a specific city—Bogota, Colombia. The study developed tools that can be used to estimate the spatial and economic impacts of policy interventions in the planning, development, and evaluation of projects. The study was carried out in part by consultants, half of whom were Colombian, and by two local institutions. The Bank, through such work, is seeking to develop the analytic approaches for designing city strategies—i.e., defining the medium or long-term development focus for a city and as a result the public sector investment program and institutional forms required to carry it out.

In the preparation of projects, the Bank encourages borrowers to engage consultants with the capability of designing to standards appropriate for the income, population density, location, and other factors in the project area. The Bank carefully reviews feasibility studies and advises borrowers on their suitability; in some cases it may commission additional studies.

The Bank frequently includes pilot components in projects so that there will be experience on a number of key design features such as tenure arrangements, mutual help response, organization, and staffing and will be a vehicle for continuing discussion between the borrower and the Bank regarding policy and implementation arrangements for the subsequent program. Experimental efforts to create employment under a first loan to El Salvador, for example, are being expanded and placed within a permanent institutional base under a second loan.

The Bank is carrying out a program of monitoring and evaluation of the urban projects it finances. In El Salvador, Senegal, and Zambia, attempts are being made to measure the impact of various project components, such as credit provision and self-help programs, on urban population groups. Comparison of actual impact with original project objectives provides insights that can be expected to have an immediate pay-off in terms of project design and appraisal. In El Salvador, analyses carried out to date have found that Bank-supported sites and services projects and slum upgrading components obtained higher financial returns than government-sponsored housing schemes.

Some Bank-financed urban projects are monitoring their effects on women. Others are providing services and activities of special interest to women, such as child care, retail markets, and water supplies and are involving women’s community groups from the early planning stages. The high proportion of female-headed households among the urban poor has been recognized and efforts are made to ensure that they, and women in general, benefit from the credit components of some urban projects that support activities such as carpet weaving, food processing, or trading.
E. Lessons Learned

The crux of the Bank's approach to urban shelter is the ability of the householder to begin with an investment he can afford and gradually to increase the investment and standard of the housing as money becomes available to him. By starting with minimum standard dwellings that the poor can afford, that are replicable, and that are designed to be upgraded as the services also provided increase the new homeowners' incomes, the result over time has been more low-cost housing of all standards than has proved possible when high standards alone have been the starting point. Under Bank-financed projects, some 1.25 million poor urban dwellers are being provided with serviced plots; an additional 4.5 million are being covered by upgrading schemes. Already, enough projects are sufficiently advanced to show that the approach can provide acceptable dwellings, utilities, and other services at costs that most of the urban poor can afford and at a fraction of the cost of earlier public programs for low-cost housing.

Over the last few years, developing countries have increasingly adopted the progressive approach of the Bank's program as an alternative to slum clearance and "low-cost" housing schemes. Those schemes, because of the heavy subsidies involved, could not possibly meet even a fraction of the needs of the urban poor. In this change of attitude, the Bank's program has played a leading role. Moreover, in almost all the countries with Bank-assisted projects, the initial projects are now leading to programs on a multi-city, regional, or national scale. This development reflects substantial progress towards the long-term objectives of appropriate urban policies and strengthened implementing agencies, though there still is a long way to go.

The earliest projects for serviced sites were designed to reach not far below the median level of family incomes. Compared with conventional schemes of public housing, that already was an achievement. These projects have since been refined and adapted to reach urban families at much lower levels of income, often excluding only the poorest 10-20 percent. The build-up of technical design expertise—among local authorities and consultants as a result of Bank initiatives and indeed among Bank staff—has been a principal factor in this process. New methodologies and analytical tools have been developed, for example to test trade-offs between alternative design features. Because market values of project sites often are well in excess of the costs, it has been possible to charge more for commercial plots and the plots allotted to higher-income families in the target group and to charge poorer families correspondingly less than the share of the costs indicated by the plot costs.

Projects for upgrading slums and squatter settlements can reach even lower income groups. An outstanding example is the Kampung Improvement Program in Indonesia, where two Bank-assisted projects are succeeding in reaching some 2,290,000 inhabitants of the poorest quarters by providing basic improvements in living conditions at a cost of roughly US$50 a person. Such projects for existing squatter areas can accordingly provide a most important supplement to the serviced sites, which increase the total stock of housing and thus provide for a growth in population. Moreover, the projects providing
serviced sites or upgrading squatter areas can benefit even those urban poor who cannot afford such modest dwellings. The provision of additional sites and the stimulus given to new dwellings or expansion of old ones increases the availability of rented rooms, which are often of critical importance to the very poor.

The economical layouts, the better location in relation to employment opportunities, the improved facilities for transport, health, and education—all these contribute to urban efficiency, though the contribution is difficult, if not impossible, to quantify. The quick take-up of commercial and other employment sites indicates their success in fostering productive employment, if on a rather limited scale so far. The evident expansion of commerce and small-scale enterprises in project sites also indicates a significant addition to local output and employment, even though net employment gains from the project cannot be measured because of the wide secondary effects. Part of this local expansion of economic activity—which adds to net output, savings, and employment—is directly attributable to the construction associated with the projects; part to the indirect effects of improved access and transport.

The experience to date also demonstrates the need for a sequence of projects to overcome some of the inherent difficulties in developing appropriate programs and policies in this field. In large part these difficulties derive from limitations in local administrative capacity and the constraints of existing social-bureaucratic-legal frameworks. The general shortage of even poorly trained local staff and the time required to alter basic procedures, particularly those related to land and tenure, make first projects especially difficult and limit the advances that can be made. Yet without the stimulus of the initial projects, it is doubtful if many of the obstacles to a more rational approach to meeting the needs of expanding urban populations would be attacked, let alone solved, in the near future.

II. Project Components

As explained earlier, a distinctive feature of sites and services and slum upgrading projects, and of urban projects generally, is that they are multisectoral. Most sites and services projects include planning and provision of land, low-cost public utilities, social services, arrangements for beneficiaries to build their own housing, and attempts to improve the employment opportunities of the target populations. For slum upgrading projects, the housing is largely already there, though there may be provision of credit for improvements to it. These projects may also provide communal and social services, as well as public utilities and components to address employment needs.

The Bank is broadening in a number of ways the urban projects it finances. An example of an extremely comprehensive project is the Second Calcutta Urban Development Project. It provides for: (a) residential, industrial, and commercial sites and services development involving a low-cost integrated approach to providing accommodation, community facilities,
and employment opportunities; (b) redevelopment of the Howrah fish and pan (betal nut) market; (c) participation in an ongoing bustee improvement program which provides basic infrastructure services in slums serving over 1 million people; (d) construction of new primary schools and the remodeling and extension of existing schools; (e) training, equipment, and buildings for a pilot health program; (f) institutional credit and studies to assist very small enterprises; (g) fringe area and municipal water supplies to provide water to over 1 million people, improvement of tubewell supplies in the central area, and renovation of the system to supply water to the Calcutta Corporation; (h) provision of sewers, including house connections, to some areas presently served by bucket latrines, cleaning of partially blocked sewers, improvement of storm water drains, and installation of prefabricated sanitary latrines to replace bucket latrines; (i) rehabilitation of the system of refuse collection, street cleaning, and night soil collection for an area with 3.15 million people, and pilot projects to develop long-term solutions to solid waste management; (j) provision of water supply, drainage and sanitation, and road works in the rural fringe areas of the city; (k) traffic engineering with emphasis on pedestrians and slow-moving vehicles, new roads, and road improvements to facilitate economic development; and (l) technical assistance to State Government agencies, the Calcutta Corporation, and the Calcutta Metropolitan Development Authority.

The following sections give more detail from a technological point of view on three important components of projects—water supply and waste disposal, energy, and small enterprises.

A. Water Supply and Waste Disposal 3/

1. Introduction

Providing safe water and waste disposal facilities to the urban poor, particularly to densely populated squatter settlements, is a major challenge faced by developing countries. Ideal or preferred solutions, such as individual house connections and waterborne sewerage, are usually too expensive for urban poverty groups, at least initially. Five percent of income for water and waste disposal services is frequently used as a rule of thumb for estimating affordability.

In addition to financial considerations, cultural, technical, institutional, political, and other factors must be investigated. What is important is to consider the range of alternatives. This is more likely to result in an appropriate solution.

2. Water

a. Financial Considerations

Some countries could provide the poor with access to safe water if they could develop a system for charging users and collecting the amounts

3/ For a more general treatment of Bank support for water supply and waste disposal see chapter 6.
owed. The lack of such a system may mean that low-income groups, depending upon vendors, are increasingly burdened by the cost of water. In one large Central American city, for example, many low-income families pay seven times as much for water per liter as middle-income families and five times as much as high-income families; their per capita water consumption is about one-fifth the average consumption there because of the poor facilities.

Water-metering is the conventional approach used to charge for water supplies and to prevent waste of water. Without it, cities face the expense not only of providing increasing quantities of water but also of removing, treating, and disposing of additional wastewater.

Unfortunately, many countries lack capacity to keep meters properly repaired and read and to detect and repair leaks. In one East African city, according to a recent Bank study, only about 40 percent of the water delivered was being metered, and much of the metering was of dubious accuracy. In many cities, over 50 percent of the water is unaccounted for. The problem is particularly great for cities in which much of the water is delivered by standpipes.

While more research and experimentation is needed, some countries have developed innovative administrative systems for dealing with this problem. Under the second Bank-financed Kenya Urban Project, for example, the Nairobi City Council has agreed to provide water kiosks at appropriate locations in a number of low-income areas of the city. Operators will be licensed and regulated. Inspections are to be periodically carried out to ensure that the appropriate quantity and cost of water are maintained.

b. Technological Choices

The per capita costs of providing household connections to urban dwellers is estimated to be several times the amount necessary for providing service by standpipes, if in-house facilities are also included (US$120 compared with US$40 for standpipes). The price difference depends on such factors as the number of taps provided, the quantity of water involved, and the availability of skilled personnel. Because of the expense of individual house connections, some governments are recognizing the possibility of initially introducing standpipes to low-income areas and then, as the ability to pay increases, to install yard connections, and, ultimately, house connections.

Because lower income groups are frequently ignorant of the relationship between unclean water and disease, a hygiene education program is regularly included in Bank-financed projects. With increasing public understanding of the importance of clean water, residents may be willing to pay for a higher level of service. In a Latin American city, this happened within five years of standpipe construction, causing barrios to petition for a full water distribution network including metered house connections.
A country which is approaching its water-supply problems in a progressive way is Liberia. In Monrovia, as in many other cities, some of the poorest inhabitants are found scattered among high income residential areas while others are in high density, well-defined slum areas. The poor in high income residential areas often obtain their water through illegal connections. However, an estimated 70,000 Monrovians have limited or no access to pipe water.

To encourage legal connections in areas with access to piped water, the current US$35 water connection charge has been abolished in the first Bank-supported water supply project in Monrovia. Instead, a more progressive tariff structure will be introduced, subsidizing service to the poor. At the same time, about 100 standpipes are to be installed, together with more than 50,000 feet of piping, providing water to most of the city's slum areas.

3. Urban Waste Disposal

a. Technological Options

Because of the expense of the conventional sewerage system, many developing countries are studying alternative solutions. The suitability of these technologies depends upon water supply service levels, soil conditions, housing density, financial constraints, cultural practices and hygiene habits, and institutional capability.

The Bank is encouraging a step-by-step approach, leading from one option to another and designed from the outset to minimize costs over the long run. Thus, a community could initially select one of the low-cost technologies in the knowledge that, as their socio-economic status improves, it could be upgraded, depending on the desires of the users and their ability to pay.

Various schemes are feasible for a staged sanitation system. One such could involve starting with waterless latrines and eventually evolving into a pour-flush/cistern flush system with small bore sewers. The initial installation could consist of a ventilated improved pit (VIP), Reed Odorless Earth Closet (ROEC), dual-vault improved pit latrine, or composting latrine. For the first two types, emptying could be required every 5-20 years. The latter two require emptying every 6-24 months; since users select them in part for their output, they are less likely to be upgraded. This stage would last until the community water supply was upgraded from communal standpipes or wells to yard hydrants, and sullage management became a problem. With increased water availability, a dry latrine could be converted to a pour-flush system. In densely populated areas a vault or soakaway would have to be added—except in the case of ROEC, which already has an offset vault. Regular collection of accumulated sludge would be required for vault toilets not equipped with drainage facilities, along with a facility to dispose of the sludge. Vaults could also be provided with a baffle and overflow pipe to carry the overflow liquid to a soakage pit or drain field. Only occasional collection of sludge would be required for these baffled vaults/septic tanks.
The third stage would begin when the water supply service is upgraded to house connections and a large quantity of sullage water has to be disposed of. At this point, a small diameter sewer system could be constructed to accept the overflow from the baffled vaults/septic tanks (replacing the drain fields and soakaways). This solution could permit the use of low-volume cistern flush toilets.

Because of persistent problems with odor and harmful insects with pit latrines, experiments are being made for possible improvements. One apparently useful innovation is the provision of a pit venting pipe located externally on the sunny/windy side of the latrine superstructure. The air in the vent pipe circulates in such a way as to eliminate odors. By screening the vent pipe, fly nuisance can be substantially reduced. The latrine can be designed to be emptied manually or mechanically. Under favorable conditions, the ventilated improved pit (VIP) latrine appears to be a low-cost, trouble-free, and hygienic solution.

Another example of appropriate technology is stabilization ponds in place of conventional sewage treatment plants. Household privies, septic tanks and filter drains, and other minimum technology solutions may create environmental and health problems. In waste stabilization ponds, however, the decomposable organic wastes are stabilized by microorganisms and the number of disease causing agents is reduced significantly. The advantages of stabilization ponds over other methods of treatment can be summarized as follows:

1. **Low Cost.** Provided that land is available, both construction cost and operating cost are cheaper than for other methods which provide comparable treatment.

2. **Ease of Operation.** This treatment system requires very much less operating skill, as the process is very simple.

3. **Little Mechanical Equipment.** Very little imported mechanical equipment is required for this process.

4. **Decentralization.** In contrast to other methods of treatment, the construction and operation of a treatment works at each of the present sewer outlets is economically feasible. There is no significant saving in the construction of one large stabilization pond rather than a number of smaller ones. The cost of conducting all the sewage to one or two points is therefore saved and other advantages of dispersal maintained.

5. **Redundancy.** The land acquired for the stabilization ponds can be put to other use if more economical treatment methods are found to be feasible in future.

In a number of cases the Bank has financed the construction of stabilization ponds in place of "conventional" sewerage treatment plants.
b. Training

Next to insufficient financing, the lack of trained personnel is perhaps the greatest constraint to the improvement of community water supplies. While many developing countries have the necessary small number of professional staff to serve the water sector, most do not have adequate numbers of sub-professionals. The situation is even worse for sanitation or sewerage staff at both levels.

The lack of trained personnel at operating as well as the managerial level accounts for the frequent lack of spare parts and preventive maintenance in developing countries. As a result, some of these countries rely excessively upon expatriate engineers and contractors.

Among the countries that have recognized the importance of training in water supply and sanitation and have instituted training programs are Brazil, Tunisia, and Colombia. In Gwangju, one of Korea's poorest and least developed regions, a second Bank-financed project is providing technical assistance to improve Water Bureau operations, administration, and management, based on studies carried out under the first project. This assistance will include training of Bureau staff in the design and installation of accrual accounting systems, training of treatment plant operators and laboratory technicians (using local and expatriate expertise in the various disciplines involved at one central location in the region), and training of selected Bureau staff in planning and implementing a water loss control program, including field use of leak detection equipment.

c. Community Acceptance

There are many examples of people ignoring, rejecting, or misusing sanitary and water facilities provided by governments. Each innovation requires behavioral changes or adjustments: acceptance of increased taxes or charges, new hygienic practices, cooperation with neighbors to maintain the facility and prevent misuse of it, training and supervision of children's utilization, etc. Unless people understand and appreciate what is offered or available, innovation may do more harm than good.

What is necessary is increased communication or dialogue between communities and government agencies. Agencies should encourage dialogue with communities in order to encourage them to play a major role in: (a) defining their existing situation; (b) choosing among alternatives; (c) determining methods of implementation; and (d) setting up social controls for continued use and maintenance.

Cities such as Jakarta, Calcutta, and Manila use voluntary or community health workers to provide information to local families on many aspects of health, including personal hygiene and environmental sanitation. Visits to demonstration projects, lectures, and slide or movie presentations (particularly in schools), and the use of radio and other mass media devices may also be effective. While particular attention must be paid to community leaders, it is also important to include women insofar as they are responsible for the health, training, and well-being of their families.
4. Solid Waste Disposal

Solid waste disposal is a problem that particularly affects the urban poor. Generally they do not receive the collection services necessary to provide clean and healthful conditions. Solid waste, however, has the potential for providing employment for the poor in both the collection and re-use or sale of refuse and for energy production.

Some Bank-financed urban projects have included components for the improvement of solid waste collection and disposal schemes. For example, solid waste collection is a major problem throughout urban Egypt. The governates' responsibility for refuse collection is limited to street cleaning. House-to-house collection is left to small private contractors called Zabbaleen, who pay fees to middlemen for the right to collect waste from designated buildings. Zabbaleen are usually squatters earning their living by sorting the refuse at their settlements and selling all reusable matter. In Cairo, the Zabbaleen also feed organic waste to pigs which they raise to sell to supplement their incomes. Composted waste is sold to farmers as fertilizer. It is more profitable for the Zabbaleen to collect refuse from the wealthy areas, so poor neighborhoods are neglected.

The objectives of a Bank-financed solid waste management project component in Cairo is to set up a planning organization and test a number of concepts: (a) formation of a Solid Wastes Planning Unit that will manage the current program and later form the nucleus of a Cleansing Directorate; (b) provision of improved water supply and sanitation, community facilities, and development of prototype zeribas (family units comprising a dwelling, sorting yard, and pig pen) at the main Zabbaleen settlement; (c) provision of composting and metal baling facilities at this settlement for cooperative operation by the Zabbaleen; (d) negotiation and control of a contract with the Zabbaleen for a daily collection service from the town where their settlement is located (as a test of the contract system); (e) a pilot project for windrow composting at a third site, followed by design and construction of a plant with 200 tons per day capacity to replace the existing plant at that site; and (f) a pilot project for street cleaning and collection for about 40,000 people of various income groups to serve as a model district for subsequent extension.

B. Energy 4/

The urban poor need energy for cooking, especially, but also for lighting, heating water, ironing, protection, and small enterprises. They spend as much as 25 percent of their incomes for the purchase of fuels, both commercial (mainly kerosene, but also coal, town gas, bottled gas, and electricity) and traditional or non-commercial. Some must spend considerable time in collecting and preparing their own fuels, principally firewood and charcoal, but also crop and animal wastes—all of which are becoming increasingly scarce—to meet their energy requirement.

4/ See also chapter 9.
The Bank regularly includes support for electricity in urban projects, generally for security lighting and small enterprise needs. For private connections, it is largely a question of users’ priorities and economic capacity, which varies considerably. For example, in some countries—especially Latin American—priority for electricity is higher than for other utilities and users are willing to pay a relatively high proportion of their housing costs towards a private connection, whereas many low-income households in other countries prefer to use cheaper fuels.

The distribution of electricity does not involve major works and can easily be made at any time, so long as major increases in supply equipment are not required. Its staging does not affect the physical layout of a project area to the same extent as other facilities. Economics permitting, initial servicing levels include security lighting in major community areas. This can later be extended into full street lighting. Subsequent provision for private connections is relatively simple and generally managed by local power companies.

Possible approaches to providing improved energy services to the urban poor include the use of renewable energy sources. With this in mind, the Bank has begun surveying the energy needs and uses of the urban poor in a number of countries. Work has been done in Burundi, is underway in Cameroon, and should soon begin in Liberia, Ivory Coast, the Philippines, Indonesia, and Mali. A project component involving the development and use of improved stoves is under consideration in Burundi.

The Bank-financed Second Calcutta Urban Development Project provides for a combined waste treatment/fish farming complex and a khatal (buffalo) resettlement program that will produce biogas from up to 50 tons per day of dung. The gas will be used to generate electricity for chilling milk, running pumps, and street lighting, as well as for operating the biogas plant.

C. Small Enterprises

The employment distribution of the urban poor is similar to that of the distribution of occupations in the city as a whole—about 50 percent in services, 20-25 percent in manufacturing, and the rest across transportation, construction, and miscellaneous categories. In the cities of lower income countries (e.g., in Asia) 40-50 percent of the poor can be described as self-employed or own-account workers. In higher income countries (e.g., Latin America) over two-thirds are employees. A surprising number, particularly in large cities, are low-paid employees (both casual and regular) in medium and large firms and in government. It is clear that on the urban side there is no equivalent of the small farmer—i.e., one fairly homogeneous group of producers with access to the basic factors of their production process.

It is obvious that accelerated creation of productive employment opportunities in non-farm production will be central to progress in reducing poverty in both rural and urban areas. Although more rapid rates of overall growth are essential to absorb the rapidly growing labor force, it is unlikely
that this growth in overall output will be rapid enough given the present organization and use of the factors of production. There is substantial evidence to indicate that modern large-scale enterprise will not provide employment opportunities for more than a minor fraction of this growing labor force. Although additional efforts are required to ensure that such enterprises exploit every opportunity for expansion utilizing efficient labor-intensive techniques, it is clear that the incomes of a large part of the non-farm work force will depend on the growth of earnings opportunities in the small-scale industrial, construction, trade, transport, and other service sectors.

In this context, the success of any strategy to promote this growth will be as dependent on an appropriate policy environment as it will on the levels of investment. The main elements of such policies are well known: removal of capital market imperfections (such as artificially controlled interest rates) which limit the capital available to small-scale, labor-intensive industries and skew technological choices toward capital intensity; modification of legislation that discourages labor use; and the introduction of realistic prices for the major market variables in the economy—from foreign exchange to farm products. It is also clear that any efforts to increase the absorptive capacity of urban areas and the productivity/welfare of the urban poor will not be effective unless there are significant changes in the attitudes of governments towards self-help activities, the acceptability of low-standard, low-cost solutions to water supply, sanitation, shelter, transportation, and health care, the management of urban land, and the pricing of urban services in general. There are political difficulties inherent in this approach.

The Bank is increasingly lending for poverty-oriented employment creation projects and project components. The bulk of such lending is and will continue to be through lines of credit to financial intermediaries with very much smaller amounts for small business support components in urban projects. Significant technical and managerial assistance is provided in all these projects both to the financial intermediaries and to the small entrepreneurs or artisans who receive financial support through the projects.

Substantial employment creation for the urban poor also occurs directly and indirectly through more capital-intensive industrial investments by the Bank and IFC and due to the project expenditures of many other Bank-financed projects, in particular for construction. The Bank is attempting to better understand and to increase these employment effects of its activities.

Since 1974, the Bank has included business support components (BSCs) in the urban projects it finances. Most of these components are in the early stages of implementation. So far, they are almost exclusively site-specific—i.e., directed either at the target population living within the boundaries of the project sites or, exceptionally, within the city boundaries in which the

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5/ See the part on technology and small enterprises in chapter 10.
The urban project will be implemented. The project components mainly provide financing for small enterprises and for physical infrastructure to meet their needs. For example, some Bank-supported urban projects (Tanzania, Kenya, Ecuador) have financed the construction of workshop clusters in low income areas which can house a number of small establishments at a lower rent and with better and lower cost security and other services than would be available to each firm individually. BSCs will continue to be included in most urban projects, but will remain a small part of overall funding.

The Bank has begun a series of case studies of the BSCs it has financed primarily to see what impacts they have had on employment, but also to see how any problems that arose could be dealt with and what kind of monitoring system could be put in place at an early stage. A first study of a Bank-financed BSC in El Salvador found a number of innovative features. These included the making of very small loans, daily collection of loans, and group signatures as the basis for loans rather than the usual physical forms of collateral.

Part of the problem of meeting the employment needs of the urban poor is finding and developing suitable financial intermediaries. The Bank is attempting to determine whether there exist "grass roots" organizations in poor urban communities that could serve as intermediaries. Exploratory Bank missions in Brazil and Cameroon found that there are a number of such organizations that have this potential. Bank-financed projects in other sectors have also sought and used intermediaries specifically intended to meet the needs of small enterprises.

III. Urban Transport Projects 6/
A. Introduction

The transportation sector in urban development has as its basic function to provide essential linkages between residence and employment, and between producers and users of goods and services, both intermediate and final. Urban transport is complementary to a large number of other urban public services because the accessibility of an urban neighborhood determines to a considerable extent whether, or at least how easily, solid waste is collected; water, sewerage, drainage, and electricity networks are provided and maintained; police and fire protection is made available; and schools and health care are accessible to the inhabitants. Furthermore, since the transport system has an important impact on a city's physical extension, in particular the population density, and population density in turn directly affects the cost of infrastructure provision, urban transport policy may have a considerable impact on the cost of other urban services.

The urban transportation sector is important in other respects. It provides employment to a significant although varying proportion of the urban population. It also places a considerable financial burden on the public
authorities in urban areas. Although the proportions vary, it is not unusual for urban governments to spend between 15 and 25 percent of their annual budgets on transport related investment and operating activities. Total public investments programmed for the transportation sector in Bombay and Calcutta for the period 1972-78 accounted, respectively, for 26 and 48 percent of total planned investment.

For the urban poor, transport facilities are particularly important because the poor, by definition, are at the margin of subsistence and are especially sensitive to the effects of transport policies on employment or access to services, or on their small-scale commercial and trading activities. Improved transport access to poor neighborhoods can improve the employment prospects of their citizens, reduce the money and time they spend on getting to jobs, reduce the costs of inputs for their small enterprises, and improve their access to markets for selling their products. It can also facilitate the provision of and access to all the other public services in poor areas. Finally, the transport sector itself provides significant employment opportunities to the poor that can be increased or reduced by urban transport policies.

One of the prerequisites for appropriate policy in dealing with the urban transport problem in developing country cities is the realization that transportation is only a means to an end, namely access, communication, and to a lesser extent employment. These can be fostered not only by direct action in the transport sector but can also be effected by appropriate land use policy. Of particular importance are the decentralization of employment opportunities away from established centers or "corridors" within metropolitan areas, and the location of public service facilities that are close to the intended consumer of these services, especially in the case of public administration, health, and education facilities.

B. Urban Transport Technology

In the early stages of urban growth, low capacity local roads can provide very cheaply for all kinds of traffic and parking. The various types of vehicles and pedestrians get in each other's way only marginally. Costs of the rights of way are greatly reduced as compared with providing a separate track for each category.

With more traffic, the various uses tend increasingly to conflict. Initially, this conflict can be resolved fairly cheaply by road widening, traffic signals, and the like. There may indeed be increasing returns of scale at this stage, the extra costs being proportionately less than the extra capacity created—and this may also apply at a later stage for the rapidly expanding peripheral and local neighborhood road networks.

Further urban growth greatly increases transport requirements as average trip distances lengthen and incomes grow. Increasing congestion is to be expected due to both higher demand and the increasing costs of expanding central roads. Cost of delays that individual vehicles impose on others
can then exceed all other costs attributable to the individual vehicle. Pollution and social disruption increase. Great changes in the mix of transport modes occur as the transport system and land use adapt, with increasing difficulty, to this changing situation. The response is in part conditioned by the perceived costs and benefits involved in the use of various transport modes, and in part by general pricing policies and other influences on urban form.

Fundamental to the selection of appropriate urban transport modes in the conditions of rapid growth of the cities of developing countries is that rents in central areas are rapidly increasing. The effective central area space can be increased by relatively speedy underground transport needing little surface area, but the cost of subway construction is very high.

For the great majority of cities in developing countries and the great majority of their populations, the choice is, and will remain, between either very cheap walking and cycling—providing independence of timing but disadvantages of poor comfort and, for the pedestrians, very limited speed and distance—and the considerably more expensive public or collective transport by bus, surface railway, or intermediate public transport. Walking, cycling, and regular size buses all provide high capacities in relation to space requirements and low or very low pollution effects. Railways have disadvantages of inflexibility. Capacity of bus routes can be greatly increased by separate right-of-way, and with the high loadings and volumes of passengers characteristic of the developing countries may be competitive with metros at any traffic volume. Expensive land in central areas, however, remains a limiting factor.

Cities in developing countries have evolved a wide variety of bus systems and institutional structures. The jitney, the shared taxi, the minibus (12 seats or so), the microbus (less than 12 seats), and the midibus (15-25 seats)—all exist, indeed flourish, sometimes alongside the standard bus which one sees in the cities of Europe and America. Similarly, while the standard large bus is often, though not always, operated by the nationalized concern, the small buses and taxis are normally owned and operated by their main driver; they also have low capital to output ratios. In theory small buses are often appropriate, giving the best frequencies and speeds and suitably low average passenger waiting times. Direct observations of minibus services in a number of cities tentatively demonstrate the veracity of the theory. Furthermore the best institutional organization is not the large firm or municipal authority, but the small firm or the the owner/driver. There is no case for any substantial subsidy for appropriately organized urban bus transport.

The advantages and disadvantages of intermediate transport modes in terms of the overall transport system apply a fortiori to private automobiles. Comfort, convenience, and speed of total trips are so much greater than for other modes as to represent a quantum difference. The independence and liberty of movement they provide represent an emancipation for many owners; hence, the great appeal and tenacity with which their use is defended. However, in terms of road space and total costs to the community their benefits
are provided at very high cost. In developing countries, so long as resources available for infrastructure are so limited, the benefits to the people in automobiles using roads at peak periods are inevitably accompanied by intensified difficulties for many traveling by public transport, walking, or cycling. The conflict could, however, at least in principle, be considerably reduced by higher occupancy rates of automobiles.

C. Bank Lending Program

Through FY79, the Bank lent US$247 million for nine urban transport projects. The Bank has developed a set of principles that have been found useful in guiding the preparation of these projects, namely that:

(a) priority should be given to traffic engineering and management measures that increase the functional capacity of the existing street system, together with institutional and organization measures to improve the efficiency of bus fleet operations;

(b) new road construction should only be considered when the above measures are insufficient, when specific links in the road network are missing, when justified by urban or regional development strategies, or when special facilities, such as bus lanes, are required;

(c) priority should be given to projects that will improve public transport services; and

(d) public transport improvements should be oriented towards services in, or used by people from, low-income areas.

The government of Costa Rica is currently involved in a Bank-financed urban transport project based on these principles. The project is aimed at improving transport conditions in the capital, San Jose. To avoid an extensive, and expensive, road construction program, the government of Costa Rica developed a project to implement traffic engineering measures so that the medium-term travel demand could be accommodated on the existing road network, supplemented by a few critical links.

The main improvement consists of improving radial roads in seven corridors. Only one section of new road will be built, to link up with a new intercity highway. In four corridors, the streets are currently being widened (where possible, within the existing right-of-way) to allow the introduction of exclusive bus lanes during peak periods. This indicates the degree to which increases in road capacity are allocated on a priority basis to public transport. In two corridors, with lower bus flows, the road will be upgraded (new paving, gutters, drainage, etc.) without widening.
To ensure that the central area can accommodate the increased traffic flow from the radials, a program of TOPICS (Traffic Operations Program to Increase Capacity and Safety) measures will be undertaken, including intersection improvements, pedestrian crossings, and an integrated traffic signal system for the central business district.

Since the project aims only to accommodate medium-term travel demand, it is likely that growing car ownership will erode the effectiveness of the measures in 5-10 years. The government is, therefore, initiating at this time a study of alternative measures, notably methods to reduce the number of cars using the streets in the center of San Jose. Measures considered will include "road pricing" techniques of the type currently in operation in Singapore (see below). It is hoped that the current measures to increase supply and future measures to reduce demand will, together, constitute a solution to San Jose's long-term transport problems.

Finally, the government of Costa Rica has recognized the necessity of making urban transport planning a continuing government function and is taking steps, through technical assistance, training, and equipment acquisition, to upgrade its performance in this area.

The Bank is placing increased emphasis in the urban transport projects it finances on improving infrastructure, bus penetration (including terminals), and cheap road paving techniques in poor areas. Such a comprehensive approach to transport infrastructure and integrated program development is being supported for one low-income neighborhood—containing about 60,000 people—as part of the First Brazil Urban Transport Project. A 2.85 km bus penetration road will be built on the site of an existing drainage channel that will be rechannelled into a culvert. Just over 4 km of existing dirt roads will be paved as access roads for service vehicles. To improve pedestrian access to public transport, 18 km of other tracks will be provided with paving and drainage and a series of stairs will be built.

In this project component, the introduction of the transport infrastructure will be coordinated with a municipal program to provide water and sewerage (plus schools, a market, and a recreation ground). Land has been set aside in the same neighborhood for families that have to be relocated and assistance will be provided to help them move. The standards of the facilities have been designed so that they constitute a significant improvement for the current poor residents, while at the same time remaining unattractive to people with higher incomes. As an additional measure to ensure that the benefits of the project go to the current residents, a new zoning law will be passed establishing maximum lot sizes and densities for the area.

In the same project, consultants participating in the technical assistance component, project executing staff, and local engineers are collaborating to identify simpler, low cost paving techniques for use in poor areas. Options being considered involve simplified drainage works, less than normal pavement thicknesses, and the use of local materials and labor.
Many Bank-financed projects in other sectors, such as ports, airports, industry, public utilities, tourism, and intercity transport have important implications for urban transport. It is not possible to assess all these projects for their impact on urban transport and urban physical form. But where such impact appears likely to be substantial, and particularly where cities are involved in which urban transport projects are contemplated, an attempt is made to evaluate the impact. Where such evaluation indicates it to be desirable, complementary projects in urban transport may be undertaken as part of larger efforts to expand the evaluation of all Bank-financed projects in urban areas to include wider economic and social aspects of urban development.

D. Bank Research

The Bank has carried out a number of urban transport studies, generally as a preliminary step in the generation and design of projects. In addition, the Bank believes that it is important to begin to consider the use of measures that affect not only the supply of transport services, but also the demand for travel, especially by automobile. "Road pricing" is frequently advocated as a means of achieving that goal of reducing the demand for scarce road space. The Bank has experience with such schemes in Singapore. 7/

If the selected approach to reducing traffic congestion is "pricing," i.e., charging fees for some aspect of the use of the city streets, the selection of the most suitable form of pricing in any city warrants careful study of the effects of the different approaches in the context of local conditions. The important point is that, given the basic principle, it is possible to develop innovative and effective solutions for cities that differ widely in geography, topography, travel habits, infrastructure, and administration. This offers a "software" alternative to the financing of transport "hardware."

In the Singapore context, the key concept underlying the Area License Scheme is that a special, supplementary license must be obtained and displayed if a motorist wishes to enter a designated restricted area within which congestion is to be reduced.

7/ The Bank's involvement in the development and introduction of the Singapore Area License Scheme was largely that of an observer. While the Bank had supervised the transport planning study that recommended that some form of pricing scheme be introduced to reduce congestion, the analysis of alternative methods, the choice of the preferred method, and the arrangements for implementation were made by the Singapore Government. The Bank took advantage of the event to mount (in conjunction with the Singapore Government, the United Nations Environment Program, the U.S. Environmental Protection Agency, and the U.S. Department of Transportation) a major program of monitoring and evaluation, with the objective of gathering and analyzing information on the directions and magnitudes of as many as possible of the changes resulting from the Area License Scheme.
The motivation for the planners of the Area License Scheme was the general objective of changing people’s attitudes toward the use of cars for commuting. The aim was to prevent the existing moderate congestion from growing progressively worse. To solve the problem the planners perceived that they had to, first, explain the rationale behind the need for more widespread use of public transport and other high occupancy vehicles, and second, induce motorists to review and fundamentally change their attitudes towards the ownership and use of cars. This revision of motorists’ attitudes and, hence, behavior was expected both to reduce the problems caused by congestion, and at the same time create an environment in which public transport services could be improved. To translate this objective into practical and measurable terms, a target was set at a 25 to 30 percent reduction in traffic entering the central area in the morning peak. This target was more than achieved. Therefore, it is clear that the Area License Scheme has induced motorists to modify their behavior, at least in the short run. The Area License Scheme has reduced congestion in the central area, largely by inducing a shift towards public transport and car pools. Whether these are simply short-term behavior modifications or whether they represent fundamental changes in the attitudes of motorists cannot be determined at this point. It seems likely, however, that the continued use of such measures will result in a more widespread acceptance (rather than tolerance) of public transport and car pooling in the long run.

It is likely that in different cities the objectives will be somewhat different from those of the Singapore Government. One city might wish to reduce the number of people going downtown, rather than just influence their choice of mode without inhibiting their trip-making. Another might want to exert less impact on trips to downtown destinations but discourage people from driving through to destinations beyond the central area. In another, the concern for leaving commercial traffic alone might be absent. Since different objectives require different measures, it is important to have the objectives defined and agreed upon before going very far in working out the design and operating details. It is worth noting that a variety of physical, legal, and fiscal measures may be combined with different approaches in a policy package. For example, Singapore, in addition to the Area License Scheme, also made use of parking charges, reserved bus lanes, and prohibition of trucks with more than two axles from the area inside the ring road.

E. Policy and Institutional Considerations

Urban transport projects presented to the Bank are considered in the context of their contribution, direct and indirect, to the wider problems of improving the basic urban transport system and the form of urban growth. Unless attention is concentrated on these longer-term interlinkages, attempts to solve the urban transport problems based on existing needs can easily aggravate the future situation.

In practice, this means that Bank lending for urban transport is concentrated in cities where the authorities demonstrate willingness to consider and implement measures progressively to adapt their policies to the mounting pressures of rapid urban growth. For example, in view of the wide dependence of the success of projects to improve public transport on measures
to assign road space to public transport on a priority basis and other supplementary measures that might restrict the use of the private car, a demonstrable willingness to advance in this direction must be regarded as a sine qua non for Bank support of such projects.

Even more than in many other sectors, neither the policies nor the institutions involved can be transformed in a period of a few months, not least because so many agencies and interests are involved. These considerations point to the need for extended programs of progressive improvements. As a basis for a continuing program, technical assistance for management and policy formulation, and further studies which may be necessary are given consideration as an integral part of initial projects.

F. Lessons Learned

The Bank's experience has demonstrated that wide opportunities do exist for viable improvements in urban transport, but has also shown the difficulty of preparing satisfactory projects for financing. In addition to severe management and coordination problems and weaknesses of methodology, problems of financial viability of public transport undertakings have proved extremely complex and are sometimes intensified by the existence of high-cost local operations for assembly of vehicles.

Above all, the experience so far has emphasized the importance of policy measures in achieving the full benefits of urban transport investments—as also the practical difficulties of adopting significant reforms. Though these difficulties are most evident in relation to policies concerning public automobiles, similar difficulties extend to the choice between types of public transport, including intermediate personal transport, and to land use regulation. Opposition to new policies, while largely of political or social origin, also derives from absence of relevant experience, or convincing studies, demonstrating the benefits that might be secured.

A no less pervasive lesson has been the size of the inputs of expertise required in preparing projects and the accompanying policy measures. Project preparation periods will inevitably be substantial, due to the inherent complexities and the long-run importance of the decisions taken, not least the influence on the structure of urban development. The problem lies, however, even more in the shortage of expertise, locally and worldwide.

As a consequence of the complexity of the issues and the limitations of expertise, the burden on the Bank in the preparation and supervision of the projects has proved particularly great. Insofar as extensive studies and technical assistance are required both before project formulation and as an integral part of the projects in developing longer-term policies, this supervision burden is roughly doubled.
The most promising aspect of the experience so far has been the policy initiative engendered by project preparation and preliminary studies. Significant institutional and policy changes, including measures involving automobile restraint in congested areas, have resulted from these activities. The technical assistance and the studies incorporated in recent projects are designed to result in further progress in these directions. The effectiveness of these technical assistance activities depends on the quality of the consultants available and the absorptive capacity of the local organizations.
3. SCIENCE AND TECHNOLOGY IN EDUCATION
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Introduction

The growing utilization by developing countries of science and technology creates strong demands for changes in education. These countries' educational systems, while preserving traditional subject matter and cultural values, have had to cope with a variety of new needs—e.g., for instructional material in agricultural skills, for improved scientific and technical manpower training, for adult education courses, for more rural teachers, and for more appropriate school buildings and equipment. The last may include media such as radio, television, or simply textbooks.

In helping developing countries adapt to these changed demands on their educational systems, the Bank follows three broad principles:

1. Basic education should be available to all children and adults as resources and conditions permit. This principle translates into making education available to those who have had no prior access to formal education or training—e.g., women, semi-skilled workers, and rural children. Such outreach obviously requires new manpower, curricula, and educational technology generally.

2. Education should be related to certain national objectives; it should provide the knowledge and skills necessary for the performance of economic, social, and other developmental roles. Thus, the Bank is concerned with both general education and specific skill training.

3. Developing countries should acquire their own capacity to design, analyze, manage, and evaluate education and training programs.

From these basic principles, the Bank's lending activities in the education sector involve science and technology both directly and indirectly. The direct applications include the hardware of school buildings and instructional equipment (treated in section D). The indirect applications include strengthening the science-based and technical curricula of schools and increasing the internal capacity of developing countries to utilize science and technology in education. The former activity is discussed in section B; the latter is treated in the technical assistance discussion of section A and throughout the other three parts wherever a project component involves increasing reliance on local resources.

Before discussing each of these direct and indirect uses of science and technology, a review will be made of the evolving rationale for the Bank's educational lending strategy.
A. Overview of Bank Education Lending

1. General Approach

The World Bank's education lending program reflects its overall policies and philosophy on development. In FY63, the Bank joined with other members of the development community in the belief that economic development required an increased supply of trained manpower. This view became the major justification for the Bank's investment in education. The Bank began to lend for manpower training projects, with special emphasis on vocational and technical training.

By the late 1960s, however, it became apparent that manpower preparation was not the greatest or the only educational need of developing nations. Thus, the Bank began lending for such new and diverse purposes as: non-formal education and training, educational radio and television, local production of learning materials and equipment, and, on a more systematic basis, administration and management.

By the mid-1970s, the Bank concluded that the emphasis on developing modern economic sectors of developing countries had led to an over-allocation of resources to secondary and higher education at the expense of education in rural areas. In this period, the Bank adopted a policy of lending for balanced education development. This policy emphasized mass education, as defined by the following four principles:

(a) A minimum basic education should be provided for all, as fully and as quickly as available resources permit.

(b) Further education and training (beyond the basic level) should be provided selectively to improve, both quantitatively and qualitatively, the knowledge and skills necessary for performing economic, social, and other developmental roles.

(c) A national education system should be viewed as a comprehensive system of learning and embrace formal, non-formal, and informal education with maximum possible internal and external efficiency.

(d) Educational opportunities should be equalized as fully as possible to achieve increased productivity and social equity.

In FY78, the Bank undertook an in-depth review of its education lending program and policy. It was considered that the accumulated experience of the developing countries, other education aid donors, and the Bank should provide the basis for some re-design of the Bank's education lending policies and program.
Aside from changing the nature of the education projects it supports, the Bank has financed a growing number of large education projects yearly. Since 1962, Bank-financed projects have resulted in the construction or improvement of approximately 10,000 educational institutions in member developing countries, including about 100 faculties or universities, 300 primary teacher training colleges, 1,000 technical schools, 1,700 general secondary schools, and many primary schools and adult centers. Through FY79, the Bank lent US$2.7 billion for 192 projects, which had an aggregate project cost of approximately US$5.1 billion. Eighteen of these projects were supported by loans totaling US$496 million in FY79.

Over the last few years, Bank-financed projects in agriculture and rural development, transportation, water supply, power, and other sectors have included an increasing amount of often on-the-job training for nationals aimed at increasing project effectiveness. (The Bank's support for this "project-related training" is described in the introduction to this volume.) On a wider scale, training components are sometimes included that aim at manpower development outside the immediate objectives of a project. The Bank also supports a small but increasing number of education components in rural development, urban development, and population projects.

2. Sector and Project Work

The Bank's education sector work ranges from comprehensive sector surveys to studies of selected sector topics or issues in order to:

(a) assess the role of the educational sector in the present and future economic and social development of member developing countries;

(b) assess the capacity of the educational and training system—formal and non-formal—to effectively promote the economic, social, and cultural development of the country;

(c) suggest alternative strategies for the sector's development within a framework of the suggested strategies and, if necessary, also suggest programs for pre-investment studies.

In addition, the Bank has had a cooperative agreement with UNESCO. UNESCO has actively participated in sector work and has played a role, for example, in the identification and preparation of education projects for Bank support.

When the Bank appraises a project it makes sure there are:

(a) firmly defined project content and educational objectives consistent with stated and feasible overall educational strategy;

(b) suitable instructional models and physical forms (i.e., building designs, equipment provisions, etc.).
(c) realistic cost estimates and evidence of a government's ability to meet its share of capital costs as well as all recurrent costs; and

(d) agreed institutional and project management arrangements and sufficient staff available.

To avoid project delays (caused by policy and content changes after lending) and resulting cost increases, the Bank generally prepares projects as fully as practicable before negotiating loans. When appropriate building plans or other necessary information is unavailable at the appraisal, the appraisal may be carried out as a two-stage process. An initial— or "pre-appraisal"—mission results in agreement between the prospective borrower and the Bank regarding project content and objectives and the educational and economic justification for the project. The second— or "appraisal"—mission ideally begins after drawings, equipment and furniture lists, and technical assistance programs (if needed) have been completed and project management has been established.

3. Technical Assistance

In recent years, the Bank has devoted an increased share of its education loans to the provision of technical assistance. In FY79, for example, the Bank lent over US$70 million for this purpose. Technical assistance is provided during all stages of project work. Before financing such assistance, the Bank ascertains what assistance is being provided by other aid agencies. The Bank then sees that the technical assistance it finances is closely related to project objectives and complementary to the assistance received from other sources. Technical assistance is often provided by foreign experts. But the goal of such assistance is always to strengthen local capabilities as much as possible, and to develop the skills needed in the borrowing country.

For example, the Bank recognizes the advantages for the borrowing country of having the education ministry undertake project management as part of its normal operations. But difficulties often arise in this type of management, including lack of manpower and lack of appropriate skills. Among the skills required are project planning and implementation, training (for staff of other institutions), and administrative skills such as accounting. The Bank attempts to improve these skills not only by financing technical assistance but also through advising on project preparation and later through project supervision.

4. Research on Education

The Bank supports educational research for planning and policy-making, for advancing knowledge of the Bank's appropriate role in promoting learning and labor productivity, and for building a strategy for future Bank action. The research concentrates on four major areas: the relationship of education to economic development and productivity, the alternative ways of
providing education and training, the internal efficiency of the educational system, and the financing of education. Although the effort is still moderate in size, the Bank has recently increased its financing of educational research. (See also the description of Bank research on the effectiveness of radio for distance teaching, below.) In FY79, monitoring and evaluation components were included in 16 of the 18 education projects, with Bank financing for 11 of them. Seven projects also provided plans for tracer studies.

B. Science and Technology Education

Many Bank-financed education projects are designed to introduce or strengthen science and technology-related courses or training. At the primary level, such projects often include environmental or agricultural science along with basic numeracy and literacy. At the secondary level, they include separate training in agricultural, vocational, and technical skills. At the post-secondary level, universities offer science and engineering courses as well as research opportunities, while specialized non-university institutes provide agricultural and technical training.

1. Primary and Basic Education

Primary education is considered by many countries to be a preparatory stage for secondary education and therefore does not provide the basic skill training needed in the industrial and agricultural sectors. Often primary education includes few provisions for training the large numbers of students who must leave school after the primary grades and find jobs.

Gradually, however, developing countries are broadening their approaches to primary education to include extended as well as conventional schools. The extended primary school emphasizes a less academic and literary curriculum than that of the conventional school and offers practical training in vocational and agricultural skills.

Typical of the trend toward practical training at the primary school level is a Bank-financed project in Brazil. The Bank is supporting the Government’s reform and re-structuring of the primary (grades 1 to 4) and lower secondary (grades 5 to 8) levels into a single, 8-year primary education cycle. While the lower four grades still follow a conventional curriculum emphasizing basic training in numeracy, literacy, and citizenship, the students in the upper four grades have the opportunity to develop practical skills in such areas as industrial arts, agriculture, and home economics.

Other Bank-financed projects seek to introduce non-traditional activities into the conventional school. In Haiti, for example, the Bank loaned money for improvements in the formal primary education system. The curriculum now emphasizes new agricultural techniques and skills through active teaching and learning practices (e.g., through the use of a nutrition center and a demonstration garden adjacent to each school). In addition, Haiti now uses its primary schools in the evenings for non-formal vocational and pre-vocational training of out-of-school youth and adults.
Other nations are also looking to non-formal education to reinforce literacy, numeracy, health, and sanitation skills or to extend these skills to the large numbers of people with no formal primary education. Target groups for non-formal, basic education programs have included out-of-school youths, women, farmers, and rural villagers. In the Yemen Arab Republic a non-formal basic education project component is aimed at teaching functional literacy and numeracy skills to the non-literate adolescent and adult populations in rural areas. In Mauritania, where the Koranic schools are the major instrument for teaching literacy and numeracy to primary age children, the Government has made provision to study upgrading their curricula and teachers and to consider integrating the Koranic schools into the formal education sector.

2. Secondary General and Diversified Education

Secondary general and diversified education programs provide a way for science and engineering subjects to be introduced into the curriculum. The goals of these Bank-financed secondary programs are to: improve science and technical manpower training (and thereby meet the country's qualitative and quantitative manpower needs); broaden the curriculum and improve its balance and relevance by including more technical-vocational subjects; and improve the employment prospects of school-leavers.

There are two basic types of Bank-financed diversified education programs. One emphasizes practical subjects as a component of general secondary education; it does not train students for specific occupations. The other stresses vocation-oriented learning and prepares students for specific occupations. Both programs employ practical courses to transfer knowledge of technology and technological skills to students.

A Bank-financed project in Cameroon supported the reform of the general secondary school curriculum to include practical courses as in the first type. Students leaving the school, at any level, would be better prepared to meet employers' needs while still having the background required to continue their studies. The reform postpones specialization by offering all students a common two-year program at the lower secondary level (grades 7 and 8). Upon completion of grade 10, academic course pupils have the option of enrolling in a three-year university preparation program, a one-year teacher training course, or technical courses of two or three years' duration. The common courses offered at the lower secondary level include several courses in the technical-vocational area.

Projects of the second type are often flexible. They offer several programs of practical courses that provide a variety of technological skills within the areas of agriculture, industrial arts, home economics, and commerce. In El Salvador, for example, students in the industrial program can choose among auto engineering, mechanical engineering, and electrical engineering subjects.
A series of Bank-financed projects in Colombia introduced this kind of diversification into the secondary curriculum. The six-year course of study progresses in three two-year stages, beginning with exploratory studies in pre-vocational subjects (agriculture, commerce, industry, and social service) and offering greater specialization in the later stages. Graduates (excluding commercial graduates) would not be regarded as fully trained; but they would be prepared after the fourth or sixth year to enter on-the-job training programs or in-service apprenticeships in industry or agriculture or to pursue further academic studies.

3. Secondary Agricultural, Vocational, and Technical Education

Secondary agricultural, vocational, and technical education projects are designed to develop industrial and agricultural skills and improve industrial and agricultural productivity in borrowing countries.

a. Secondary Agricultural Education

Skilled agricultural workers require training in agronomy, forestry, fishery, and animal husbandry. Ideally, the training involves extensive practical experience in laboratories, in workshops, and in the field. Most countries offer a combination of practical and academic courses in the curriculum. There is a tendency for the curriculum to be oriented, at least partially, to preparing students for further education rather than immediate employment.

Bank-financed secondary agricultural education projects have emphasized practical technological skill training. In many cases, this includes financing technical assistance in order to re-orient the curricula towards increased application of technical knowledge.

A Bank-financed project in Indonesia, for example, provides agricultural training for rural students, agricultural extension workers, and middle-level administrative personnel. The secondary education component of the project trains students for placement as middle-level technicians in the Ministry of Agriculture. Students spend their first three years in a junior secondary agricultural school. These schools offer a common, agriculture-oriented, general curriculum for all students and prepare them with a level of technical knowledge and skill necessary for entry into a senior secondary agricultural school or for employment in the agricultural sector. Sixty percent of the curriculum is general education and 40 percent technical courses, and there is equal emphasis on theory and practice within each course area. Students also have the opportunity to apply the technical skills learned on an 85-hectare farm that is managed by each secondary agricultural school.
b. Secondary Vocational and Technical Education

The skills required by the modern sector of developing countries need to be identified in order to plan secondary vocational and technical education curricula. Malaysia, for instance, requires skilled tradesmen in the areas of mechanics, electricity and electronics, construction, and printing, while Egypt needs skilled workers for the food processing and textile industries.

Many developing countries lack the required facilities and equipment to provide adequate training in modern sector skills. Therefore, Bank-financed projects have emphasized technical skill training and practical course work.

As an example, a Bank-financed project in Kenya provides needed skilled manpower in mechanical and electrical work, welding, motor vehicle engineering, masonry, plumbing, and carpentry. The curriculum of the secondary vocational and technical schools lasts four years. Emphasis is equally divided between general education and technical skill training. In the third year, the students begin a general study of either engineering or building, while in the final year they specialize. All courses require extensive laboratory and workshop participation.

Among the subjects taught for boys are physical science, technical drawing, woodwork, metal work, building or engineering practice, and specific trade technology and practice. For girls, physical science, fiber and fabric technology, fashion, and dressmaking are taught.

4. Post-Secondary Education

The training of high-level and middle-level manpower has traditionally been the most significant function of post-secondary education. Over the last 20 years, most developing nations have invested heavily in post-secondary education. As a result, enrollment in institutions at this level in developing nations grew at a rapid rate, more rapidly than at the primary or secondary level. However, enrollments in science and technology programs have traditionally been relatively low because of a lack of teachers, teaching facilities, and suitable candidates for admission.

a. University Education

Among the university education projects financed by the Bank, a substantial number have contained science and technology components. These projects can be classified into agriculture, science and engineering, health, and technical education.

In agriculture, the Bank has financed university education projects in agronomy, animal husbandry, fishery, and forestry, many of which expand and improve research facilities and programs. In the Philippines, for instance, the main objective of a Bank-supported project was to increase the supply of well-qualified agricultural manpower necessary for implementing
important agricultural programs in crops, forestry, and livestock. This objective was served by establishing a regional agricultural college in the Visayas as well as centers for forestry, animal science, and veterinary medicine at the University of the Philippines, Los Banos. In addition, the livestock development curriculum was strengthened to include reproductive physiology, meat science, and animal by-products utilization. The Visayas college was developed into a regional center of excellence that trains competent agricultural specialists, teachers, and technicians to meet regional requirements; promotes research activity for the region; and disseminates research results and new technology within the region. Some Bank-financed agricultural research and extension projects also support agricultural universities.

More general strengthening of scientific disciplines has occurred in Bank-financed projects at the University of Singapore, the Science University at Penang in Malaysia, and at Seoul National University and other national universities in the provinces in Korea.

Technical education projects have included the construction, equipping, and furnishing of the Technological Institute of Electricity and Electronics in Algeria. The Institute offers post-secondary education in either a five-year engineering course or a four-year technician course. The basic engineering specialties are electricity and power, communications control systems, computer electronics, and applied sciences. Technician students specialize in four areas of study: manufacture of components, electricity and power, digital electronics, and electronics communication. Condition of entry is a baccalaureat in science and mathematics for engineering studies and completion of the first cycle of secondary education for the technician courses. Curricula have been designed in cooperation with, and reflect the functional content of, corresponding occupations in Algerian industry.

Bank-financed post-secondary health care education focuses on the training of physicians, nurses, and paramedics for urban and rural areas. In Cameroon, the Bank has financed an innovative program using university students and staff in a rural health project. The project included provisions for the extension of facilities at the Centre Universitaire des Sciences de la Santé, one of the faculties of the University of Yaounde.

b. Post-Secondary Non-University Education

The Bank has also financed a wide range of projects or project components in technical and agricultural post-secondary non-university education.

In the technical area, a wide number of programs in electronics and electricity, mechanics, construction, textiles, food processing, and industrial chemistry are offered. In Nepal, for example, a Bank-financed project supports training of junior technicians for jobs assisting degree technicians in construction work, metal work, electrical installations, and road maintenance. The certificate program at the Institute of Engineering includes specializations in civil and electrical engineering and architectural drafting.
In Honduras, a three-year program is offered in general agriculture and animal science at the National School of Agriculture, with pre-employment orientation subjects.

C. **Teacher Training**

As can be seen, the main thrust of Bank lending has been to broaden educational opportunities and make them more relevant to the skills and vocations required for development. This new emphasis in the curricula of developing country education systems requires teachers who can teach agricultural and vocational skills. Many countries now require teachers to be trained in both the traditional academic and the new vocational subject areas.

Bolivia, for example, reformed its primary teacher training curriculum to reflect a new emphasis on bilingual education and practical course work in the primary schools. Under the new curriculum, future primary teachers specialize in language and social sciences, natural sciences, or agriculture and also receive training in handicrafts, health and nutrition, and community development. The program places greater emphasis on agriculture, home health skills, and rural crafts; it also trains teachers to use the vernacular for instruction for the first three grades of primary school.

In Indonesia, in-service training acquaints primary and secondary teachers with new practical course material, proper use of textbooks and other educational materials, and the use of science and other educational equipment.

In Egypt, a Bank loan helped to implement a specially designed post-secondary technical education teacher training program to help meet Egypt's urgent need for industrial technicians. The Technical Teacher Training School at Kobba, for instance, now trains many of the teachers needed for technical institutes. The curricula emphasize technical knowledge as well as strong pedagogical skills. The technical subjects include: air conditioning and refrigeration, civil construction, communications electronics, drafting and design, electromechanics, farm power and machinery, industrial electrical systems, instrumentation and process control, mechanical power and automotives, and production technology and control.

Bank-financed teacher training projects differ according to the educational level at which the trainees are to teach. The selection of students for teacher training programs also varies among countries and often reflects the country's development priorities. Thailand, for example, selects students for its teacher training program from graduates of secondary agricultural schools who have had successful experience as agricultural extension workers. Guyana, on the other hand, accepts all hinterland applicants who have met the basic requirements for its general secondary teacher training program. In many developing countries, the teacher has come to be viewed not only as a communicator of knowledge and skills, but also as an agent for community development.
D. School Construction, Equipment, and Media

While curriculum development and teacher training are the key factors in improving the quality and quantity of education in developing countries, the major financial requirements are for buildings, equipment, and teaching aids. It is these latter components where technology is most directly involved and where important choices must be made.

1. School Construction

As noted previously, the Bank has been involved in the construction or improvement of about 10,000 educational institutions.

The Bank aims to persuade borrowers to adopt building design and construction solutions that rely on local resources and are consistent with climatic conditions. In addition, designs must be appropriate for the planned curricula and teaching programs and must be suitable for replication. The success of the designs adopted and the extent to which they are based on indigenous materials and techniques depend largely, however, on the approach and skill of the architects. Where the design of the buildings requires supervision beyond the capabilities at an existing government organization, the borrower selects (with Bank approval) private architectural firms to do the work on a consultant basis. The engagement of local firms is favored whenever the design task is within their capabilities and experience; most private firms employed by the borrowing countries are, in fact, local.

The extent to which the construction process relies on local technology varies with the size and type of institution concerned. Where projects are large enough to attract professional builders, the borrowing countries' economic goals can best be met by awarding contracts as the result of competitive bidding—either internationally (ICB) or locally. However, where the building components are small, of a very rudimentary standard, or required for very remote locations (as is generally the case for primary or adult training programs), the most economical way to proceed with construction is by "force account" (i.e., by using government employees) or by other "direct administration" methods. These methods, which closely approximate traditional methods of construction, may be based on "self-help" operations with local community participation. Thus the construction content of a Bank-financed education project usually contributes to local employment. Even when bidding attracts foreign participation, construction contracts are almost invariably won by local contractors.

The Bank has financed "self-help" construction projects in Ethiopia, Tanzania, and El Salvador. In Ethiopia, school construction was provided by the local communities with the assistance of skilled workers from the Ministry of Education's Elementary School Building Unit. Construction was estimated to cost only 40-50 percent of earlier school building efforts, thus doubling the number of school constructions that could be funded. In Tanzania, construction is being carried out by village communities with the assistance and guidance of mobile teams of four or five skilled laborers each from the rural training centers for the regions concerned. And in El Salvador,
the project is intended to open education and training opportunities for both youth and adults in neglected rural areas. Construction is carried out partly by contracts awarded on the basis of local bidding, but some tasks, like site clearance and the provision of access ways, water supply, drainage systems, and site fencing, are handled by the local communities. "Self-help" operations accounted for about 20 percent of the cost of construction activities for the first 200 schools completed.

2. Equipment

Bank loans support the purchase of instructional equipment. "Instructional equipment" is material directly employed in the learning process, including books; audio-visual systems and materials; television and radio sets; physical, biological, and chemical apparatus and instruments; and tools and machines used in agricultural and industrial workshops, technical drawing rooms, commerce rooms, etc. It also includes stoves, refrigerators, and other items used for teaching purposes in the home economics departments.

In Bank-financed education projects, instructional equipment is used to help improve the students' attitudes, knowledge, skills, and behavior and to improve the productivity and efficiency of the educational institution. The equipment is usually used by the students in their work in shops and laboratories; occasionally, equipment is used by teachers for demonstrations.

The Bank seeks to ensure that the equipment used in projects serves the objectives of the curriculum and of the specific syllabi of the institution to which it is assigned. It encourages the use of equipment that is up-to-date, has the potential for future use, is flexible, is simple and stimulating to work with, has a reasonable first cost, and is easy and economical to install, use, maintain, and replace. The equipment should be well geared to the educational, economic, and social development of the borrower country.

The ways equipment needs are identified and equipment lists are drafted varies from country to country. In more advanced developing countries, a pool of indigenous equipment experts usually exists. They may be found within the ministry of education or in institutes of higher education and research. When sufficient local experts do not exist, foreign engineering and science institutions can become involved on a consulting basis. Equipment teams also include nationals who receive on-the-job training. This was done, for example, in a Bank-financed project in Egypt.

In countries with fewer indigenous experts (e.g., those in the sub-Saharan region), it is more common to use expatriates or foreign institutions for equipment work. Here, experts are hired at an early stage and may engage directly in the work of the project unit; in some cases, they perform such tasks as the drafting of new curricula and syllabi.
A somewhat different situation existed in Paraguay, where few teachers had been trained to work with the equipment in the project and no domestic pool of experts was available for drafting the equipment lists. Equipment vendors were invited to bid on the project. Decisions were based on simple bid documents that described the education and training objectives as reflected in curricula and syllabi, the education level, the students' ages, the group sizes, and the teaching technologies to be applied. The vendors then, within a given cost frame, suggested appropriate equipment lists and bid on the equipment. The bidding included staff training, maintenance, and related services.

Equipment is not always readily accessible to developing countries. Therefore, the Bank reviews the problem of instructional equipment procurement periodically. Actions taken recently include:

(a) completing more advanced preparatory work before loan/credit approval, including inventories of existing equipment stocks, preparation of equipment lists for review by the Bank, and early review of project management arrangements and procedures as they relate to equipment procurement;

(b) strengthening the Bank's support role by updating basic equipment lists, assisting with the supply of catalogues, and recruiting an equipment procurement expert to assist in the review of lists and procurement supervision;

(c) mobilizing local equipment expertise to assist in the task;

(d) trying new procurement procedures, such as specifying servicing and installation requirements in bid documents and postqualifying suppliers on this basis; resorting more often to off-shelf buying and strengthening the liaison with the end-user; and reviewing the package size thresholds attached to the requirement that international competitive bidding be used.

The problem of maintaining and servicing equipment has arisen in almost every country. In many cases, local agencies can offer servicing, though it is not always available. Some universities have established effective maintenance capabilities; others arrange for their own maintenance of specific items. However, an appreciable portion of a country's investment in equipment has been lost through lack of maintenance.

Several borrowers have considered or made special efforts to establish improved maintenance arrangements. Nigeria, for example, has had a pilot project (not financed by the Bank) in maintaining school science equipment. Tunisian school authorities have involved the students in workshops on the maintenance of equipment. And Bangladesh is studying the establishment of a central maintenance unit. But there is still an urgent need for assistance in establishing maintenance services in many countries.
Some countries have expressed interest in the production of equipment, while such production has already begun in other countries. The Science Education Center of the University of the Philippines develops prototypes of equipment items with Bank support. Manufacturers compete for contracts for mass production of these items.

3. Media

The Bank takes a special interest in the use of media (a broad category of instructional equipment) in the education projects it finances because of the promise they hold for improving and extending the educational process. The media can be part of face-to-face teaching/learning situations or can enable learning to take place when the student is separated from the teacher. Bank-financed projects have provided for the use of such media as radio, television, audio-visual material, newspapers, textbooks, correspondence materials, and mobile training units.

The primary objective of Bank financing in this area is to help promote well-articulated and logistically sound media policies. In any project using media, the Bank must be satisfied that the learning objectives have been carefully spelled out, that the target groups are identified, that the logistics are carefully designed, and that the materials financed relate to other aspects of the educational policy.

The Bank has identified several areas of potential benefit from the use of the media in developing countries. One is the possibility of a system that encompasses both national and local programming. While the costs of local broadcasting are considerable (though far less for radio than for television), local programming seems to be necessary for effective adult education, important in many cases for school broadcasting, and often a contributor to community development. A related area is the use of radio for language teaching, since the emphasis can be placed on reinforcing local language variations or on establishing a single national language. The use of media can also provide great flexibility in the content of what is taught, both in teacher training and in programs for other students.

When projects are to use media, the Bank makes sure that:

(a) the roles and reactions of teachers, parents, and students are given early consideration;

(b) simple and inexpensive possibilities are not ignored in favor of more glamorous initiatives, such as the introduction of television;

(c) wherever possible, the initiatives are locally devised;

(d) emphasis is placed on training, production, and distribution of the software;
(e) the development of media and other aspects of educational programs are mutually reinforcing; and

(f) the planning is flexible enough to accommodate the use of new technologies (e.g., satellites and video storage systems) and includes provision of funds for relevant experiments.

a. Textbook Development

The Bank and some of its borrowers are giving increased attention to textbooks as a learning material or medium of instruction. They can be produced locally, be delivered almost anywhere, depend on neither electricity nor consumable supplies for their use, can be used by unskilled teachers, and are reusable. While it is not clear that investing in improving the content of textbooks has an impact on learning, a consistent and rather pronounced improvement does seem to result from some exposure to written words.

As of FY79, approximately 40 Bank-financed education projects attempted to include the use of textbooks. A Bank-supported textbook and teacher training project in the Philippines, for example, is now focused explicitly on building a permanent capability for the preparation, production, and distribution of textbooks.

b. Mobile Training Units

The Bank has also financed the use of mobile training units as major components of projects in Brazil and Indonesia and as minor components of projects in other countries. In Brazil, for example, the government’s Department of Manpower established a system of mobile training units to provide unemployed youth with basic industrial/artisan and agricultural skills. The units are of two types: some provide modern sector skills (e.g., masonry, construction, and welding) and others, rural skills (rural construction, farm implement repair, and farming skills). Training equipment is moved from village to village on a two-month training circuit. The Bank-financed project component provided for the establishment of an additional 20 rural and 15 urban mobile units, requiring about 220 additional instructors, in order to reach 9,300 new trainees (more than twice the previous capacity).

c. Radio and Television

From FY75-79, the Bank lent approximately US$26 million for radio and television components of education projects. While the Bank has not yet developed a "typical" media project, some options can be described.

A Bank-financed project provided support to the Kenya Institute of Education in an effort to improve the quality and content of primary education. This included the preparation of radio programs and back-up materials for primary teachers and the building, furnishing, and equipping of an educational broadcasting and multimedia service station.
A Bank-financed project in the Philippines included resources for a pre-investment study on communication technology for education. The study, which was conducted by the Philippine Department of Education and Culture with the assistance of UNESCO and local and international consultants, led to a government-Bank agreement to launch a pilot project. The pilot project will be used to develop and evaluate the cost-effectiveness of two approaches to using radio for improving the quality of elementary education. The first is indirect. It uses radio for in-service teacher training. The second approach is to broadcast radio lessons directly to students as a component of their classroom activities. Secondary purposes of the project are to examine the radio as a complement to the activities of rural training centers and farmer training centers, also financed under the Bank loan; and to examine the technical options open to the Philippines for production, interconnection, transmission, and reception should the government decide to expand its use of communication technology for education. To date, the government has decided to introduce satellite technology for two-way administrative communication between the Manila headquarters and local stations. At a later date, it may utilize communication satellites to transmit radio programs from Manila for re-broadcasting locally.

The Bank has also financed the use of instructional television in the Ivory Coast, Jamaica, Iraq, and Malaysia. In Malaysia the widespread use of education television helped meet the government's objectives of improving the national educational system within both Peninsular Malaysia and the states of Sabah and Sarawak. In Peninsular Malaysia, the project purchased about 5,500 receivers for use in primary and secondary schools, and supplied 25 videotape recorders to teacher training colleges and institutes and to state audio-visual aids centers, which coordinate their distribution and use in schools. The educational television project component in the states of Sabah and Sarawak provided financial support for studio and educational media service center equipment—about 2,200 receivers and approximately 1,700 generators. This system now fully covers all primary and secondary schools and serves a total enrollment of about 500,000 students.

Bank-supported population, nutrition, and rural development projects also include occasional media components. A Bank-financed nutrition project in Colombia, for example, supported the development, production, pre-testing, and dissemination of radio messages—combined with individual and group discussions—to improve the nutritional habits of project area populations. The messages addressed weaning habits, food preparation, and food consumption.

Developing countries have also used the radio as an element of correspondence education. In Malawi the Ministry of Education's Malawi Correspondence College and Broadcasting Unit (MCC) provides correspondence courses for primary, junior, secondary, and senior secondary schools and for in-service teacher training. MCC broadcasts 15- and 30-minute radio programs over the Malawi Broadcasting Corporation network (the only network in the country), tapes programs for later broadcast, prints its own set of lessons and examinations, sends both the materials it produces and locally-produced textbooks directly to students' homes, and supplies locally-assembled radios.
At the junior secondary level (the major program), MCC has set up 58 correspondence centers and 16 night secondary schools. These now serve about 2,900 paying students, or one-third of the regular junior secondary school enrollment. The centers (which are mostly located in rural areas) and local authorities provide batteries and maintenance for the radios.

Provisions for maintenance of radio and television sets vary. In the Ivory Coast, for example, a commercial company was established to service television sets and the large, specially-designed batteries which power them. The company provides high cost repair service, which is covered by the government.

In most Southeast Asian countries, the commercial system can be relied on to provide adequate services. When a tender is made for procurement of receivers in a Bank-financed project, the condition that the bidder provide for maintenance is usually included. Large suppliers (both foreign and local) often have a strong servicing network, since the availability of maintenance services is a key to future sales. Often, as in the Philippines and Thailand, the suppliers sub-contract maintenance to local agents. In the Bank-financed project in the Malaysian states of Sabah and Sarawak, for example, there was insufficient commercial incentive for servicing the television sets provided. The government, therefore, established its own maintenance stations and requires local technical school graduates to work as technicians.

Finally, the Bank has undertaken studies of the effectiveness of radio for education and development; work in this area includes the preparation of a series of case studies, 2/ a review of their implications, 3/ and a study of the cost-effectiveness of distance teaching. 4/ These studies conclude that the radio can be both an effective and a cost-effective instruction medium in developing countries.

E. Lessons Learned

Educational development involves quantity and quality, hardware and software. All of these are needed in order to achieve such objectives as improved academic performance, changes in student attitudes, better preparation for jobs, and greater understanding of socio-economic development. This can only be achieved through curriculum changes, new teaching/learning methods, better teacher preparation, domestic development of learning aids, and strengthening of educational structures and management.


Software is more difficult to provide than is hardware. And a financial institution might hesitate before lending for it. Nevertheless, as a development institution, the Bank has felt this apparent dilemma must clearly be resolved in favor of greater emphasis on the provision of software. Many current projects reflect this emphasis.

Bank-financed education projects have shown both weaknesses and strengths. In several cases, new programs, such as diversified secondary and technical/vocational education have been established; however, some of the more innovative or experimental schools and programs have encountered problems which suggest the need for better preparation, better assessment of their administrative implications, and a more advanced stage of borrower acceptance of such innovations before they are launched. In several projects, some progress has been achieved in introducing better science teaching and more practical work in technical/vocational and agricultural education, in establishing links with employers, and setting up tracer systems and built-in project monitoring and evaluation.

At various times the Bank's operations in the education sector have encountered problems stemming from over-estimation of the borrowers' capabilities or insufficient communication with borrowers, and the projects have appeared as "Bank projects" rather than country projects. The Bank still needs to pay more attention to building up the borrowers' capabilities in regard to administering, planning, and researching their education system; recruiting Bank education sector staff from the developing countries, especially individuals who have had significant management responsibility in the sector; and ensuring that project designs are appropriate to local needs and implementation capabilities.

In addition, because of the local expert's advantage of familiarity with the social environment and the higher cost of foreign experts, the Bank should encourage borrowers to make greater use of local experts where they exist and should review from time to time this aspect of the technical assistance package for each borrower.
4. SCIENCE AND TECHNOLOGY IN THE POPULATION SECTOR
ACKNOWLEDGMENTS

This chapter was prepared under the direction of Paul Shapiro (Science and Technology Unit) and Il Hi Kang (Population, Health and Nutrition Department). It was largely written by Catherine Fogle (FHN).
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A. Bank Approach to Population

The World Bank entered the population field in 1969 because of its concern over the high rates of population growth. In the developing world, population growth has averaged over the past decade 2.5 percent per annum, which has been twice as high as in the rest of the world during this period. In several countries, the rate exceeds 3 percent and in a few it reaches 3.5 percent.

In many developing countries, the rapidly increasing numbers of young people are intensifying an already difficult problem. As they enter the reproductive years, there will be an increasing number of births—even if each woman has fewer children. Most developing countries, therefore, must reduce the present high fertility rates if socio-economic development is to proceed at an acceptable pace. In other words, lower fertility is necessary if the majority of the world's poor are to have a reasonable chance to improve the health and welfare of their families.

There are two main approaches to fertility control: one, which is indirect, concentrates on those aspects of development that are considered to have the most influence on desired family size; the second concentrates on providing direct means for fertility limitation. Over the years, the Bank, through its lending, has contributed to those socio-economic changes which lead to lower fertility. When the Bank decided to more directly help to reduce fertility, it not only spoke out forthrightly on the problem, but also provided financing for family planning through population projects. The overall expansion of Bank activities during the past decade has helped to accelerate the changes that lead to wider use of family planning. In addition, the Bank now makes marginal adjustments in its general lending program to emphasize those activities believed to have the strongest influence on fertility.

The development factors most commonly accepted as having a link to the reduction of fertility include:

(a) Health and low mortality (especially of children), to ensure the survival of a desired number of children and to give adults greater incentive for longer-run planning and investment for their children and themselves;

(b) Education, to inform individuals about the effects of population growth;

(c) Higher living standards for a significant part of the village inhabitants, to provide at least minimal validation that aspirations for a better life are not illusory; and

(d) Improvements in the status of women.
In the early 1970s, the Bank began to give increased support for projects that assist in attaining these goals. For example, investments in education, rural development, and urban development grew from 19 percent of total Bank lending for FY74-75 to 23 percent in FY79.

The Bank conducts population sector surveys to gain as full a picture of the strengths and weaknesses of the sector as possible and to identify activities which the Bank might support in a project. By identifying program gaps, a sector survey also helps other external agencies interested in assisting a given country's national population program.

Population projects financed by the Bank support national programs. Some projects include components in limited geographical areas so that new service delivery patterns, training techniques, information-education-communication (IEC) activities, and other approaches can be tested in the borrowing country. In Bangladesh, for example, several pilot activities were included in the first Bank-supported project in an attempt to make population planning a part of relevant development activities. Included in these pilot activities were the use of model farmers and cooperative managers as change agents for family planning and a rural women's functional literacy program to increase acceptance of family planning. In Malaysia, an "Intensive Input Demonstration" was designed to demonstrate the effects of various inputs on the acceptance of family planning, thus facilitating the development of long-term population policies for the country. A home visiting program, part of two successive projects in Egypt, is designed to use home visitors to make the community, particularly all eligible mothers, aware of the need for better maternal and child health/family planning care.

The Bank supports the development of effective monitoring and evaluation systems for population projects. Such systems provide the information needed by program managers within each country for determining the status of project activities and adjusting them when necessary. Such monitoring and evaluation systems are designed by those who will use them, in some cases with Bank technical assistance. Typically, such a system will include the design of a simple record system for information on the number and selected characteristics of family planning users, types of contraceptive chosen, and numbers of other services provided, as well as basic information on number and location of health/family planning personnel. Such information, initially collected by primary-level workers, is passed upward to regional and national records centers to be used as a basis for program management decisions.

Through FY79, the Bank financed 18 Bank population projects in 12 countries; Bank lending accounted for a total Bank commitment of US$287 million, or 41 percent, of the total project requirements of US$698 million. Of the remaining 59 percent, 35 percent was provided by the governments themselves and 24 percent by other donors. The loans in the population sector constitute about 1 percent of total Bank lending in the FY70-79 period.
The Bank anticipates supporting projects in one or two new countries yearly, as well as repeater projects in countries already being assisted (four such loans were made during FY79). By FY83, population sector lending should reach five or six new projects per fiscal year and constitute about 2 percent of total Bank lending.

B. Nature of Technology Used

In the development of population projects, the Bank works closely with member governments to determine what technologies will be appropriate for Bank-supported projects. Major criteria used include the nature of locally available technologies and the capacity of the country to absorb externally supplied technology.

Population projects are comprised of hardware components (e.g., buildings and vehicles) and substantial software components. The latter include training programs to allow greater use of both paramedical and community personnel to deliver health/family planning services and IEC activities; strengthening of research and the monitoring and evaluation of programs; and funding of "innovative" project activities not foreseen at the project's start. For example, in the first Bangladesh project, these "innovative" funds were used to support: (a) intensive family planning efforts in selected self-reliant villages (villages which form committees to handle certain social sector concerns, with technical assistance being provided by the government); (b) the use of folk talents and village bards to emphasize the family planning message; (c) youth leadership in fertility control, family planning, and social welfare; and (d) pilot integrated maternal and child health/family planning/nutrition services.

Bank-financed population projects are currently supporting a number of alternative technologies aimed at furthering national population program goals. One example of this is the development and provision of simpler, more acceptable contraceptive methods. Since contraceptives have often been available in the past as commodity grants (e.g., from the Swedish International Development Authority or the United States Agency for International Development), the Bank has not ordinarily supported the purchase of contraceptives. The exception to this has been in Thailand, where project funds have been made available for the purchase of additional supplies of injectable contraceptives to meet the rapidly growing popular demand for this method. The injectable (medroxy progesterone acetate or DMPA) has been available and closely monitored in Thailand for more than a decade and has been included in the national population program for over five years. During this time, no adverse side effects of any consequence have been identified. The Bank's agreement to provide funds to the Government of Thailand to purchase injectable contraceptives was preceded by a thorough review, including close consultation with the World Health Organization and other expert bodies in conjunction with the other funding agency that is also providing the injectable through the project (the Canadian International Development Authority).

The Bank is also supporting a project in Malaysia to develop one national as well as four regional family planning specialist centers. The functions of these centers will include providing various specialist services
connected with maternal health and family planning and conducting and promoting program-oriented and country-specific biomedical research in collaboration with national medical institutions.

C. Delivery Systems Used

Bank-financed population projects are based on the use of national health systems as the primary channels for the delivery of family planning services. This focus does not exclude other delivery channels, which are encouraged in appropriate circumstances. Family planning service delivery systems in developing countries are usually part of the ministry of health (MOH). But national family planning programs are not necessarily administered by that ministry. This separation of delivery system and administration can be seen in the case of Indonesia’s National Family Planning Board, Malaysia’s National Family Planning Board, the Commission on Population in the Philippines, and the Supreme Council for Population and Family Planning in Egypt.

The MOH usually provides family planning delivery services because of the advantages of combining family planning with health services, especially maternal and child health services (MCH). These advantages arise because modern contraceptive methods require the services of medical and paramedical personnel (and health personnel can readily be trained to provide family planning services) and a separate family planning service would mean an unnecessary duplication of clinics and staff. Bank-financed population projects provide strong support for the training of paramedical community workers in health and family planning skills; a reasonable measure of integration of health and family planning activities is encouraged, assuming a supportive rather than competitive relationship exists between the two activities.

The Bank recognizes that projects are dependent for organization and implementation on local institutions, traditions, and practices. They must be integrated into the socio-cultural milieu of a nation. For example, in a Bank-supported project in Bali, the Banjar (a village monthly meeting of all family heads) system is being used effectively to increase the number of family planning acceptors through community involvement and the provision of family planning information and supplies. In the Dominican Republic, the Bank-supported population project is financing operating costs for a program of community-based distribution of contraceptives in rural areas not yet covered by health and family planning services.

National population programs rely on medical delivery systems to provide needed contraceptive supplies and services. This system is limited by the number of clinics, physicians, and nurses available to staff them. Such a system inevitably excludes rural areas, in which the bulk of most developing countries’ population resides. To resolve this problem, new categories of paramedical and community workers are being developed to work both in expanding networks of rural health facilities and in their own villages. For such extension efforts to be successful, major new training programs must be developed. The Bank finances such new training programs through the construction of training centers and through the provision of project funds to pay for the preparation of new curricula, teaching materials, and fellowships. This
creates new directions—downwards and outwards—in family planning services; i.e., "downwards" in the hierarchy of medical and paramedical occupational groups and "outwards" from static service delivery points to locations closer to the people concerned. This concept is being used in projects in Thailand, Indonesia, and Jamaica.

D. Population Information-Education-Communication

The role of IEC components is also growing in Bank-assisted population projects. This happens as national programs move from a "supply" orientation (one in which it was felt that sufficient numbers of clients could be recruited through the provision of adequate family planning services) to a "demand" orientation. The "demand" orientation requires the program to focus beyond service delivery, to develop more motivationally-oriented IEC activities, and, in the long run, to adopt strategies and promote structural changes that will create new, smaller family size norms. IEC activities enable family planning programs to crystallize the potential demand of people whose attitudes are already being altered under the influence of wider socio-economic changes. Through the choice of appropriate appeals, changes in reproductive behavior can then be linked with the realization of other concrete needs.

Other projects support the use of both traditional and modern media to deliver the family planning message. These range from puppet shows and folk dances in Indonesia to support for mobile IEC vans in Malaysia and the production of television programs in the Philippines. A major challenge to IEC strategies is how to incorporate culturally relevant approaches that are typically suited to face-to-face encounters with the more efficient Western-developed audiovisual aids and mass media. In Kenya, a traditional style of banter has been adapted for a very popular radio broadcast on health and family planning.

Another important trend in IEC is decentralization and greater user involvement in the design of IEC materials. In the Philippines, rural groups have actively participated in the development of flipcharts using local ideas and analogies derived from the local way of life (e.g., fishing). Typically, a comprehensive population communication program will require a range of communication technologies. Various practical considerations (such as availability of electricity, pre-existence of necessary software for a given medium, and availability of servicing and spare parts) also play a crucial role in these discussions.

E. Population Education

Bank-supported population projects now provide for population education in both formal and non-formal education settings. These serve to instruct people in the wider socio-economic effects of population growth on their society, and, therefore, on their lives. In Indonesia, for example, the Bank supports the printing of population education books, with local rather than foreign consultants advising on the preparation and editing of texts.
Population education is also being included in Bank-financed education projects—in four to date (Ethiopia, Haiti, Egypt, and Sudan). Mass-produced, low-cost textbooks offer a particularly effective method for introducing population education content. This is also being done in science textbooks produced by a Bank-financed education project in the Philippines and is likely to be extended to social science textbooks in the future.

F. Building Local Capabilities

The Bank pays particular attention to institution building and the development of management capacity through all stages of project development and implementation. Most population projects provide about 5 percent of total project costs for studies and technical assistance to support institution building. The first Bank-financed project in Malaysia, for example, included a management study, the recommendations of which (concerning management information systems, planning and program coordination, and development of a procedures manual) have been incorporated into the second population project, following their acceptance by the Government of Malaysia. In the first population project it financed in the Philippines, the Bank encouraged the Government to conduct its own review of its population program and, following the recommendations of this review, supported a functional analysis of the Ministry of Health as a basis for upgrading its management capacity at the local, regional, and national levels. The Bank is also supporting through a second project the upgrading of staff technical background in the quasi-governmental agency responsible for overall coordination of the country's population program.

The Bank relies largely on its population staff and its own consultants to provide needed technical assistance to population projects. In early projects, the Bank supported the use of foreign consultants to advise the borrower on project implementation. A project in an Asian country, for example, supported three external advisors in the fields of management, training, and IEC, as well as an external management consultant firm; but the efforts of the latter were seen as unsatisfactory. While there are few consulting firms available in the population field, the Bank looks to and has used local consulting firms to undertake population project-related activities. The Bank helps to foster and strengthen local expertise through the involvement of local governmental and agency staff in project formulation and implementation; training programs (supported within projects) at the national, regional, and local levels (as well as overseas fellowships); and the use of individuals with population experience in one country as Bank consultants for projects in another country.

The Bank seeks consultation with the borrower on the terms and appointment of key population project managers. To help create the necessary management and technical knowledge within the country, some projects have provided for regional and overseas fellowships. Also, the Bank's Economic Development Institute (EDI) has begun conducting annually a ten-week course on Population and Development for senior and mid-level health and population program planners and managers.
Another example of the Bank's emphasis on using local capabilities is in the construction of buildings used in population programs. Such construction is usually of small, widely scattered rural health clinics or training centers, for which the Bank encourages the design and construction of simple, functional buildings. Local competitive bidding is used in most cases, and local construction standards serve to guide the choice of design and materials.

All construction designs are reviewed by Bank architects to assure compliance with the minimum standards appropriate to the purposes for which the buildings are intended. Most health facilities built with Bank support include medical equipment and furniture; these items are purchased locally, if available. As part of the second Bank-financed project in Bangladesh, about 900 new family welfare centers are being built in close cooperation with local government units. The government units will purchase the construction materials locally and find local laborers. This local input and responsibility is an innovative approach to project construction and will be assisted by the provision of a manual on design and quality of construction being prepared by a project architectural consultant, who will also be responsible for technical supervision. Local building techniques are also being used in Bank-financed projects in Thailand, to build 180 child nutrition centers, and in the Philippines, for the construction of Barangay Health Stations.

G. Research Supported

Bank-financed population projects support research. 1/ In early projects, research components focused mainly on improving family planning service utilization aspects. In India, for example, the Government had provided family planning services for almost two decades and wanted assistance in developing a comprehensive demonstration program in two states. The project included components of the government program but added a substantial research element including the establishment of two population research centers, as well as support for several management institutes to advise the centers, an experimental nutrition program, and the testing of family planning service delivery variables. Normally, project research components represent about five percent of total costs of a population project.

Currently, project research components focus on topics designed to provide information applicable to strengthening program management and on socio-economic considerations affecting family size decisions. A community incentive scheme in a Bank-financed project in Indonesia will test whether the promotion and acceptance of the small family norm by the people themselves and their community can be fostered by the application of rewards for pre-defined community achievements in family planning.

1/ The Bank also carries out socio-economic and behavioral research related to population. For further information see World Bank Research Program, Abstracts of Current Studies, October 1979.
The Bank does not normally involve itself in contraceptive research (the project in Malaysia described in section B is an exception made at the request of the government), since such research, both basic and applied, is carried out by other international agencies (principally WHO), national governments (e.g., the Department of Health, Education, and Welfare in the United States), and pharmaceutical companies. The Bank does, however, participate in WHO-sponsored meetings on the Research Program on Human Reproduction, thus enabling Bank staff to be involved in discussions of trends and results in current bio-medical research.

The Bank is supporting a feasibility study in Bangladesh to determine whether two-way radio hook-ups between MCH/family planning fieldworkers and the local health center are feasible, in order to allow health center staff to better supervise fieldworkers, and permit fieldworkers to ask the center for advice and support when needed. The Bank is supporting studies in both the Philippines and Indonesia to determine the feasibility of their national family planning programs developing computerized Management Information Systems.

Population projects are also supporting an increasing number of studies intended to better identify those factors in socio-economic development that may have an impact on fertility. In Malaysia, a study was designed to analyze the inter-relationships between sectoral development intervention and demographic change. In Kenya and Bangladesh, studies are being done on the determinants of fertility. In Bangladesh, a review of the effect of existing national laws on population growth is being conducted in order to reveal pro- or anti-natal biases. A Bank-financed project in Egypt includes establishment of a Research and Development Unit to strengthen research on ways of obtaining more effective cooperation from community leaders, traditional birth attendants, and other part-time community workers in MCH/family planning.

A number of Bank-supported projects work with, or provide support to, local universities or research institutes. In India, a population research center was established in each of the two project states to conduct demographic and operational studies of importance to project implementation. In Indonesia, a feasibility study to manufacture oral contraceptives from local raw materials will be carried out with the assistance of the Bogor Agricultural University. In Bangladesh, the Bangladesh Institute of Development Studies has undertaken a study of the determinants of reproductive behavior in that country. And a project in Kenya included support for the establishment of a Population Studies and Research Center. The center is to be established at the University of Nairobi, which has undertaken research and training of Kenyans in the broader implications of, and solutions to, the population problem.

H. Lessons Learned

The Bank’s experience in population projects has indicated that the type and level of technology employed must be consistent with the absorptive and adaptation capacity of the project country. Project organization and
Service delivery mechanisms must be consistent with, and acceptable to, the shape of national program development, as well as the degree of educational and professional development present. For instance, the Bank no longer supports establishment of project implementation units for population projects. Experience has shown that such a unit causes numerous problems (including rivalry with existing units) and drains support away from existing administrative mechanisms and staffing patterns of the ministries and agencies through which the project is implemented. This differs from the urban development sector, where such units are often required.

In terms of technical assistance provided for in population projects, the Bank's experience indicates that better results are obtained when local rather than external consultants are used. Middle-level rather than high-level advisors were found to be more effective, especially when appointed for short rather than long-terms. The experience with consultants from other countries in a region has been mixed; while they are often more sensitive to a local situation than consultants from developed countries, they are still "external."

Population programs are evolutionary activities. Countries progress from relatively elementary to highly sophisticated programs. The Bank's intervention and the technologies applied must be appropriate to each stage of their evolution.
5. SCIENCE AND TECHNOLOGY IN THE HEALTH SECTOR
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A. Bank Approach to the Health Sector

1. Nature of Bank Lending

Poor health and disease are a consequence of poverty and under-development in much of the world. Studies indicate that in 1975 the life expectancy at birth in the least developed countries was less than 40 years, in developing countries generally it was just over 50 years, and in developed countries, 71.4 years. Similarly, infant mortality is less than 25 per 1000 in the developed countries but exceeds 100 per 1000 in much of the developing world and in some instances is greater than 250 per 1000. Morbidity patterns exhibit equally significant contrasts; developing countries have high incidence of infectious and parasitic diseases which are rooted in lack of sanitation, unsafe drinking water, uncontrolled disease vectors, and lack of basic health education. In some developing countries, more than 40 percent of the population experiences several illness episodes in any given month. Malnutrition and high birth rates are also important features of the developing world's health problems.

Improvements in the well-being of the world's poorest peoples have been an essential part of the Bank's development strategy. Good health contributes directly to human well-being; thus, the need to provide essential health services to a much larger proportion of the world's population has become an increasingly important aspect of development. It has also become an increasingly important part of Bank lending. The Bank began including health components in projects in 1971. In 1974, the Bank established a formal policy for health sector involvement. The policy noted that Bank activities would, through the reduction of debilitating illness and premature death, increase productive potential and enhance the quality of life. Thus, programs to improve health can be viewed both as a productive investment and as a way of raising living standards, the ultimate aim of development. In July 1979, the Bank adopted a policy of supporting free-standing health projects.

Poor health and disease impose economic costs by reducing the availability of labor, impairing the productivity of both human and capital resources, and impeding the development of natural resources. Relatively small expenditures to improve health conditions can substantially improve productive capacity. A Bank-financed study in Indonesia, for example, provided anemic workers with very inexpensive iron supplement pills. The iron supplement resulted in a 20 percent increase of productivity. In other cases, by treating the environment, moderate investments in appropriate health technology helped restore large tracts of fertile land that had become partially depopulated because of the severity of vector-borne diseases.

Through FY79, the Bank lent US$307 million for health components of 123 projects—72 agriculture and rural development projects, 19 urban development, 12 education, 1 transportation, and 1 technical assistance
5-2

project. It is estimated that through FY78 an additional US$151 million was lent for health components of 15 population and 3 nutrition projects. In FY79 alone, Bank lending for 15 health components totaled US$105 million, not counting population and nutrition projects (for which data are not yet available).

In addition to its own efforts, the Bank cooperates with multi- and bilateral organizations that play a major role in promoting health improvements in the developing countries. These organizations include the World Health Organization (WHO), the United Nations Children's Fund (UNICEF), and the United Nations Development Programme (UNDP). WHO's resources mainly have been channeled into expert technical assistance. In addition, WHO has undertaken major disease control activities—such as the worldwide efforts against smallpox and malaria—that require extensive coordination of national programs. Since the early 1970s, WHO has placed increasing emphasis on health care management issues and, more recently, has promoted primary health care and the integration of health in development programs. UNICEF has collaborated with WHO both in analyzing issues emphasizing mothers and children in primary health care and in sponsoring the worldwide Alma Ata Conference (September 1978) on this subject. UNICEF also assists countries in developing small-scale health programs and in procuring medical supplies and equipment. UNDP administers assistance to countries, some of which is used for health care, and has acted as joint sponsor, with the Bank and others, of various specialized programs.

2. Critical Points in Project Work

Bank-supported projects in all sectors are carefully monitored to avoid possible adverse impacts on health. In agricultural irrigation and dam projects, for instance, there is concern about expanding the habitat for vectors of schistosomiasis, malaria, and onchocerciasis. Thus, such projects frequently incorporate specially-designed vector control components. Similar precautionary components are included in rural development projects—e.g., when populations are to be resettled in new areas.

Health components of Bank-supported projects are normally targeted on the poorest segments of a population—those who have had virtually no previous health services. For this reason, the health components often have a considerable impact on the health sector in the borrowing country. The most significant impact is the creation of extensive demands on the health manpower training system, the health management infrastructure, and the medical supply and logistics systems.

These factors receive careful consideration during component preparation, and specific activities are often included to deal with the increased demands. For example, when health care services are only available to 20 percent of the population and the existing health manpower training system is marginal for meeting even those needs, it is not possible to establish rural primary health care units to serve an additional 50

1/ Defined in section C, below.
percent of the population without also establishing training programs and institutions to produce additional health workers to staff the new health units. Similarly, it is often not possible to expand the outreach of primary care without greatly expanding the existing logistic systems required to maintain the flow of drugs and other medical supplies. Thus, these impacts serve as a major impetus for important institution building activities.

Health issues are frequently important to other development activities—e.g., nutrition, population, sanitation, water supply, irrigation, agricultural development, and resettlement. Most integrated rural and urban development projects incorporate multifaceted health interventions. A rural development project, for example, may apply one or more of the following technologies to improve health: development of health system management and supply infrastructure and strengthening of the organizational structure and project management capabilities of local health agencies, training of health auxiliaries, training and management of community health promoters, provision of nutrition education (and sometimes food supplements), maternal and child health programs, construction of primary health care centers, construction of latrines and other sanitation measures, and construction of protected wells or other safe water supplies.

There are several factors that affect the management of health components, including: (a) the need to reach viable component size—i.e., sufficient scope and depth to accomplish the identified objectives without overburdening the organizational structure of the parent project; (b) the need to identify, prepare, appraise, supervise, and evaluate a large number of small "miniprojects" while maintaining reasonable staff-cost ratios; (c) the need to obtain the necessary commitments of support from the ministry of health when it is not the lead agency on the project; (d) the need to develop sufficient leverage to promote the needed changes in policies and systems identified in sector work; (e) the need to reconcile different management and technical characteristics of components and overall projects; and (f) the need to coordinate the component with the project area (e.g., in some cases health posts may be established in a rural development project area, though the referral centers and hospitals are in urban centers away from the project area).

B. Health Sector Use of Science and Technology

Bank support of the health sector includes application of science and technology in: health care services, health manpower training, health facilities construction and renovation, community health education and mobilization, immunization, nutrition, vector control, and environmental sanitation and water supply. Activities in some of these areas are mainly concerned with institution building and are discussed more fully in section C.

Health components may be limited in scope and, therefore, require the use of only a single kind of technology. More often, several interventions, employing a variety of technologies, will be used to improve health. Section D presents an example of the latter approach.
1. **Major Diseases and the Interventions Used Against Them**

Most health sector science and basic technology interventions focus on the major infectious and parasitic diseases that are found almost exclusively in developing countries. The major group of infectious diseases in developing countries is diarrheal diseases. They, like the major parasitic diseases (most of the latter are transmitted by vectors), are associated with water and/or sanitation problems.

**Diarrheal Diseases.** This group of diseases is caused by a wide variety agents—e.g., bacteria, viruses, parasites, and fungi. They affect both children and adults to an extent that is often underestimated. This is especially true for younger children who suffer the greatest exposure; young children may have mortality rates of more than 25 per 1000 from this cause alone. Safe water supplies, good sanitation, and proper personal hygiene are the main preventive measures; with the exception of those for typhoid and cholera, vaccines are not yet developed.

The main threat of these diseases is dehydration; loss of as little as 15 percent of body fluids, which in severe cases may occur in a few hours, can be fatal. Oral rehydration, consisting of a simple solution of sugar and salt can be given in place of intravenous fluids. This approach is highly effective in reducing the mortality and severity of diarrheal diseases, regardless of etiology. It has an additional benefit in lessening malnutrition problems, since diarrhea and malnutrition have a powerful mutual synergism. In one Asian cholera epidemic, mortality was reduced from about 50 percent to less than 1 percent through the introduction of oral rehydration.

The treatment solution is readily prepared at home, since the necessary ingredients are found in virtually every kitchen. However, a household member must know how to prepare the solution. Teaching the method of preparation to local populations has been made an integral part of many Bank-financed health components.

**Parasitic Diseases**

**Malaria.** Approximately 200 million people are currently infected with malaria. While drugs are available for prevention and treatment of this disease, they are not available for mass distribution in developing countries. The predominant method of prevention is insecticide-based vector control. Emerging resistance of mosquitoes to the standard insecticides, however, has become a major problem. The development of new tools for malaria control is a priority of the Special Programme for Research and Training in Tropical Diseases (TDR) described below.

**Schistosomiasis.** This snail-borne parasitic disease is also under investigation by TDR. During the past decade, notable advances have been made in understanding the factors responsible for the transmission of schistosomiasis; developing new drugs for treating the disease; and
using available chemicals for control of snail vectors. It is estimated that 250 million people are victims of this disease, which is spread throughout Africa, Asia, and Latin America. The newer molluscicides, properly applied, can kill at least 99 percent of the host snails. For several months after application, the snail populations will remain below 5 percent to 10 percent of the original levels, depending on temperature conditions. A second main thrust has been habitat elimination, but this is made difficult by the inherent conflict with dams, irrigation, and other water projects.

A good example of control technology is found in a large irrigation project in one of the worst schistosomiasis-endemic regions of the Philippines. Here the disease prevalence averages 18 percent ranging from 5 percent to 45 percent. The climate and topography are particularly suitable to the snail vector. Lifestyles of the rural population, which involve constant exposure to water and a low level of public hygiene, produce optimum conditions for a high infection rate. The Bank-financed control program incorporates the following measures: (a) improving drainage to make the habitat less favorable to the vector; (b) conducting area-wide malacological surveys; (c) creating community awareness of preventive measures for schistosomiasis through education and information activities; (d) improving the general hygiene through environmental sanitation, upgraded water supply, and education; and (e) reducing the parasite reservoir in humans through chemotherapy.

Onchocerciasis. Approximately 20 million people are infected worldwide with river blindness, onchocerciasis. One million Africans are afflicted, of whom 100,000 are partially or totally blind; in some villages over 50 percent of adult males are blind. Suitable means for a mass chemotherapy campaign are not available. Because it is not practical to directly attack the adult blackfly vector, control technology focuses on two approaches: elimination of the habitats required by the larval states and treatment of watercourses with chemical larvicides. One of the larvicides has such low toxicity for humans and fish that it can safely be added to rivers and streams. The Bank’s Western Africa Regional Office is administering the present 20-year Onchocerciasis Control Program in the Volta River Basin with support from a consortium of sponsors; WHO is the executing agency. Drug development to combat onchocerciasis is being supported through TDR.

2. **Major Interventions and Their Applications**

The above examples of applying standard technologies to the major tropical diseases demonstrate that every disease requires a different strategy for prevention and control. Often several interventions are brought to bear because of their synergistic effect, as in the case of diarrhea and malnutrition. Other interventions are described below.

**Immunization.** Where vaccines are available for major infectious diseases, immunization programs are extremely effective in reducing morbidity and mortality, particularly in infants, young children, and expectant mothers.
**Nutrition.** Education and direct food supplementation (projects involving the latter are implemented and managed by the Bank’s Nutrition Division) are the two main approaches in this area. Nutrition education is provided by health workers, who communicate to people in target areas of projects basic information on the effective use of available foodstuffs to avoid malnutrition and particular vitamin and mineral deficiencies. Food supplement programs provide special fortified foods, principally to mothers and children who are diagnosed by health workers as having nutritional deficiencies. An example of both approaches is given in section D.

**Vector Control.** The bulk of Bank-financed efforts in this area have focused on control of malaria, schistosomiasis, and onchocerciasis vectors. This intervention emphasizes chemical methods, such as residual DDT spraying and mollusciciding, and environmental change, through drainage and watercourse control, to eliminate vector habitats.

**Environmental Sanitation and Water Supply.** Poor hygiene and poor sanitation contribute to infectious and parasitic disease distribution. Sanitation efforts focus largely on proper waste disposal and involve construction of low-cost latrines, water seal toilets, and similar disposal methods. Water supply concentrates on such methods as protecting wells and springs, constructing boreholes and deep wells, establishing standpipes, and initiating other types of distribution systems.

**Special Programme for Research and Training in Tropical Diseases**

The Bank co-sponsors with WHO and UNDP the Special Programme for Research and Training in Tropical Diseases (TDR) and acts as fiscal agent for the TDR Fund. This program has two principal objectives: to develop and apply effective and low-cost methods to control malaria, schistosomiasis, filariasis, leishmaniasis, trypanosomiasis, and leprosy; and to train scientists and technicians and to strengthen research institutions in the countries affected by the diseases, thus increasing the capability of these countries to deal with the problem.

**C. Building Local Capabilities**

1. **Institution Building and Infrastructure Development**

One of the most important aspects of Bank-supported health components is the development of local capabilities to absorb and manage the technologies required for health care programs.

**Health Care Services.** Personal care services provided through health components are of three types: prevention, diagnosis, and cure. Considerable attention in all three areas has been directed to establishing simplified procedures that can be performed by semi-skilled health auxiliaries and rural health workers rather than by highly trained physicians and nurses, who are in short supply.
Over the past several years, the Bank has emphasized primary health care (PHC), which has been the subject of worldwide discussion at the 1978 Alma Ata International Health Conference sponsored by WHO and UNICEF. Primary health care (basic health services) includes: simple methods of diagnosis and treatment, first aid, maternal and child health care, prevention and treatment for endemic and epidemic diseases, and health education.

The reasons for emphasizing PHC are two-fold: first, the cost-effectiveness of PHC is higher than for the more elaborate hospital-based approaches used in many developing countries, since many of the most important causes of mortality and morbidity respond readily to simple, low-cost interventions. Second, for a health care program to be effective, it must be utilized by the target group. This means that it must be both accessible and acceptable. Therefore, introduction of widely distributed, simple, effective services is essential to bringing these benefits to the maximum number of people. These services are intended to focus more on preventive aspects than is customary in hospitals. However, an essential feature in PHC is the use of an effective referral system which enables patients who require more advanced curative care to be directed to health centers or hospitals.

Health Manpower Training. Significant expansion of health service capabilities, especially along the lines of PHC, requires not only large numbers of additional health workers, but a different emphasis in their training. Therefore, teaching and training technology has played an important role in developing the necessary cadres of health technicians, auxiliaries, village health promoters, and rural health workers. This training is less comprehensive and requires less time than that required for regular medical and nursing personnel, yet it produces a satisfactory level of competence for performing the simplified procedures and services that do not require the intuitive judgements that are part of full professional qualification.

Health Facilities. A major thrust of Bank-financed health activities is to bring services to the unserved or underserved. In most cases, this necessitates construction or renovation of facilities. The trend to date has been toward the provision of a large number of small, inexpensive structures, widely distributed. The majority of these are in rural areas. This approach is keyed to the community outreach concept in health programming, which dictates a need for smaller facilities.

Community Mobilization. A key feature of Bank-supported projects is to involve the community. This participation takes many forms including: (i) nomination of candidate health workers; (ii) establishment of a cadre of village health "promoters," who explain where and how to get services, and generally heighten community awareness of health matters; (iii) organization of village health committees to advise program managers; (iv) organization of work parties to attend to drainage and sanitation problems; (v) establishment of cooperatives to construct and maintain village water supplies; (vi) donation of sites and materials for construction of facilities; (vii) provision of labor and assistance for construction; and (viii) providing community education, especially to women, on health-related matters.
2. **Technical Assistance and Training in Project-Related Skills**

Technical assistance that utilizes foreign and local consulting expertise in health components has played a part in the areas of health manpower training, health system management, vector control planning, and epidemiological studies. One example is found in a Bank-financed rural development project in Latin America, where foreign experts provided initial instruction to the Project Coordinators and Regional Director on the operation of the rural health systems. Additional assistance was provided in developing the training programs for health workers. During the second year of the project, two additional technical assistance missions are planned during the training courses. Technical assistance in selecting and training new candidates and in supervising those already working is continuously being provided. During the third year, a technical assistance mission is planned for supervision, adjustments to the program, and evaluation of the rural health systems operations.

Such technical assistance and training are designed to achieve a significant transfer of technological expertise, thus enabling broader local participation in future project design and implementation. An example of this is a Bank-financed education project in The Gambia, in which outside consulting services were provided to assist the Ministry of Health in the development of health manpower training programs. Ministry of Health personnel were also trained to develop the planning base and implementation plan for expanding health care delivery systems as proposed in the National Development Plan.

Another example is the Bank-supported Integrated Nutrition Improvement Project in Colombia. To strengthen the organization of the Colombian Ministry of Health and the regional health offices, the health component of this project provides, over a four-year period, for: (a) a health systems management consultant to the Programming Office of the MOH, (b) a consultant with experience in community organization and development work to the Division of Community Participation of the MOH, and (c) seven health systems management consultants to the regional health offices.

3. **Involvement of Local Universities and Research Institutes in Projects**

Health components of Bank-financed projects utilize and strengthen local capabilities wherever possible. This has been particularly true in the area of health manpower training. An education project in Cameroon, for example, has a component that supports a training program for rural health workers at the University of Yaounde. The university’s Center for the Health Sciences program trains physicians, nurses, and technicians in medical and paramedical aspects of rural health and emphasizes: (a) the different health problems of rural and urban population, (b) a shift from mainly curative to a greater use of preventive techniques, and (c) integration of various types of workers into an interdisciplinary health care team rather than having them function as individuals. The health component described below includes training programs by the local university and nursing school.
D. Description of a Comprehensive Health Component

The Integrated Rural Development Project in the state of Minas Gerais, Brazil, illustrates the present thrust of Bank-financed health activities. The main characteristics of the Minas Gerais health component are: (a) the provision of approximately 275 simple health posts (miniposts) that are distributed throughout the project area, each serving approximately 2,500 people; (b) the provision of low-cost health services; (c) an emphasis on preventive medicine and promotional activities; (d) strong community participation in the organization, operation, and financing of the centers; (e) an effective mechanism for referral to higher levels of health care; (f) intensive ongoing supervision and training activities; and (g) an information system for monitoring/evaluating the health component of the project. The health component includes four service programs (primary health care, vaccination, sanitation, and nutrition) and two support elements (training and administration).

The basic objective of the PHC program is to deliver services not only to the immediate target group, but to the total rural population. Priorities are: (a) pregnant women, (b) children under five years, (c) children between 5 and 14 years, and (d) adults. By increasing coverage over time, the program would eventually reach 80 percent of the first two groups; 40 percent of school-age children; and 25 percent of adults.

Most of the project activities for disease control and prevention are provided by the health posts. Each post is staffed by a locally-recruited health attendant. It is estimated that 40 percent of the posts will operate in existing or planned schools or in municipality buildings; 30 percent in upgraded houses bought by the Health Secretariat from the community; and 30 percent in new structures. The project is upgrading 63 existing centers and constructing and equipping 36 new ones. Each health center supports an average of three health posts.

The vaccination program element, while only a small portion of total project costs (estimated at US$100,000, 80 percent for the vaccine), represents a cost-effective method of diminishing the incidence of infectious diseases and substantially improving local productivity. Routine vaccination is carried out by the health attendants at the health posts in special campaigns supported by health center staff. The simple information service included in the project maintains efficient epidemiological surveillance.

Morbidity and mortality from diseases caused by poor sanitary conditions are attacked by the sanitation program. Priority localities are those with the poorest sanitation facilities and with a high incidence of water-borne infectious diseases. As part of the state's overall health and sanitation program, the project aims to install 18,000 water filters and 15,000 pit latrines for a total coverage of approximately 12 percent of the local families. Additional drainage and other sanitary improvements would serve about 42,000 people. These figures are considered minimal goals; coverage could be increased according to community response. In addition, the public health authorities are developing a program for the investigation of schistosomiasis foci in the project area.
Problems of caloric and protein malnutrition, especially in children under five, are the focus of the nutrition program. Priorities have been defined in the following order: (a) pregnant women, (b) lactating mothers, (c) children under three years, and (d) three- or four-year-old children who are undernourished. Strategies include nutrition education and diet supplements using food purchased in the project area. The supplements are based on regional products, according to preliminary nutrition standards fixed by the National Institute for Food and Nutrition. Also, community and family gardens are being promoted in coordination with the Rural Credit and Extension Agency. Nutrition education is provided through the cooperation of the Agency and the Education Secretariat of the state government.

The training of health staff is an important component of the project. The training provides 240 to 300 hours of basic training plus periodic refresher courses for some 800 health attendants, health center staff, and project supervisors. Training covers diagnostic and treatment methods to be used in the health posts and the fundamentals of preventive programs. Personnel from the health centers receive training in organization and referral procedures, while their supervisors are trained principally in program management. Training takes place at several regional education centers and selected health posts and health centers. The organization and execution of the training component is the responsibility of the Human Resources Development Unit in the state Secretariat of Health.

E. Lessons Learned

The Bank's experience confirms that good quality primary health care is highly cost-effective. Such care can be provided at a development cost of from US$2 to US$25 per capita and an annual recurrent operating cost of from US$1 to US$10, depending on local costs and conditions.

The application of biomedical, environmental, and social technologies is required for successful planning and implementation of health activities. The major lesson of Bank-financed health components is that innovative and carefully planned social technologies are crucial factors in delivering effective health services. The technologies include cost-effective methods for mobilizing communities; selecting and training health workers; and developing supervision, management, and logistic support systems.

Practically all successful low-cost primary health care programs have a significant amount of community involvement. This participation is best stimulated by enlisting community leadership and social networks to mobilize resources and effect change, building commitment through gradual involvement and change, and providing start-up funding for activities the community values highly and for which it will assume full operating responsibility. Initial emphasis should be placed on problems that respond dramatically to modern health technology in order to rapidly gain credence for the program. Changes in traditional practices should be introduced where those practices prove harmful to personal and community health.
Experience shows that local villagers can be trained at low cost to be effective health workers. Recruitment of candidate health workers, chosen through nomination by local councils or committees from the villages where they will serve, has proven effective.

Supervision, technical support, and strengthening of skills are essential for village health workers because of their relative isolation from other health workers. These requirements can best be fulfilled by integrating village health care into a well designed and implemented referral network and by periodic retraining programs.

Adequate logistic support, particularly as it affects the delivery of drugs and other medical supplies, is also critically important and normal and rigorous administrative control and accountability are essential. However, few health ministries have adequate procedures or managerial staff for effective implementation of these practices. Bank-financed health components have not permitted addressing these issues at national levels, although the need is very pressing.

Finally, strengthening management capabilities at all levels of the health care system is crucial to the effective functioning of the expanded services that are implemented through Bank-supported projects.
6. TECHNOLOGY IN WATER SUPPLY AND WASTE DISPOSAL
ACKNOWLEDGMENTS

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TECHNOLOGY IN
WATER SUPPLY AND WASTE DISPOSAL

A. Bank Approach to the Water Sector 1/

The Bank's objectives in this sector are to provide water supply and waste disposal services to as many people as possible, to do this in the most efficient and affordable way, and to ensure that the full benefits of such services can be realized. This is because without adequate and convenient supplies of safe water for drinking and washing, and adequate waste disposal facilities, people cannot attain a reasonable minimum standard of existence. Water which is unsafe for human consumption carries and spreads disease; water which is inconveniently situated leads to considerable loss of productive time for those who have to fetch it, makes it difficult to obtain adequate quantities, and requires careful handling to avoid contamination; inadequate supplies of water can frustrate attempted improvements in many aspects of social welfare; and inadequate waste disposal leads to the spread of a wide range of parasitic and other debilitating diseases. In addition, people must be convinced to create and maintain sanitary living conditions by taking action (e.g., health education) to promote hygiene and prevent disease. This usually involves a promotional or educational process to make people aware of the causes of disease and the preventive measures possible through the use of safe water, hygiene and general cleanliness, and proper waste disposal.

In the 1960s, the Bank's major emphasis in the sector was in developing urban water supply and waste disposal facilities. The Bank was particularly concerned with increasing the efficiency of large investments in major works and facilities for collection, treatment and disposal, and in building up strong sector institutions.

From the early 1970s, the Bank has broadened its lending objectives of providing efficient and affordable water supply and waste disposal facilities to include the poor in the rural and urban fringe areas. This expansion has been made possible, and supported, by an extensive program of research. This research made it clear that waterborne sewerage, which is the standard mode in the industrialized countries, is unsuitable to many cities and communities in the developing world at the present time. Thus, as a first step toward the rapid expansion of improved sanitation, it has been essential to examine thoroughly and critically the alternative, low-cost techniques available.

1/ This chapter should be read in conjunction with the section on water supply and water disposal in chapter 2.
1. The Bank’s Lending Program 1961-1979

Since the Bank’s first loan for water supply and waste disposal in 1961, lending for these services has increased to 21 projects in FY79 and a total during this period of 127 projects in over 53 countries. The total cost of the 127 projects, as estimated at the time of appraisal, was about US$8.2 billion, of which the Bank financed US$3.0 billion. Lending in FY79 amounted to US$894 million for projects costing in total US$2.2 billion.

The growing recognition of the value of adequate waste disposal in enabling the full benefits of water supply to be realized is implicit in the changing pattern of loans over time. In the years since FY73, for example, 57 percent of projects involved a waste disposal component, compared with 31 percent before that year.

During the ten-year period FY69-78, Bank lending for water supply and waste disposal was about four percent of total Bank lending; in FY79 it was 10 percent. In addition, the Bank continues to be involved in financing the water supply and waste disposal components of urban development, rural development, and tourism projects, as well as of a number of multipurpose projects such as hydroelectric dams.

2. Size and Scope of Future Lending

Over 70 percent of the Third World population which does not have adequate supplies of safe water or adequate waste disposal facilities is located in 20 developing countries. Therefore, to achieve the goal of providing the maximum number of people with basic water supply and waste disposal facilities in the shortest possible time, much of the Bank’s increased lending in this sector should be concentrated in a few of these countries, such as Bangladesh, Brazil, Burma, Egypt, Ethiopia, India, Indonesia, Kenya, Nigeria, Pakistan, and the Philippines.

Past investment in these countries to improve sector facilities has been relatively low—both in terms of overall Bank lending and of total country investment in the sector. The recently completed sector studies in all of these countries indicating country needs and identifying potential projects, have laid the foundation for an increased lending program. The Bank expects that over 70 percent of the increase in lending for water supply and waste disposal will be in these priority countries. Where necessary, as in the cases of Egypt and Peru, engineering loans will be made to assist in project preparation.

Present estimates put total sectoral investment required by 1990 between US$200 billion and US$600 billion if 100 percent access to adequate supplies of safe water and sanitary waste disposal is to be achieved in the Third World. Since there is no prospect of raising funds of this magnitude, the objective will have to be phased differently. Such estimates do not, however, take fully into account progress made in using low-cost technology to meet the basic needs of the people in developing countries.
B. Nature of Technology Used

There is very little of the theory or technology of water supply and waste disposal that has not been known for a long time. Over two thousand years ago, the Romans drew water from the Tiber River and wells and springs. When these sources became inadequate, aqueducts were built to bring water in from beyond the seven hills, sewers were built to drain the marshes and in turn to dispose of the waste water, and, then, to control the use of water, metering devices (orifices) were installed.

Today, in most advanced industrial nations, the water supply systems, particularly in the towns and cities, are quite similar, as are the waste disposal facilities. Indeed, in many developing countries it is now realized that there are distinct advantages in the construction and operation throughout every urban community of a water supply system along the lines of those now found in the towns and cities of the advanced countries. Such a system incorporates a centrally controlled and treated source of water, wide-ranging transmission lines, distribution networks, and metered, multiple-tap connections in every house or apartment. With proper management, there can be large social and economic benefits in such a system. They are convenient for the consumer, they reduce the user's costs of storage and purification, and, through the universality of use, they can limit the possibilities of infection. Meters can be used to levy a range of tariffs which in turn can be used to produce a financially viable public undertaking, to discourage waste, to assist investment decisions, and, possibly, to help in a general movement to redistribute income.

Experience in both rich and poor countries shows that cheaper distributional technologies, such as public standposts, have their drawbacks. Standposts are subject to vandalism and lead to wastage. Health hazards can result if adequate drainage is not provided around them. Also, the quantities of water obtained by each person are limited, long lines of people waiting to fill containers make the practice time consuming and water can be contaminated during transport and storage. In addition, it is difficult to collect revenue from the standposts' users to ensure their maintenance as well as that of the system. "Patio" connections—outside connections serving a single house—are usually more convenient and facilitate the collection of revenues. However, these also have their drawbacks, especially since the disposal of wastewater poses a problem.

Nevertheless, for most small communities, ranging in size from a few individual households to, say, one thousand people, it is always desirable to employ simple technology to obtain a safe water supply. This may be in the form of a properly protected rain-water collection system, a simple gravity feed system from a safe surface source or spring or, a somewhat more complex technology, a hand-dug or bored well equipped with a pump. The well should be protected against pollution from contaminated surface or groundwater as well as from external contaminants such as contaminated ropes and buckets used for drawing the water. In most cases, this implies a sensible location of the well, a good lining, a well-head consisting of a headwall and drainage
apron, and a covered top with a fitted pump. The per capita investment costs of these rural area systems will be substantially lower than those of the urban area full-fledged, treated-water supply systems, but experience shows that it is difficult to ensure that proper maintenance is carried out on the rural area systems and that the supply is uninterrupted.

For waste disposal, the technological options are more numerous. The Bank research project "Appropriate Technology for Water Supply and Waste Disposal," which covered 29 countries in various stages of development, found that there are many technologies between the unimproved pit privy and sewerage that can be recommended for widespread replication. In all, five types of household (on-site) systems and four types of community systems were identified, and many variations of each type were observed. Improved designs were prepared for several of these, and for only one technology (bucket latrines) was it concluded that introduction into new sites should be avoided. Two of the other technologies, aqua privies and communal facilities, are limited in their applicability by social factors. All of the remaining technologies (improved pit latrines, pour-flush toilets, composting toilets, modified toilet tanks, vault and cartage, smallbore sewerage, and conventional sewerage) can be recommended for adoption subject to the physical conditions of the site and the social preferences and economic resources of the beneficiaries. Except in unusual circumstances, both scattered rural and densely populated urban communities should find themselves with two or more technically feasible options, each with a range of design alternatives.

One of the most important technical contributions of this research is the design of "sanitation sequences": step-by-step improvements leading from one option to another and designed from the outset to minimize costs over the long run. Thus the community can initially select one of the low-cost technologies in the knowledge that, as their socio-economic status rises, they can upgrade it in a known series of improvements. This is something that is not possible with conventional sewerage, for which large investments and large waterflows are needed from the outset. It is noteworthy that none of the sanitation sequences developed results in conventional sewerage. In urban areas the final upgrading is generally to a low-volume cistern flush toilet connected to a vault which overflows into a small diameter sewer.

As this example makes clear, sewers are required to dispose of sullage water (laundry and kitchen wastes plus flushing water), not excreta, and therefore the key element in an economic solution to sanitation is the reduction of non-essential water use. Toward this end, work is underway to adapt water-saving showerheads and other appliances for use in developing countries. This also leads to the conclusion that water supply schemes, even

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2/ From a public health standpoint, a pit latrine should not contaminate the surface soil or surface or groundwater (even under flood conditions), while it should be insect and rodent proof, free of odors, culturally acceptable, and easy to clean and maintain.
when the sanitation component is not included, should consider in their design and in the establishment of service standards the requirement to dispose of the water being supplied to the community and the costs (even in the future) associated with its disposal.

It is important to note that social customs have an impact on the types of technologies that are acceptable. There are countries in which reuse of human waste on the soil is against local custom, where communal facilities are frowned upon or where, for example, deposition is always into running or stagnant water. In contrast, there appears to be no social constraints in any country to the use of waterborne sewerage—possibly because the system, except for deposition facilities, remains "unseen." When considering the costs of alternative systems this must clearly be taken into account.

Since 1971 the Bank has published 27 background papers on water supply and waste disposal and has conducted 13 research projects on these subjects costing over one million dollars. Topics included village water supply, design of low cost water distribution systems, wastewater reuse, pipelines, hand pumps, health benefits, reduction of wastewater, and fabrication of polyvinyl chloride well screens. By far the most important research project was "Appropriate Technology for Water Supply and Waste Disposal" mentioned above. This project emphasized the previously neglected field of waste disposal and its impact on water supply and health, and had as its objective the identification of technologies appropriate for providing urban fringe and rural communities with socially and environmentally acceptable services at an affordable cost.

Through this research the Bank has determined that methods exist for the disposal of excreta which can meet every public health test, and which cost one-third to one-tenth as much on a household basis as conventional sewerage. It is important to note that a properly located, constructed, and maintained latrine will meet all public health requirements for the sanitary disposal of human waste whatever the design, be it a simple vault or borehole, one with a complex water seal, or a multiple vault unit. No one design is better than another from the health standpoint; other things being equal, it is a composite of cultural, aesthetic, social, and technical factors which lead to selection of one design over another. The principal objective of a conventional water flush system is to provide a higher level of convenience, not better health.

C. Building Local Capabilities

The use of different types of technology and service standards for water supply and waste disposal often require different institutional arrangements in the sector. For example, operation and maintenance of small rural water supply systems may best be done by organizations at a community level in the villages concerned with government institution support; waterborne sewerage, however, is usually done by a municipal organization administered as a department of the local government or as part of a water and sewer
corporation; simple well protection or cartage of human waste may be carried out by extension agents of the government or by the private sector. Rural communities should aim to pay as a minimum operation, maintenance, and, wherever possible, a contribution in kind or cash towards construction; urban communities should strive for operation, maintenance, debt service, plus a reasonable contribution to the investment program. The range of technologies, organizational structures, and systems of rates and charges are wide, as are the concomitant requirements for institutional development and for trained engineers, community workers, maintenance men, accountants, and administrators.

The Bank assists its members in strengthening their competence to develop and apply technologies best suited to their needs in a number of ways. It is emphasizing in its work the introduction of the following techniques and project components:

(1) Provisions in loans to finance experts, both local and foreign, to evaluate the methods and facilities currently in use in the country and to advise on shortcomings and possible means for improvement. For example, in Nicaragua the borrower engaged the services of the Pan American Health Organization (PAHO) to serve as a consultant and undertake a comprehensive review of the administration and organization of the agency in charge of the water supply system of Managua.

(2) Provisions in loans to finance pilot and test facilities for development of new or modified designs, equipment and materials, and installations better suited to local conditions, that are more cost effective and are easier to operate by local personnel. Since it is known that the application of concepts and design criteria of large urban water supply systems to smaller communities is often prohibitively expensive, a pilot design project is underway in Minas Gerais, Brazil, for 63 communities of under 3,000 inhabitants. Depending on the results of this project, some 1,600 small towns in Brazil could be provided at a more reasonable cost with adequate water service in the 1980s. In the Kingston Water Supply and Sewerage Project, the Bank has financed the improvement of a slow sand filter plant and studies to treat and re-use the sewerage effluent to irrigate sugarcane. The slow sand filter can be operated by middle-level technicians. The re-use of sewerage effluent will relieve harbor pollution and permit good quality ground water now used for irrigation to be used for public water supply.
(3) Provisions in loans for visits by key national personnel to other countries for observation and training in order to stimulate and expand insights into alternative technologies and institutional arrangements. These visits also allow for in-service training at local urban and rural water supply agencies, attendance at seminars, short courses, observation of manufacturing processes, and symposia on technical subjects relevant to developing countries.

(4) Stimulation of training programs within the sector in each country to upgrade and strengthen the technical capabilities of the staff for innovation and the application of relevant technologies. In Manila, for example, the water supply project includes preparation of a staff development plan, the construction and equipping of a training school, and a program to train 1,200 employees over a seven-year period.

(5) Encouragement of development and use of designs utilizing local labor and materials that are suited to the technical capacities of local personnel for construction, operation, and maintenance. This, in turn, stimulates local manufacture and the development of further skilled resources—personnel, contractors, manufacturers, and allied businesses.

(6) Assistance in evaluation of specific projects, processes, and facilities through the identification, appraisal, and project supervision procedures carried out by the Bank through its permanent staff. These evaluation procedures of alternative technologies and organizational structures are intended to ensure the selection of solutions appropriate to local needs, conditions, and the operating and maintenance capabilities of all personnel involved—technicians and administrators, as well as the users of the facilities. The application of the procedures also serves to stimulate thought, challenge existing methods, and encourage local initiative in the design of present and future projects.

(7) Involvement of local ministries and technical schools in both training and applied research is an important means for developing local awareness of problems and providing talent for resolving them in ways best suited to the country. In Paraguay, for example, through the Bank-financed rural water supply and sanitation project, the Ministry of Public Health is being supported to promote community education programs on water use and basic public health. The program includes seminars for local Sanitation Committee members on basic administration and operation of rural systems, operator training, and seminars and lectures to housewives and school children on water uses and their benefits and on basic hygiene practices.
D. Lessons Learned

The Bank's role in the water supply and waste disposal sector may be characterized as a combination of a learning and a teaching process. As the Bank's perception of the process of economic development has broadened, it has come to regard water supply and waste disposal not only as part of the economic infrastructure, but also as social services that have a major impact on the quality of life. Since the early 1970s, the Bank has directed a growing number of loans in an expanding lending program in the sector towards smaller towns and villages, and has placed greater emphasis on the development of waste disposal so that the full health benefits of safe water supply can be obtained.

While the conventional wisdom in development policy has favored the use of waterborne sewerage systems for human waste disposal in urban areas, recent Bank-financed research has indicated both its unsuitability at the present time in many situations, and the availability of a surprising number of waste disposal technologies which can be recommended for widespread replication under appropriate conditions.

Over the next few years, the Bank will emphasize the dissemination of the results of its recent research through seminars, workshops, publications, pilot projects, and the incorporation of low-cost technologies in appropriate projects. The success of these low-cost technologies tends to require greater participation—in decision-making, design, construction, and operation and maintenance (payment of recurrent costs)—by the members of the community to be benefited. This, in turn, often requires greater efforts in informing eventual users of the costs and potential health benefits of the technology. In the coming years, therefore, the Bank will be providing to a much greater extent than at present, hygiene education and training components in the water supply and waste disposal projects it finances.
7. TECHNOLOGY AND TELECOMMUNICATIONS
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TECHNOLOGY AND TELECOMMUNICATIONS

A. Telecommunications in Developing Countries 1/

Economic, social, and political development requires an adequate means of conveying information rapidly and over long distances. Two-way communications facilities, provided on a countrywide basis, function as the central nervous system of the development process. Among the benefits of investment in telecommunications are: expanding the country's absorptive capacity for investment in other sectors; increasing productivity; reducing energy consumption; supporting decentralization and regional development; supporting the development and expansion of markets at the urban, regional, national, and international levels; facilitating broader access to services in backward and rural areas and in urban slums; and promoting national unity. Telecommunications also has special importance where transport is lacking or difficult.

Telecommunications encompasses a number of services and facilities for transmission of written messages, voice communication, and a variety of other communication modes such as TV and radio programs, data and facsimile transmission, and telemetering and telecommand applications. Telecommunications entities provide telephone, telegraph, telex, and data facilities to the public, giving customer service for video/voice and written communications; in addition most entities lease telecommunications facilities to other users to meet a wide variety of needs, including intercommunication among computers.

At the beginning of 1977, the total number of telephones in the world was estimated at about 400 million. The developing countries of Central and South America, Africa, and Asia, with 70 percent of the world population, had less than 30 million telephones, or about 7.3 percent of the total.

In developing countries, telephone expansion has generally lagged behind development in other sectors, although in recent years there has been a trend towards faster growth, particularly in countries that are developing local telecommunications industries. As a result, the annual rate of growth of telephones in service is now higher in most developing countries than in the developed countries—e.g., 20.1 percent in Korea, 18.3 percent in Brazil, 24.9 percent in Taiwan and 13.5 percent in Mexico, compared with 8.0 percent for Europe and 4.2 percent for North America during the period 1973-78.

There is a large gap between the supply and demand for telephone services in developing countries. The number of potential subscribers on waiting lists often approaches or exceeds the number of telephones in service,

and the average waiting time for a new connection can extend over a considerable number of years. The shortage of telephones results in many users per telephone, which leads to the telephone being used an excessive proportion of the time; other callers must therefore dial repeatedly before getting through to the intended party. In addition, business-hour traffic generated by telephone subscribers often exceeds the network’s capacity, giving rise to poor service, particularly on long distance networks where there is frequently a wait of several hours until a call is completed.

Typically, investment in telecommunications facilities in developing countries is in the neighborhood of 0.3 percent of GDP. This is less than half the average investment in developed countries. Despite recent increases in investment for telecommunications in many developing countries, there is still a clear indication of underinvestment in the sector as is apparent in the extent of unmet demand, frequently overloaded networks, and inadequate penetration into rural and backward areas.

Among the costs of underinvestment in telecommunications are a failure to take advantage of economies of scale and inefficiencies associated with inadequate communication in other priority development sectors. In addition, wherever public telecommunications facilities of adequate quantity and reliability do not exist, there is widespread recourse to communications systems built by individual business or government units for their own use. While specific institutional networks may be necessary in certain cases to meet operational needs, widespread fragmentation results in inefficiency in national resource allocation; these independently operated links are not only more costly than public systems, they are also only a partial substitute since they do not properly interface with each other and they do not provide access to the wider local and national community which would normally be connected to a well-functioning public system.

B. Bank Role in Telecommunications 2/

The World Bank recognizes the links between telecommunications investment and economic development and has been lending for telecommunications since the 1950s. The Bank has, however, attempted to limit its involvement in the sector to that of lender of last resort—i.e., becoming directly involved in the sector only when sufficient financial and technical assistance are not available from other sources, and when lack of investment in or inefficiencies associated with the sector become a significant bottleneck to the general economic and social development of the country.

Even with this limited involvement, the Bank is the principal multilateral source of finance for telecommunications development in developing countries, and has financed part of the foreign exchange requirements for

urban, rural, local, long distance, and international telecommunications facilities. Through FY79, the Bank provided US$1.8 billion for this purpose in 78 loans to 35 countries for projects costing a total of US$6.6 billion. This amounted to approximately 3 percent of total Bank lending since 1960. The bulk of external finance, however, has been provided through bilateral lending agencies and by suppliers in industrialized countries.

Well over 85 percent of the Bank’s lending for telecommunications projects has been in the last ten years. The volume of lending was increased from US$3 million in FY62 to US$135 million in FY79, for projects with total costs that rose from US$6 million to US$396 million. The average size of telecommunications loans has been US$22.5 million; the largest loan was to India (in FY78) for US$120 million and the smallest to Upper Volta for US$0.8 million. The Bank has also supported telecommunications components of projects in other sectors—e.g., transportation, tourism, urban development, agriculture and rural development, health, and industry.

Given that the World Bank is first and foremost an institution concerned with the efficient and equitable economic development of less developed countries, there are two general reasons for the Bank’s involvement in the telecommunications sector in any specific country. The first relates to attempts to influence or refocus investment, pricing, and telephone allocation decisions so that overall government objectives for national economic development can be more efficiently pursued.

In some developing countries there seems to be the misconception that since telecommunications can be operated as a successful business, there are no possibilities for substantially increasing its contribution to the overall development of the country. This, however, fails to recognize the nature and importance of the benefits to be derived from telecommunications investment, the sector’s growth problems, and the adverse results which may arise when the telecommunications sector is left alone under the pressures of tied financing and other interests. For example, there is significant evidence that the role of multilateral institutions such as the World Bank in assisting developing countries with telecommunications investment programs is in many cases not replaceable by other agencies or groups. The World Bank can provide a developing country with an independent, unbiased, technical and financial overview, and can serve a significant coordinating function. In relation to national economic development, the Bank can assist countries in attempting to ensure that the level of investment available to the sector, and the allocation of sector output, complement investment in other sectors and in other national development programs. In particular, recent World Bank telecommunications involvement has helped focus country attention on the economic efficiency and social equity aspects of extending service to more backward and rural areas; on tariff-related and technical possibilities for a more efficient allocation of telephones within urban areas; and on possibilities for increasing public savings.
The second general reason for World Bank involvement relates to the promotion of needed institution building, and efforts to help implement more rational long-term technical and financial planning. Generally, such aspects are addressed as sector consolidation, assisting in the achievement of a least-cost solution, ensuring that the principal sector agency has sufficient autonomy for efficient operation, developing in-house engineering and financial capabilities, technical and financial planning assistance, deriving and implementing a responsive system of financial accounts and management controls, attracting other external assistance and cofinancing to the sector, promoting lower equipment costs through international competitive bidding, and reducing dependence on government budgets.

Since telecommunications facilities are capital intensive, it is important that costs be minimized through an effective process of international competitive bidding, particularly where foreign exchange resources are limited. The Bank has been able to help member developing countries introduce better procurement practices. International competitive bidding has led to considerable reduction in costs—possibly about 30 percent on average and more in some cases. Capital and foreign exchange costs have also been reduced in some cases through import substitution in local assembly and manufacture of telecommunication equipment.

C. Technological Considerations

A telephone system consists of the subscriber apparatus (telephone and private branch exchanges), subscriber local lines, local exchange equipment, junctions, trunk exchanges, and a long distance and international network. The major operating components of the system (the internal plant) are the equipment the exchanges use for switching (i.e., control and connecting circuits) and the means used for transmission (i.e., providing circuits).

1. Switching

As the complexity of a national telephone network grows, it becomes virtually impossible to provide adequate service standards at a reasonable cost using manual switching facilities. With any local system which is manually operated, delays are inherent; very large manual exchanges would be technically impractical and very costly to operate. In the case of long distance, it also becomes virtually impossible to operate efficiently without going to either full or semi-automatic operation, when the options for alternative routing increase. As a result, it is now normal practice in almost all countries to provide automatic switching facilities throughout most of the network.

Most developing countries have adopted the objective of a national automatic service. New manual exchanges are kept to a minimum and confined generally to small exchanges in rural areas. Even so, as they grow in size, it is the practice to upgrade service standards and provide automatic facilities. Automatic exchange designs have been developed that permit calls to
be put through at very low cost even over complex routings and that allow more efficient use of the local and long distance circuits interconnecting the exchanges. Since telephone demand is constantly growing, it is rare that replacement of manual working by automatic exchanges reduces overall employment by the telephone system.

Automatic switching systems are controlled either directly (step-by-step) or indirectly through a common-control mechanism. Common-control systems permit independent subscriber numbering, routing, and charging. A sophisticated form of this system is electronic stored-program control (SPC). Until recently, because of the flexibility of common-control systems, the vast preponderance of advanced and developing countries alike adopted common-control crossbar and crosspoint systems as standard for their network development. Under exceptional circumstances, however, a few countries found it convenient to continue installing somewhat more modern types of step-by-step systems because of the basic simplicity of these systems, their historic ability to stand overload conditions better than common-control systems, and the existence of local manufacturing capacity.

In the past, when a country changed to a new type of electromechanical switching system it had to make a number of decisions about the strategies for introducing it, including how rapidly to taper off installation of the original system. Approaches included standardization of switching type by region—e.g., one system for the capital city and another for the provinces—or on a functional basis, with one type for local networks and another for the trunk network. If both used a common signalling system, interworking difficulties were minimized. This approach in particular was used successfully in several countries that wanted to maintain a competitive balance between two or more suppliers.

On the other hand, some countries felt that a certain measure of standardization of electromechanical switching equipment within a country was desirable. Hence, the Bank has under certain conditions financed a limited amount of tied procurement of switching equipment where initial procurement was by international competitive bidding. A compromise had to be reached, however, since from time to time competition was needed to keep costs down and more broadly based technical innovation could be economically advantageous. The Bank has been flexible in accepting, where appropriate, sampling of market prices, or, where standardization offered advantages, borrowers inviting tenders for initial supplies with a provision for placing additional orders over a reasonable period.

Recently, major technological developments have been made in switching equipment with the development of electronic SPC switching systems. Analog systems were developed and introduced in the early 1970s, but these are already being surpassed by digital systems. The latter offer great flexibility; savings in space, energy, operations, and maintenance; and significantly reduced cost of the cable network and, ultimately, of the exchanges themselves. An integrated electronic switching and transmission
system, especially one that is completely digital, will also greatly reduce interfacing, re-wiring, and related problems. Some developing countries have already begun to purchase digital systems and it is likely that these systems will come to dominate the market within the next three years.

Digital electronic systems are almost always introduced by overlay—i.e., by putting a digital central office and remote subdivision line units in to serve geographical areas already served by a number of electromechanical exchanges, since the greatest benefits would accrue by introducing the new system as early as possible. The Bank is providing technical assistance and advice on procurement and application of electronic switching equipment to borrowers who want to introduce such systems in the projects it finances.

Issues relating to standardization are changing with the introduction of electronic systems. With regard to hardware, it is not known whether any of the traditional telephone manufacturers will continue to dominate the world market, and what effect that would have on equipment prices in the future. Small innovative firms are now able to produce new electronic systems in as little as two years time, yet they often face marketing problems. If major computer companies enter the field, however, they could offer enough competition to continue to drive the price of electronic systems down at a rapid rate. The software involved can also potentially be provided by any number of small specialist firms in both developed and developing countries, thus introducing a new element of competition into the industry. Nevertheless, there is likely to be a shortage of qualified people and, therefore, of appropriate software programs for the next ten years. In addition, users are likely to be more dependent on the major equipment suppliers for repairs and replacement parts than was the case with electro-mechanical switching. All of these issues lead to more questions than answers at the present time.

2. Transmission

The primary means of transmitting telephone conversations are cable and radio. Fiber optics, in which the message is carried by light transmitted through thin glass fibers, is a new technology that already has a number of potential applications in developed countries and is on the point of feasibility for use in developing countries.

Local use of cables generally involves primary cables of up to 2,000 or more pairs of wires, distribution cables of intermediate capacity, and subscriber drop wire. Coaxial cables (usually containing from two to eight tubes under a common sheath with each pair of tubes able to carry up to 10,800 speech channels) are used for high density and/or long distance circuits.

Local cables are the major cost component in telephone systems, amounting to 35-45 percent of total equipment costs in developed countries and even more in developing countries. In urban areas it is usually standard practice these days to provide underground ducted construction. Cables are covered by a variety of protective materials depending on the hazards that may be encountered—e.g., corrosion, termites, or rodents.
The major advantage of introducing integrated digital electronic switching systems should be a significant reduction in transmission and distribution costs. Digital transmission permits the use of pulse code modulation (PCM), a method of converting analog information to digital form using sampling, quantizing, and coding. PCM systems allow an increase in capacity on cable pairs originally used for single telephone channels. Other advantages of PCM include transmission quality almost independent of distance (through the use of regenerative repeaters) and integration of services other than speech transmission (e.g., data). The integration with digital switching systems also reduces PCM terminal costs.

The possibilities for radio transmission of telephone conversation depend primarily on the frequency band used. VHF and UHF systems are used on the lower capacity spur routes, along with carrier cables, small-diameter coaxial cables, and open wire. VHF systems may also serve individual subscribers in conditions where cable or open-wire distribution would be too costly. VHF and UHF bands are also suitable for mobile communications within cities that are hard pressed to meet the many demands for these services. Where the topography is suitable, the communication distance in the UHF spectrum can be extended somewhat beyond the normal line-of-sight limitations for VHF and UHF. High-capacity microwave radio systems are used extensively, along with coaxial cables, to provide main, "backbone" routes in a country's long distance network. Microwave transmission is also used in satellite communication systems, to which many developing countries now have access. Satellite communication has so far been primarily limited to international communication and to linking a few distant and somewhat isolated areas within developing countries.

The availability since the mid 1960s of new radio and new cable systems has made possible economical provision of large numbers of long distance circuits of high quality between cities, provincial towns, and rural areas. These two developments have reduced costs and made possible the major extension of the networks to meet growth and the improvement of service standards.

In general, coaxial cable has a higher capital cost, longer life, and a larger possible capacity than radio. Conditions favoring its use include flat terrain (where higher radio towers would be needed), suitable soil composition for easy laying, and the requirement to serve a number of intermediate locations at short distances along the route. It would also be favored in larger countries where there is a possible shortage of microwave frequencies.

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3/ The frequency bands used are very high frequency (VHF), from 30 to 300 MHz; ultra high frequency (UHF), from 300 to 3,000 MHz; and microwave, above 300 but normally refers to frequencies above 1,000 MHz.
3. Investment Choices

In telecommunications planning, choices have to be made between feasible alternatives. In some cases the choice is clear-cut: for example, the least-cost solution in providing, say, 500 trunk channels between two large centers separated by several hundred miles of uninhabited and moderately mountainous terrain would clearly be a microwave radio system. In the present state of technology it would be pointless to cost out other systems such as coaxial cable. In other cases—e.g., if the terrain were fairly flat with access roads, and there were a number of intermediate towns to serve—both microwave and coaxial solutions would have to be costed.

All Bank-financed telecommunications projects since 1976 have included investment in rural facilities. Wire and radio-based systems are alternatives for meeting rural telephone requirements. Local conditions and the nature of desired applications determine which system is preferable. In terms of a least-cost solution, the choice very largely depends on the telephone density—wire-based systems for higher density and radio for lower density areas. Recently developed VHF concentrator systems offer for the first time a combination of features essential for successful rural applications, including low investment and low recurring costs. They can provide telephone connections up to about 50 km from an existing or new exchange and fully automatic 24-hour service.

D. Building Local Capabilities

The Bank provides considerable technical assistance to its borrowers during the course of telecommunications project preparation and supervision. Technical assistance has also been provided for a number of Bank-financed telecommunications projects through the United Nations Development Programme (e.g., in Burma) and bilateral financing (Swedish in Ethiopia, Canadian in East Africa, and British in Nepal) and, to a limited extent, has been financed under Bank loans. This assistance has been provided both through using consultants on an intermittent basis and making full-time resident experts available. In general, where long-term technical assistance is required, it has been less costly and given better continuity to provide for the use of experts rather than consultants. Assistance has been provided for management (particularly for the development of commercial accounting systems) and in relation to technical factors such as the introduction of new technologies, route surveys for microwave systems, preparation of consultant terms of reference, and equipment specifications.

In many cases where management consultants have been employed, it has been appropriate to use local associates who are aware of local conditions and are proficient in local languages. When technical matters are involved and local expertise is lacking, wholly foreign assistance has often been required. In all cases, however, it has been the practice to appoint local counterparts from within the telecommunications administration in order to provide the training and impart the knowledge necessary for future similar operations to be undertaken by the administration using its own resources.
For example, at one time in Nepal, the Chief Engineer, Business Manager, and Chief Accountant were foreign experts who spent as long as seven years in the respective positions training local counterparts.

The Bank has usually provided only very limited financing for telecommunications training facilities, as it has generally been possible for countries investing in telecommunications facilities to obtain grants from UNDP for such purposes. Training centers have been set up as national centers, financed as joint projects between UNDP and the respective governments, or as multinational training centers. Identification, appraisal, and execution of the training center projects and supervision of the centers have often been carried out by experts recruited by the International Telecommunication Union (ITU), with UNDP financing, with these posts subsequently being taken over by nationals of the country involved.

Telecommunications training facilities have been set up in almost all countries where the Bank has financed projects in this sector. The type and capacity of the training facilities provided have depended on the size of the country and its training requirements. It has been fairly common to set up regional training centers covering a number of countries (e.g., in East Africa) and for advanced training purposes (as in India for satellite communications). Technical training is usually centralized, while vocational training is carried out on a decentralized basis. Most often a single national training center will provide both technical and vocational training, offering a range from introductory to advanced technical courses. It is estimated that, after the initial provision of facilities, the average telecommunications administration in a developing country spends from two to five percent of its operating budget on staff training.

Telecommunications research institutes have been set up in a few large developing countries, with Bank support in the case of India. Research in other developing countries has been directed to confirming the suitability of and/or adapting existing equipment for use under the special conditions in the country in question—for example, under different traffic loadings, the effects of flora and fauna, and high heat, light, and humidity.

In view of the highly technological nature of telecommunications work, the Bank’s borrowers usually limit the use of local contractors in their projects to civil works and erection of buildings. Most operating agencies have their own "in-house" capability for installation, but are sometimes assisted by suppliers and installers. Local manufacture of both cables and telecommunications equipment has been developed in some developing countries, including Brazil, Morocco, Yugoslavia, and India. The Bank frequently accepts financing of training for local operating staff in association with equipment supply contracts let to foreign firms.

The Bank also encourages and supports the development of domestic telecommunications manufacturing by allowing a preference margin for domestic manufacturers under international competitive bidding, by occasionally financing some of the foreign exchange component of domestically manufactured products, and by assisting in improving—through technical assistance and the financing of machinery and equipment—the local industry's performance.
8. TECHNOLOGY AND TRANSPORTATION
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TECHNOLOGY AND TRANSPORTATION

Introduction

Transportation, in any but strict subsistence economies, is indispensable for economic growth. Demand for transport is derived from the demand for commodities and personal travel. As the demand for transport services increases, its availability can be an important determinant of the pace and location of growth. Meeting this demand requires that transportation planning and systems be integrated into national economic development plans. The Bank's emphasis has been to reduce the real resource cost of transport and to encourage the development of local transport capabilities and institutions.

Transportation needs can be met by any one or a combination of the following modes: aviation, inland waterway, coastal or ocean shipping, port, rail, or road services. (Pipeline transportation of gas, oil, coal, and ores is now part of the energy sector of the Bank.) The extent, interconnections, and modal structures of a transport system are shaped by many influences including the country's geography, terrain, economy, and development history and growth. Population density and distribution of population and the disposition of natural resources, which determine the geographical pattern of the supply and demand for goods and travel, are most significant in determining the concentration and mix of transport modes in the national system.

Within any system, the modes included both complement and compete with each other. Each mode has different mixes of infrastructure and technology, different vehicle unit sizes, different speeds, and different service characteristics. Hence, transport and distribution costs incurred in the use of one mode can vary widely over different lengths of haul, shipment size, terrain conditions, and volume flows. The situation, therefore, is not one of perfect competition or substitutability of one mode of transport for another; each mode has certain comparative advantages depending on the conditions and potential for development.

A. Bank Approach to the Sector

To handle the complex context of transportation planning, the Bank has been evolving a comprehensive transport sector approach to the analysis of the developmental impacts of transportation investments on the economy as a whole. Transport sector work focuses on the strategy of intermodal and inter-sectoral relationships, emphases, and priorities, and analyzes not only the physical requirements but also the institutional needs of the sector. Transport sector studies have been made for more than 80 countries and are periodically updated. These studies, and the experience of past lending operations, have demonstrated the importance of policy, management, and institutional development and reform in determining the success of Bank-financed projects.
Bank lending for highways can be taken as an example of this evolving sectoral approach within transport. The traditional approach was to finance particular highways in a country on a project-by-project basis, although within the framework of assessments of the transport sector and the highways sector more broadly. Beginning with Ethiopia in 1977, a new form of highways lending is evolving, focusing specifically on the overall objectives of the highways and road networks sector and on the improvement of its policies and institution-building, rather than on the investment in road construction. This emphasis on "software"—as compared with construction which represents "hardware"—broadens the development effects of the lending operation and focuses more on the main issues of the sector, such as planning, regulation and maintenance. The Bank and the borrower agree on sector objectives and policies, on the investment program, and on the set of criteria on the basis of which individual sub-projects and roads are approved for implementation. This approach is being selectively introduced in a number of countries.

The Bank also supports the construction of roads as components of agriculture and rural development projects (occasionally also in other sectors, such as industry). Roads are included in some 40 to 45 such projects annually, to support specific project objectives ranging from promotion of agricultural and industrial growth to improvement of access to social institutions such as schools, health centers, and hospitals. In this way the Bank and the borrower attempt to deal in a more effective way with the complex problem of coordinating the multiplicity of complementary actions required—roads representing an efficient cost-reducing link between farms, markets, cooperative processors, etc., for local and regional economic development. This integrative approach also helps in developing the local human and institutional capabilities. Increased emphasis is also being given to the proper design of the road component, to its subsequent maintenance and to the coordination of this component with other activities.

B. Bank Research

Transportation was one of the Bank’s earliest subjects for research. Developed in the 1960s, the research program was in direct response to issues emerging from the Bank’s operational work. Initial efforts were concentrated in areas of planning, design, pricing, and evaluation of transportation investments. In recent years (FY71-79), the scope of research has widened; the Bank has spent nearly US$2 million plus 38-40 person-years of staff time on transport study projects. In addition, other agencies have provided a like amount for some of the work.

The two largest studies to date involved the extensive collection and analysis of primary data on the substitution of labor and equipment for roads and other civil construction (US$760,000), and on the economics of highway design and maintenance standards (US$600,000). The principal concern of the first study was to determine whether efficient technologies could be identified that would permit economic use of the abundant surplus labor available in most developing countries. The study found that the substitution of labor for equipment is technically feasible for a wide range
of construction activities in low income areas, provided adequate supervision and incentives are available. Two programs were implemented—in Honduras and Kenya—and similar efforts were initiated in several other countries. The research on highway design and maintenance standards was aimed at developing a framework for evaluating alternative design and maintenance strategies for low volume roads. The purpose was to minimize long-term construction, road maintenance, and vehicle operating costs. The research involved extensive empirical work to determine the necessary relationships between vehicle speed and operating cost under free-flow conditions and road deterioration related to traffic, design, and maintenance standards. Field studies have been undertaken in Kenya, Brazil, and India, and a model has been produced to optimize road design and maintenance strategies that have been applied in developing highway projects for other countries.

Other research has addressed the use of feeder roads in rural development and their socio-economic impact. Specific research projects have been undertaken in Yemen, Ethiopia, and Madagascar (US$178,000) and, subsequently, components to monitor their socio-economic impact (notably in Brazil and Kenya) have been included in several Bank-financed projects. Simultaneously, methodology development has continued. A computer-based package of computational procedures that uses the "producer surplus" approach represents one of the practical applications in the appraisal of rural road projects. Research on ports has focused on the development of planning models (PORTSIM), and a major study of fundamental economic principles to guide pricing of port services has been conducted. For railways, Bank research has been rather limited in scale, focusing on broad management issues. A 1974 effort produced a manual on railway costing methodology. More recently, a series of small studies has been initiated to address the economic role of railways in an age when railways throughout the world are facing major financial and operating difficulties.

C. Bank Lending

Bank lending for transportation projects in FY79 was US$1.9 billion, compared with a cumulative total of US$14.6 billion. The latter amounts to about 18 percent of total Bank lending. Nearly three-fourths of the amount lent was for highway projects; one-fifth for railways; about 5 percent for ports and shipping, and the rest for airport and pipeline projects.

Due to the expansion of the Bank's range of activities and shifts in emphasis in loan requests, the share of transport of total lending has declined from some 31 percent through FY63 to 17 percent in the FY74-79 period. This reduction in share overstates the actual reduction since an increasing number of transport projects are now financed as components of other integrated projects—rural development, mining, tourism, urban, and industrial projects—and are not identified specifically in the transport sector accounts.

1/ Excluding lending for rural roads under agriculture and rural development and other projects which amounted to about US$157 million in FY79.
I. Ports and Shipping

A. Bank Approach to Ports and Shipping

International trade, except for intra-continental Europe and intra-continental North America, is largely seaborne. Ports, therefore, represent an essential link in the foreign trade chain of most countries and particularly developing countries. Adequate port capacity and efficient port operation are necessary elements for the economic development of developing countries. For countries with extensive inland waterways, long coastlines, or numerous islands, domestic shipping and accompanying domestic ports provide a potentially low cost and fuel efficient component of the national transport system. An efficient national flag shipping fleet may also constitute a significant saver of foreign exchange.

Although the particular objective of Bank lending for ports and shipping may vary from case to case, depending on the particular transportation situation and the needs of the borrower, lending for this sector most frequently involves several of the following results and activities:

1. Increased productivity of existing resources through improved operations resulting, for example, from improved procedures and better trained manpower;

2. Increased productivity or extended life of existing port facilities, floating craft, inland waterways, and ships by rehabilitation/improvement or the replacement of worn out or uneconomic equipment and vessels;

3. Increased capacity through expansion of existing port facilities and/or the construction or acquisition of new facilities (e.g., new berths, new cargo-handling equipment, and additional floating craft, new or second-hand);

4. Provision of special facilities to handle certain types of cargoes more economically, such as multi-purpose or specialized port facilities for container or roll-on/roll-off (RO/RO) trailer traffic or specialized facilities for handling bulk commodities—oil and petroleum products, grains, ores, fertilizer, etc.;

5. Provision of dredging or dredging equipment to enable larger, more economic vessels to enter the port or canal;

6. The establishment of new or the strengthening of existing institutions through the provision of consulting services for operational, organizational, or planning studies; the evaluation and modernization of accounting, management information, and tariff practices; and the design and implementation of training programs.
Bank loans may also provide funds for feasibility studies and detailed engineering or construction supervision.

For example, the Bank has paid increasing attention to the adequacy of soil investigation and hydraulic studies, efficiency indicators, financial objectives and targets, cost accounting and pricing policies during the preparation and appraisal stages of potential port and shipping projects. Environmental and safety considerations are taken into account at the preparation, appraisal, implementation, and supervision stages of port and shipping projects.

The Bank made its first port loan in 1950. By the end of FY79, US$2.15 billion had been lent for ports and shipping (about 3.1 percent of total Bank lending). Of this total, US$46 million was for inland waterways, US$124 million for coastal and inter-island shipping, US$120 million for international shipping, and the remaining US$1.96 billion for ports. This sum includes only direct loans for port and shipping projects; subproject loans by Bank-financed development finance companies for the purchase of vessels and components of projects in other sectors (e.g., fishing ports financed under fisheries loans, port improvements financed as part of agriculture and rural development projects, and vessels financed as part of agricultural, industrial, or general development projects) are excluded.

Between FY74 and FY79, direct lending for ports and shipping totaled US$1.1 billion—covering about 32 percent of the total project costs. The number of port and shipping projects approved annually, which averaged about 9 (including pipeline projects now financed by the energy sector) in the FY74-78 period, fell to 2 in FY79 (both port projects). Overall, the average size of port and shipping loans during FY74-79 was about US$24 million. They exhibited a wide range in size—from US$2 to 80 million—in response to the needs of the borrowers. In many cases, Bank lending was complemented by co-financing. Bank lending in the future should be substantial, although with continued yearly fluctuations in volume.

B. Nature of Technology Used

Ports serve as the link in the transport chain between vessels and inland transport modes. Port technology, therefore, must take into account not only changes in the inland transport system, cargo composition, and volume, but also technological developments in shipping itself—bulk handling techniques on ship and on shore, containerization, roll-on/roll-off (RO/RO) facilities on ship and shore, etc. The technological developments in shipping and the types of ships used in particular international commodity trades are in turn influenced by conditions at both ends of the trade route.

Ideally, the planning of shipping and port investments and technology in a particular commodity or shipping mode should be integrated. It should take into account inland transport and trade organization with an emphasis on achieving the most efficient, low cost, total transport chain. Due to the multitude of parties involved, however, this ideal is seldom fully
realized in international trade and shipping, except, perhaps, in the case of completely integrated transport. In coastal/inter-island or inland waterway transport, coordinated investment and technology in ports, vessels, and inland transport may be easier to achieve.

Major technological developments in international shipping in the last decade have encouraged and in some cases necessitated technological changes and investments in ports. These include:

1. increased sizes of bulk vessels in response to economies of scale, improved vessel technology, and increased trade. This has required berth enlargement, rehabilitation or construction plus dredging, together with new or improved cargo handling equipment and storage facilities in ports all over the world.

2. increased unitization in general cargo commerce, particularly growth of container and RO/RO vessels. These initially existed between industrialized countries but now include trade between developed and developing countries. The Bank has financed container berth construction projects in Brazil, Nigeria, Korea, Indonesia, Mexico, Papua New Guinea, Thailand, and Singapore, for example. The Singapore project, which began with general cargo handling improvements, was modified to include containerization when it became important to that market.

3. increased use of specialized vessels for certain cargoes and trade routes with a relative decline in conventional liners and tramp vessels. Several of these developments represent a shift to more capital intensive shipping and port facilities. Some, particularly increased sizes of bulk vessels, represent not only a relative increase in vessel capital costs over other costs but also increased investment requirements in port facilities (e.g., facilities for liquefied natural gas in Algeria).

Due to the great differences in trade and local conditions, the range of technology used in port and shipping projects has varied widely. Port projects have ranged from the rehabilitation of existing labor intensive, general cargo facilities to the construction of highly mechanized container berths, to the construction of a completely new port with specialized bulk facilities to serve a new steel complex at Jijel, Algeria.

In 1973 the Bank completed PORTSIM, a computerized model that simulates major aspects of port operations (number and type of ships, number and size of berths, berthing priorities, unit costs for ships, berths, port equipment, etc.) as a multiqueue system. PORTSIM has been used by the Bank as an appraisal tool in, for example, New Guinea, Gambia, Brazil, Sudan, and Cyprus. It is available to prospective borrowers and port planners. Shipping projects or components thereof have ranged from rehabilitation of existing
inland water transport (Bangladesh) or inter-island fleets (Philippines) and determination of the most suitable vessels for relatively low volume coastal trade (Haiti) to the acquisition of bulk, self-unloading vessels for fertilizer transport (Indonesia) and two 80,000 dwt tankers for crude oil import (India).

While only smaller sail and power vessels are built in many developing countries, commercial ship building has grown rapidly in such countries as Korea and Brazil. Nevertheless, the larger, more sophisticated ships and their associated shore-based cargo/container handling equipment probably will continue—at least for some time—to be produced largely in the industrialized countries.

C. Building Local Capabilities to Use and Develop Technology

Ports and shipping projects increasingly include technical assistance and training components in an effort to achieve institutional and operational improvements. The extent and type of technical assistance and training depends on the existing situation and the requirements for future development. In some projects, the identification of training needs and the design of the training program is done as part of project preparation and appraisal. In others, the project may include funds for the use of consultants to design and implement the program. Of the 45 ports and shipping projects approved during FY74-79, over half included a training component.

Apart from specific training programs, ports and shipping projects usually include provisions for consulting services for organizational, accounting, tariff, and planning studies. These are normally undertaken by foreign consultants or experts; specialized knowledge is rarely available locally. In some cases project preparation, including preliminary and detailed engineering, is undertaken by the domestic organization responsible for the project (such as the port authority); however, local organizations often have insufficient staff and facilities for such work. They may then either complement their own staff with outside experts or have the whole work performed by outside experts. The foreign consultants, however, often undertake such work in collaboration with local firms and with counterparts from the responsible national organization, thus transferring knowledge and experience to these organizations. The Dakar Fishing Port Project is an example of this.

Major civil works, such as berth construction or major dredging, are normally contracted out via international competitive bidding, although careful attention is given to the possibility of dividing contracts in such a way as to encourage bids from local contractors, as in the Suez Canal Rehabilitation and Expansion Projects. Relatively smaller civil works may also be awarded on the basis of local bidding or carried out by force account (government employees). Port craft and equipment, such as tugs, cranes, fork lifts, bagging plants, conveyors, and piping systems are generally procured from abroad. Occasionally, local industries have developed to a point where they can supply certain types of equipment, perform maintenance, or undertake vessel rehabilitation. The latter capabilities existed in Bangladesh and Panama and were strengthened as the result of Bank-supported projects. Local universities and research institutes in Brazil, Israel, Indonesia, India, and Yugoslavia have participated in Bank financed ports and shipping projects.
D. Lessons Learned

Major lessons learned from past ports and shipping projects include:

(1) the need to look at the total transport chain, nationally and internationally, and at its interactions and interdependency with technology, investment requirements, and operating costs to obtain efficient, low cost transport;

(2) the importance of a realistic and mutually agreed upon time-phased plan of action with performance targets, and the provision of adequate technical assistance and training to permit these targets to be achieved on time and within budget;

(3) the need for mutually agreed upon financial objectives and targets and supporting cost accounting and pricing policies to encourage financial viability and efficient use of resources;

(4) the need for adequate soils and hydraulic studies before loan approval;

(5) the need to strengthen the institutions responsible for the operations of ports and shipping;

(6) the need to encourage local contracting industries and, to the extent economically justified, selective local capabilities for equipment or vessel maintenance, rehabilitation, and manufacture.

II. Airports

A. Bank Approach to Airports

The Bank has financed the expansion, relocation, and improvement of airports--primarily in Africa and Latin America. Bank support is based on country development plans and loan requests. The Bank has also provided for technical assistance, training, and managerial development for newly formed national aviation authorities in Venezuela and Panama and for one currently being organized in Afghanistan.

The Bank’s first involvement in an airport project was in Panama in 1971, when the impact of the new generation of wide-bodied jets required expansion of international airports throughout the world. While the new aircraft decreased air congestion, they increased ground congestion at terminals and required longer and stronger runways. In other cases, small jets required the relocation of runways, as at the airport in Medellin, Colombia.

The Bank approach in the airport sector now is to support comprehensive analyses of economic development factors in airport project selection
and design, including intermodal relationships and sound airport institutional development. The Bank's activities can be categorized under four air traffic headings:

1. **International transit traffic**, where direct earnings from services to transit aircraft are accompanied by benefits in the improvement of air transport for the country itself. Airport projects in Panama and Senegal are of this kind.

2. **International traffic to and from a country**, where projects are designed to facilitate air travel and trade for the borrower, including airport improvements under tourism projects. Examples are in Kenya, Venezuela, Niger, Jamaica, and part of the Colombia project.

3. **Domestic regional trunk traffic**, where projects are intended to facilitate passenger and freight movement over the major internal air routes—as in Mexico, Colombia, the Sudan (which has only 250 miles of paved roads), and Bolivia, where three airports in the Amazon Valley are being replaced in settlements that can be reached only by air or water eight or nine months of the year.

4. **Sub-regional or low density traffic**, which so far has not been the principal purpose of an aviation project, but rather a subsidiary element in some agriculture and rural development projects. An example of low density airport improvement as a component of a domestic trunk system improvement is also found in Bolivia, where equipment is being supplied for the maintenance of unpaved airstrips.

The Bank has now lent US$258 million to 11 countries for 12 airport projects costing about US$707 million total. In addition, seven tourism loans have included airport construction components totaling US$18.6 million. Two agriculture and rural development projects included cold storage facilities at the airport for perishables (the cold storage facilities provided in the Kenya airport project are the largest in Africa), and four others included provisions for the development of air service and airport improvements in low density areas. Only one airport project is planned for the FY80-82 period.

B. **Nature of Technology Used**

Bank-financed airport projects provide the hardware and technical assistance required for civil engineering work (runways, aprons, roads, drainage, parking areas, etc.) and building construction (hangars, terminals, control towers, warehouses, etc.), as well as provide for the purchase and installation of materials handling equipment, communications and navigation systems, and crash, fire, and rescue equipment. The size and scope of airport projects ranges from runway extensions in Senegal and Niger for less than US$5 million to the major expansion of Maiquetia International Airport at Caracas at a cost of some US$238 million.
Bank-supported projects generally follow internationally accepted standards and procedures of such organizations as the International Civil Aviation Organization for the design, planning, construction, operation, and maintenance of airports and their supporting facilities. The Bank also encourages borrowing countries to take the following factors into consideration when designing and selecting aircraft-airport-navigation systems: (1) direct benefits and costs to the country from the choice of specific technology, taking into account both the present system and possible future levels and stages of improvement and expansion; (2) the adequacy, capacity, and scope of improvements and expansions to be made over the next 10 years; (3) the quality and availability of skills needed for the operation, maintenance, and management of the system, and present and future training requirements; (4) the potential of direct cost-recovery for improvements, especially from tourism development; (5) coordination of plans for development of the domestic air system, particularly in areas where surface transport is deficient or offers real or potential competition; and (6) maintenance of the safety and efficiency of the national air transport system consistent with internationally accepted practice.

C. Building Local Capabilities

Bank-financed airport development projects typically include technical assistance and training related to aircraft and airport maintenance; baggage, mail, and cargo handling; crash, fire, and rescue operations; and air traffic control, airport engineering, and navigation aids. Scholarships are used as the primary training mechanism for courses held at the Regional Centers of the International Civil Aviation Organization or through such agencies as the British Airports Authority and the U.S. Federal Aviation Administration. Bank-financed projects have also provided technical assistance for financial planning, supervision, and management.

Much of the project engineering design work and construction contract management is performed by foreign consultants because the specialized skills and experience are rarely available locally. The airport projects in Senegal and Niger, for example, were planned and executed by a well-managed multinational aviation agency supported by France. Local contractors or partners are used depending on their availability and skills.

Technical training and assistance components of airport projects have averaged 2.6 percent of lending. It is slightly higher in domestic projects (3.6 percent) where authorities have responsibility for the national system than in international airport loans (2.1 percent).

D. Lessons Learned

Normally, Bank-financed airport projects have been implemented by newly formed aviation authorities (Venezuela and Panama) or with agencies that have recently adopted tighter fiscal management control systems (Bolivia and Colombia). The newness of these agencies and their systems has led to difficulties in performing as originally planned. The development of smoothly running organizations, especially those involved in such demanding and complex
activities as airport operations, takes time. Financial performance needs continuous close attention to ensure that a Government's general budget is not excessively burdened with operating and maintenance costs for air transport facilities. The recently adopted Bank policy requiring detailed pre-engineering designs and estimates should help to minimize some delays in future projects, but the development of high-quality, high-performance airport organizations will require close and continuous supervision, training, and recycling at all levels.

III. Railways

A. Bank Approach to the Railway Sector

Since a large proportion of the natural resources of many developing countries is in high bulk agricultural and mineral products, and railways were uniquely suited to their transport needs, railways became the primary mode of mass land transport in the late 19th through the middle of the 20th century. Railways were the first of the modern transportation technologies to be used in many developing countries and contributed to their initial modernization and economic advancement. The historical development role played by railways led to operating and investment practices, government policies and regulations, and pricing structures that are often no longer economic or financially sound. In both developed and developing countries this situation does not provide a basis for effective service and competition with other transportation modes, especially rapidly growing road transport.

The major problems of contemporary railway operations in developing countries are primarily administrative, economic, financial, and political. Technical issues are largely limited to maintenance and the periodic replacement of worn-out or obsolete equipment, sometimes with equipment of quite different design that is better adapted to a particular type of traffic. The construction of major new rail lines will be rare, except in the case of special purpose lines to serve the movement of large volume, bulk ores, such as recent lines in Brazil and Guinea. As a result, most Bank-financed railway projects focus on rehabilitation, modernization, extensive institutional reform, and retreat from over-extended networks in order to enable the railway system effectively to fill economically justified roles in its competitive sector environment.

In its loans in the railway sector, the Bank emphasizes transport pricing, regulatory and investment policy reforms, operational efficiency, the achievement of appropriate financial targets, the strengthening of management, and the development of better management tools, especially in the marketing and costing-pricing fields. Where necessary, reforms in the relationships between the railway enterprise and the state will be attempted. Disinvestment and the elimination of uneconomic services are important complements to railway investment programs. Comprehensive agreement on sector policies and sustained commitment through a series of Bank loans are also necessary.
Bank-supported railway research has been primarily in the areas of economic and financial analysis. For example, developing countries have had an acute need for a system of costing railway services for such uses as setting tariffs, controlling costs and investment decisions. The Bank's "Railway Traffic Costing" system helps meet this need.

The Bank has also developed computer programs to facilitate comprehensive analysis of railway projects such as "FAST" (Financial Analysis System Transportation). FAST has been used in other sectors and also has been applied to country economic work on national accounts, in a package for feeder road analysis, and other project cost calculations. Work is also proceeding on a flexible "Railway Model" which will permit the evaluation of alternative investment strategies and their possible effects on network operations, finances, etc.

Other research (that is in progress or planned) involves a comparative analysis of the composition and trends of transportation patterns in several developed and developing countries; examination of the commodity composition in different transport modes; factors governing shipper choice and demand elasticities; some commodity studies in developing countries; and an assessment of the role of rail in import/export trade and in the provision of passenger service.

Over the next five years the Bank also plans studies to: (1) improve the assessment and knowledge of the long-term economic role of railways in national development, (2) provide better benchmarks and analytical frameworks of railway cars, and (3) to develop and adapt existing computer models for Bank project appraisals with the aim of achieving better quantification of the system effects of investments.

Through FY79, the Bank invested slightly over US$4.4 billion in 114 railway development projects in 40 countries. Future lending in the railway sector may be expected to continue at the rate of about 5 projects per year, with a lending total of US$200 to 400 million per year. Bank loans typically represent 25-30 percent of total railway project cost. In FY79, Bank loans for railways amounted to US$383 million for projects whose total cost was US$1.6 billion.

B. Nature of Technology Used by Railroads

There are two broad categories of technology used by railroads -- that which directly involves the physical movement of freight and passengers and the related maintenance and the technology used to plan and control the efficient utilization of rolling stock, switchyards, maintenance crews, repair shops, etc. The latter refers to computer technology, which is being used more extensively, whereas the first category includes classical railroad hardware consisting of:

(1) track, marshalling yards, structures, bridges, tunnels, and earthworks;

(2) locomotives--steam, diesel, electric;
(3) freight cars—open, covered, hopper, flat bed, fluids, refrigerated, etc.;

(4) passenger cars, rail cars (self-propelled), and trailers;

(5) components, parts, and materials for rolling stock;

(6) signalling and communications equipment and materials; and

(7) other railroad equipment, buildings, and materials including those for maintenance.

One of the greatest innovations in railroads—when the diesel-electric locomotive began replacing the steam engine—occurred over 40 years ago. Many other technical innovations are of more recent vintage, such as the unit-train—one complete train loaded with one product or material (such as coal) that is shipped from one specific point to another on a closely scheduled and controlled basis. Flat cars have lent themselves to containerization and to piggy-back operations hauling highway trailers. Car couplings can now be automatic rather than manual, and airbrakes have replaced the older vacuum systems. Concrete ties are common, as are welded track and sophisticated track inspection instrumentation. Mechanization is found frequently in track maintenance with on-track tampers and ballast cleaning equipment. Finally, advances in electronics have improved communications and the control and safety of trains in transit.

A major problem in the utilization of new technology or even of standard replacement parts or equipment is that railroads are an on-going operating enterprise; track repairs and modifications must be fitted in without excessively disrupting service, losing revenues, and inconveniencing users. The wide geographic areas covered by railroad systems and the differing ages, types, and states of repair of rolling stock, tracks, and related facilities make the tasks of rehabilitation, modernization, and development more difficult.

The selection of technology for replacement or modernization in railroads is constrained by the physical configurations of the existing system, which may vary from location to location within a country and the capabilities of the railroad's personnel, both managers and workers, to properly use and maintain the new technology or equipment. High performance locomotives, for example, require rigidly scheduled and precisely executed maintenance routines. If the railroad staff is not organized, trained, and disciplined to provide such maintenance services, the preferable technology is then something more rugged, reliable, and forgiving of maintenance lapses and abuses in use.

Criteria for the selection of railroad technologies are more or less standard and include compatibility with existing equipment and operating and maintenance skills, reliability, maintainability, availability, operating and maintenance costs over product life, cost/effectiveness compared with available alternative technologies, and so on.
As to the possible substitution of labor for equipment, the situation in railway operations and maintenance is changing. While track installation and maintenance have historically been labor intensive, the financial condition of many railways and the need to maintain high operating and safety standards under increasing track loads has required that less costly and more technically efficient solutions be applied wherever possible. This has led, for example, in Korea, Brazil, and Turkey, to the use of mechanized track welding, track laying, and maintenance equipment, including on-track tamping devices, which have displaced manual labor. They have resulted instead in cost savings and less disruption of service and schedules. In addition, the growing scarcity of wood suitable for ties—or the realization that its best economic use is other than for ties, as in Thailand—has led to the use of concrete ties. This has resulted in mechanized rather than manual handling, which further reduces labor requirements.

Technologically-oriented aspects of railway projects also include engineering design and feasibility studies. In Cameroon, for example, it was expected that overall traffic growth would reintroduce a capacity restraint. One solution suggested was a major realignment of the 300-km Douala-Yaounde section at a cost in excess of US$300 million. This railway section is paralleled by a road of poor standards which could be upgraded at considerable cost. Therefore, a feasibility study was programmed to examine in depth the trade-offs and least-cost solution to future traffic requirements of the Douala-Yaounde corridor (involving an appropriate mix of road and rail).

Bank-financed railway projects typically provide for repair and renewal of track; maintenance and workshop equipment, parts, and material; purchase of rolling stock, motive power, spare parts, and rehabilitation of stock; station installation and repair; purchase and installation of telecommunications equipment; and training, technical assistance, and consultants services. Usually 80 to 90 percent of the loan is for hardware related items.

C. Building Local Capabilities to Use and Develop Technology

Since railways are one of the oldest continuously operating organizations in many developing countries, their technology-related administrative efforts are directed towards "modernizing" or "streamlining", restructuring and retraining, and, in many cases, reducing staff in the interests of efficiency, effectiveness, and economy. The struggle against technological obsolescence must be matched by similar efforts to avoid managerial obsolescence. The institutional situation of many railways is further complicated by government interventions and regulation, government ownership itself, low compensation levels, the scarcity of qualified professionals, and restrictive operational practices tied in with union agreements.

In an effort to systematically relate the changes in organizational, supervisory, maintenance, and operational behaviors required to properly utilize existing equipment and new technology, the Bank has developed an "action plan" approach in railway projects. Action plans are measures required, in parallel with investments in physical facilities and equipment,
to accomplish corporate enterprise development goals (institutional, organizational, financial, and marketing), and improve technical and operational performance.

Two periods are distinguishable in the content and manner of establishing action plans. During the first period (FY65 to FY71/73), action plans generally concentrated on some operation's statistics, with targets for improvement over a 2-3 year span. Then, the major thrust in investment programs was the replacement of steam with diesel locomotives. However, as replacements proceeded, they were often followed by unexpectedly low performance due to the serious deterioration in the availability of diesel locomotives for service. Change of traction was often regarded as a straightforward substitution of steam by diesel power. In reality, it was a radical change in systems technology that required matching of improvements in fixed installations (workshop reorganization and expansion, sometimes crossing loop lengths, supporting signalling and communications systems, etc.), train operation methods, and in the training of back-up technical and operating personnel to exploit the higher hauling capacity and higher average speed potential of diesel locomotives.

In the second period, FY71/73 to date, action plans have been expanded to incorporate requirements for expansion of workshops, signalling, telecommunications staff reorganization and training, operating methods, and data processing. The expansion of content reflected the growing concern over the limited success achieved in the earlier period, as well as the experience gained by borrowers and the Bank.

A broad range of technical assistance activities related to institution building are part of the action plans of most railway projects. This is demonstrated in the recent railway modernization project in Bolivia. Technical assistance was provided for: assistance in track maintenance and training of 150 track crews; reorganization and improvement of rolling stock maintenance procedures and techniques; improvement in telecommunications utilization for car distribution and switchyard operations and reduction in turnaround time for rolling stock; cost accounting system and tariff structure; reorganization of railway warehousing system and installation of efficient procurement procedures; evaluation of whether to retain the existing computer system or replace it; and the organization of systematic training and recycling of the 5,500 employees in all departments--track, operations, repair shops, maintenance, and administration. The cost of this technical assistance is US$1.7 million or about four percent of the total project cost of US$47 million.

The on-going Third Railway Project in Senegal is further illustrative of the scope of Bank-financed railway work. The project is not only important to Senegal itself, but also to neighboring Mali, (for which the railway is the only external rail line and provides the least-cost land transport service to the Atlantic Coast). Hardware portions of the project include renewal of 60 km of track; procurement of switches, gang-cars, and other items of maintenance equipment and material; procurement of spare parts for locomotives and rolling stock and workshop equipment; and extension and
rehabilitation work at the Dakar marshalling yard, including telecommunication improvements. The institution building aspects of the project include a three-year staff training program aimed at improving the standard of railway operations, maintenance, and safety with annual basic and re-training sessions for some 300 skilled laborers, low-level supervisors, and selected middle-level and higher-level managers. The Bank-financed a US$1.7 million training program that accounts for about 15 percent of the total project cost of US$11.8 million. Consulting services were also provided for studies to determine the optimal administrative structure and ownership of the railway and the least-cost mode for groundnut transport and its effect on railway traffic. The latter task is part of an effort to develop a realistic commercial strategy for the railway.

Bank support for development of indigenous capability to design and manufacture railway equipment is directed primarily to those countries with extensive knowledge of metallurgy and with the capability for large scale metal processing and machining operations (e.g., India and Argentina). The recent Bank-financed railway project in India includes provisions for designing and building a manufacturing plant to produce 100,000 wheels and 27,000 axles per year; the acquisition of thyristor control/transformer sets and the design technology and know-how for their manufacture so that similar controls can be made in India to up-grade 750 AC locomotives; and extensive related advisory services and training. The existing Indian Railways research, design, and standards organization will be strengthened with equipment for testing and design adaptation, acquisition of design, and advisory services and overseas training in railway equipment design. On a similar theme, the on-going Argentine railway project provides for a review of the need and possible scope of a railway research, design, and standards institution to increase Argentina's self-reliance in these basic areas.

D. Lessons Learned

In many developing countries, railway systems need modernization--both of physical equipment (extensive repairs and replacement programs) and of institutional policies, structures, procedures, and training programs (in the railway itself as well as in related government agencies). Necessary changes are complex and can best be accomplished slowly, which requires Bank involvement over extended periods of time. Significant lessons learned that serve as useful guidelines for future railway sector development are at two levels. The first is that railway modernization and expansion projects need to be considered in the broader framework of national economic development and transport sector development as a whole.

At the second level, equal emphasis should be placed on physical investments and parallel action plans. Action plans should be carefully devised to suit the circumstances of the railway concerned, and thus enable it to fully develop the institutional capabilities required for the maximum effective use of the available technology.

A final and fundamental lesson is that the existing investment in many railway systems is not being well used. The resources, facilities, and
capabilities are in place but cannot run themselves. Railways need direction, leadership, and determination to produce the transportation benefits to national economies for which they are designed.

IV. **Highways**

A. **Bank Approach to the Highway Sector and Rural Roads**

Developing countries are spending, at a minimum, an estimated US$10 billion per year on the construction and maintenance of highway systems.

Road and highway development is a complex task; it must respond to a multitude of economic and social needs throughout the economy. Although a well-functioning highway network is a prerequisite for undertaking large-scale development in other sectors of the economy, most developing countries have only limited amounts of the resources required for efficient highway development and maintenance. The Bank has, therefore, supported highway development throughout the world, and through FY79 loaned US$7.5 billion for this purpose.

While the Bank has been extensively involved in development of highway infrastructure, institutions, and policies in borrowing countries, the full impact can only be realized over a long period of time. The most important reforms—development of appropriate institutions and of managerial and technical skills—involve difficult issues that cannot be fully resolved in isolation from the entire sector, economy, and public administration. In the past, the need to expand the highway infrastructure was apparent in most developing countries. However, with the development of highway networks, maintenance of existing assets has become increasingly important. At the same time, domestic highway administrations and private consulting and contracting capabilities have been developed, so that in some countries most of the tasks can be undertaken with domestic resources. Finally, development needs have become increasingly complex, and there is an increasing awareness of the need for designing projects that, to the extent possible, respond to the needs of the poorest segments of the society.

All this has led the Bank to focus increasingly on sectoral and institutional issues, including development of managerial and technical skills and not just on the financing of a particular section of road or procurement of maintenance equipment. Although not entirely new, this approach has been formalized as highway sector lending and focuses on: (1) highway investment and maintenance programs; (2) assessment of these programs against sectoral priorities and the needs of the economy as a whole; (3) the criteria used in identifying projects to be included in these programs; and (4) the institutional capability to implement and administer these programs. The Bank normally finances a 2 to 4-year slice of the agreed programs and only examines individual roads and other sub-projects on a sample basis. This enables staff to concentrate on issues critical to the highway sector as a whole.
This approach also allows for increased flexibility. Individual roads included in the program are of lesser interest after agreement has been reached on the criteria used in project selection and mechanisms exist to review the application of these criteria. Sector lending is demanding on the domestic institutions involved and is only introduced in countries that are relatively advanced and where Bank participation in the sector is long-standing. Mexico, Yugoslavia, Kenya, and the Ivory Coast are countries where sector loans have either been made or are being prepared. In many countries, however, sector lending cannot be expected to overtake rapidly the traditional type of highway lending. As indicated earlier, institutional development is a gradual process.

Lending for highways will continue to include projects ranging in technical complexity from low-cost earth and gravel roads to multi-lane limited access expressways. However, with the improvement of main highway networks in many countries and the emphasis on rural accessibility, the composition of Bank highway lending has shifted. For example, Bank highway loans made in FY65 supported construction of 3,700 km of rural roads and 7,000 km of other types. By contrast, FY79 loans supported construction or improvement of nearly 14,000 km of rural roads and approximately 10,000 km of all other roads. In FY65, the Bank lent US$30 million for rural roads and US$249 million for other roads; in FY79, Bank lending for rural roads under highway projects amounted to about US$145 million, while lending for other roads was US$791 million. Total lending for highways, including maintenance, training, and technical assistance components, was US$1.37 billion in FY79.

As indicated above, rural roads may be supported as components of agriculture and rural development projects. In recent years, about 75 percent of rural road kilometrage included in Bank lending was financed as components of agriculture and rural development projects and 25 percent as part of highway loans. However, in terms of amounts loaned, about 60 percent was in the highway loans and only 40 percent for roads included in the rural development projects. The primary reason for this difference is that most of the major rural access roads, which are of more expensive construction, are financed under highway loans while less expensive feeder roads are financed under agriculture and rural development loans.

As a whole, Bank lending for rural roads was US$303 million for roughly 35,700 km of roads in FY79, as compared with US$34 million for 4,300 km in FY65. The main factors underlying this shifting pattern of road construction have been the increased support of projects oriented toward helping the rural poor. Lending for rural roads is likely to continue to increase in the short term, as agriculture and rural development projects assume a larger share of Bank lending, and then stabilize sometime in the early 1980s.

Besides the shift in highway lending to rural roads over the past few years, the Bank has placed increased emphasis on highway maintenance and related management and training; institutional development; encouragement of the development of domestic civil works contracting capacity; and the substitution of labor for capital in road construction and related civil works wherever appropriate and economically justified.
While the Bank has long been concerned with highway maintenance, this has increasingly become a key issue in developing countries due to the completion of extensive additions to national trunk networks in the late 1960s and early 1970s and the aging of sections built earlier. Current construction of large amounts of secondary and rural roads adds to the maintenance workload. Problems relating to maintenance are complex and rarely the result of a single constraint. Existing inefficiency is often closely connected with poorly trained, motivated, and organized staff and with the diversion of their efforts to other works. There may be insufficient budgetary allocations, and shortages of necessary spare parts, equipment, and materials (due to cumbersome procurement and administrative procedures, problems which are compounded by the almost perennial shortage of foreign exchange allocations).

Increased emphasis on institution building is closely related to the increased need for highway maintenance, as well as the expanded role of the highway administrations in planning, executing, and maintaining rural road projects. These tasks require not only the development of appropriate legal and administrative structures and institutions, but also increased participation by the local population.

The promotion of domestic construction industries and the use of local laborers are additional efforts to increase the capacity and use of domestic resources and capabilities. Programs involving the use of labor-intensive construction methods are underway in Honduras, Kenya, and other countries. The development of domestic construction industries involves strengthening and setting up institutions for the channeling of resources and technical assistance to them, and the streamlining of relevant government regulations and procurement procedures. Both are highly important to developing countries. They serve as ways to reduce underemployment and the reliance on imported technology and project execution capability.

B. Nature of Technology Used

Because of the variety of road and highway projects funded by the Bank, a wide spectrum of civil engineering technologies are in use. These range from manual labor to large-scale earth movers, concrete mixers and pavers, laser-equipped surveying instruments, and the application of computers for optimizing highway alignments and estimating the requirements of cut and fill and materials hauling.

The use of technology in road and highway projects depends on the size, scope, and location of the project; the availability and stage of development of local resources (technical, managerial and worker personnel, public and private institutions, financing, equipment production and/or distribution, etc.); the capability of local institutions to use indigenous or imported technology appropriate to the conditions of the project; and the relative input factor prices.

By far the majority of Bank lending for both highway construction and maintenance is equipment intensive, since this is normally the least-cost solution. The Bank strongly encourages wherever possible, however, the use of
a factor mix which includes labor-intensive components and has financed labor-
intensive construction, rehabilitation, and maintenance pilot components in a
number of projects.

Although not a physical research organization, the Bank does try
to keep abreast of technical developments and of how innovations and possibly
underutilized traditional technologies can be applied to the best economic
use.

There are two areas of applied research where the Bank has contri-
buted to more efficient use of highway technology. The first relates to the
substitution of labor for equipment, which involves the use of appropriate
tools, techniques, and organizational structures. The second concerns the lack
of sound empirical evidence for many of the physical and cost relationships
necessary to determine economic road design and maintenance strategies.

The principal labor/capital equipment issue in road construction
is to find efficient technologies that utilize to the maximum extent the
abundant surplus labor available in many developing countries. In its effort
to examine this problem, a major study of the substitutability of labor and
equipment in civil works construction, especially feeder roads and irrigation
schemes, was begun in 1971.

The research has concentrated on the construction tasks of excavat-
ing, loading, hauling, and stone crushing, which typically account for more
than 50 percent of the total costs of road building and are the main area of
doubt in the issue of labor's competitiveness with machinery. There has been
less doubt that labor-based techniques could be highly competitive for building
of structures, such as culverts, which are often major cost items.

The central finding from the hundreds of cost-accounting observations
carried out in India and Indonesia is that, for typical construction jobs in
populated areas, heavily labor-based techniques are often less costly at wage
rates up to $1.00-$1.50 (in 1976 US dollars) per day (double or triple the
current rate in India) provided that labor supervision and incentives are
good. Nutrition and appropriate handtools were aspects of particular impor-
tance in the supervisory and incentive program.

The engineering economics research on highway design and maintenance
standards is of a different order. Bank financing for roads and highways is
directed to lower income countries with capital scarcities. There, the
trade-offs between initial construction costs and future maintenance and road
user costs could dictate highway design and maintenance strategies that vary
greatly from those used in industrialized countries. The importance is
indicated by the amounts of capital involved: the Bank is lending at a rate
of over US$800 million per year for roads and highways and the developing
countries themselves are spending at least US$10 billion per year. Funds
cover the construction and maintenance of highway systems but exclude the
operating costs of vehicles—which is more than double that amount. It is
clear that research towards improved management information for decision-
making to minimize the sum of construction costs, road maintenance costs and
vehicle operating costs can potentially pay high dividends and rationalize the
choice of much highway technology.
In 1969, a major program of research towards a new decision-making framework for evaluating alternative design and maintenance strategies for low volume roads was initiated by the Bank and research institutions in the United Kingdom, France, and the U.S. Based on work in Kenya and elsewhere, a computer model—Highway Design and Standards Model (HDM)—has been developed to predict the costs of different highway design and maintenance options. The model can be used to quickly estimate the total costs for large numbers of alternative designs and maintenance policy combinations on a year by year basis and, thus, to arrive at the alternative with the lowest total cost.

The Bank is also studying the transport needs of rural communities to identify how transport services for farmers and other rural inhabitants can be most effectively improved. The scope for development of vehicles specially adapted to such use is also being studied. Information on such vehicles produced and sold commercially anywhere in the world has been collected as well as information on prototype vehicles. Many of these vehicles are wholly or in part designed and constructed in developing countries, thus making use of local resources and labor.

C. Building Local Capabilities to Use and Develop Highway-Related Technologies

The Bank has been instrumental in transferring technology and know-how to the highway sector in developing countries. The first phase of Bank assistance normally involves strengthening or setting up highway administrations responsible for the main and secondary highway networks. Brazil, Ethiopia, the Ivory Coast, Mexico, and Thailand are countries where the Bank has been extensively involved in highway development through frequent lending operations. These countries are being considered for highway sector lending, itself an indication of institutional development of an advanced level.

Highway maintenance is another related area where the Bank is making efforts to develop local capabilities. Economic evaluations clearly demonstrate that timely maintenance has a high economic priority: keeping an existing road in good condition through grading, patching, resealing asphalt overlays, etc., yields far higher returns at a given traffic volume than new construction.

A recent highway project in Colombia may be taken as a current example of the Bank's efforts in the field of highway maintenance. Colombia's major highway network of 6,500 km of asphalt pavement has reached a stage where a shift from expansion to conservation is necessary. Most roads were paved in the 1950s and now some 1,700 km require rehabilitation. Although maintenance had not been neglected entirely, a strengthening of maintenance efforts is clearly required. Periodic maintenance and the replacement of maintenance equipment had been sporadic; highway maintenance districts suffered a permanent lack of funds for spare parts; qualified engineers, mechanics, storemen, and field personnel were in short supply; and the institutional framework needed strengthening. The project was designed mainly to address these characteristic highway maintenance issues, in addition to rehabilitation of main trunk highways, efforts to reduce overloading of vehicles and improvement of intermodal transport planning. The project includes procurement of
maintenance equipment and spare parts and expansion of existing workshop and store facilities for an amount in excess of US$20 million. Just as important is the technical assistance and training in supply, distribution, and storage of spare parts; programming of preventive and corrective maintenance; and costing and execution of all maintenance activities undertaken by the districts.

Although highway design and the construction of specific road projects could, to a large extent, be entrusted to foreign or local firms, maintenance requires total national and governmental involvement. The technology of maintenance per se may not be complicated, but certainly the planning, organization, logistics, and management often are. Problems exist in the areas of trained manpower, adverse climatic and topographic conditions, long distances, sparse population, and the usually indifferent attitude toward maintenance. Building up the necessary institutional capacities is a great deal more difficult than executing road construction programs. The effort has to be concerted and sustained. Past experience shows that satisfactory basic maintenance systems can seldom be established in less than 15-20 years, and that further help may be needed to deal with expansion of the maintenance workload and to sustain performance.

Measures to encourage the development of domestic, private sector capability in road construction and maintenance have been incorporated over the years in a number of highway projects. Notable success has been achieved in Brazil, Korea, Mexico, and Taiwan with the formation of a number of local construction and consulting firms. In India, some highway projects having parts that could be carried out more cheaply by labor-intensive techniques are let out to small sub-contractors who take on the responsibility of recruiting, managing, housing, and paying the labor. A variation of this theme is called "community construction," where the village or town organizes itself to plan and execute the road work with technical and financial assistance from higher government levels. This approach appears to have operated satisfactorily in Bank-supported rural development projects in Mexico and Korea. The Bank has also financed the planning, building, and operation of intermodal transport terminals (Brazil). And, finally, considering the extremely high road accident rate in developing countries, highway safety measures are gradually being included in Bank loans (e.g., in Argentina).

Other Bank efforts in institution building, especially in highway planning and maintenance, are exemplified by the following:

(1) Establishment of an institutional framework aimed at increasing decentralization of planning, construction, and maintenance responsibilities to lower administrative levels (e.g., in Kenya);

(2) Provision for preparation of a feeder roads organizational study and/or project preparation, including issues related to inter-ministerial coordination, adequacy of central technical units, and arrangements for decentralization (e.g., in Ecuador, Togo, and Indonesia);
(3) Pooling of road construction and maintenance capacity in several rural development projects through the establishment of a national feeder roads organization (e.g., in Ethiopia, Cameroon, and Upper Volta);

(4) Establishment in the framework of a regional agricultural project at one or more model feeder road construction and maintenance units in such a way that they should be replicable elsewhere in the country (e.g., in Liberia, Costa Rica, Nigeria, and Zaire);

(5) Specific provision in rural development/agriculture loans for training of staff concerned with roads (e.g., in Costa Rica, Haiti, and Tanzania).

D. Lessons Learned

The accumulated experience of the Bank's work in the highway sector may be briefly summarized in the following comments:

(1) The first priority in programming available highway budgets should be to achieve and sustain adequate levels of highway maintenance; economic returns for maintenance can exceed returns for new investments in roads or in virtually every other sector of the economy.

(2) The development and enhancement of institutional capabilities to plan, construct, and maintain roads and highways must be supported on a continuous basis in order to reach and sustain minimum levels of economic well-being, especially in rural areas.

(3) Road construction using heavily labor-based techniques can be cost effective under certain labor supply conditions provided that competent supervision and incentives are well integrated into the project.

(4) Since the demand for roads and highways is derived from other economic activities—farming, forestry, fishing, mining, manufacturing, etc.—the implementation of complementary productive projects in those areas must be closely planned and coordinated with road construction so that the roads are ready when needed and fully utilized.
9. TECHNOLOGY AND SCIENCE IN ENERGY
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TECHNOLOGY AND SCIENCE IN ENERGY

Introduction

Adequate energy supplies are crucial for the continuing growth of the developing countries—to develop primary resources, for industry, for irrigation, and to improve living standards. Energy's role in economic development is exemplified by the fact that electricity growth rates are usually double GNP growth rates. The total power capacity of some 90 developing countries is only 10 percent of the world total, but power growth rates in the developing countries average 10 percent annually compared to 5 percent for the developed world, notable examples being 11 percent in Brazil, 10 percent in India, 17 percent in Korea, 11 percent in Kenya, and 17 percent in Nigeria.

The World Bank supports the timely provision of energy supply systems and the strengthening of related organizations in developing countries. Energy development accounts for one-fifth of all past Bank financing. Before the oil crisis, this effort was mainly concentrated on electric power. Since the oil crisis, with its adverse effects on developing countries which must import oil, the Bank has begun supporting the exploration for and development of all forms of indigenous energy resources in its member developing countries—including electric power from hydro and geothermal sources, oil and gas, coal and lignite, and solar, biomass, and other renewable energy sources. The Bank has also begun to provide technical assistance for improved energy planning to the many developing countries that are experiencing for the first time the need to do this in an integrated manner.

Under the new conditions of the supply and price of energy, developing as well as developed countries need coherent policies to address national energy needs and an appropriate strategy to implement them. The importance of helping the oil importing developing countries improve their energy situation is evident. The various elements of an energy program have to be pulled together and fitted into the totality of the government's economic and financial plans. Assistance is needed in many cases to create, or reorganize and strengthen, an energy planning authority and to train the necessary administrative and technical staff. Assistance is also required in some countries to revise petroleum and minerals legislation, as well as official regulations and fiscal measures that affect the energy sector.

The Bank's sector and sub-sector work, which will be geared to its expanded program for energy, is intended to help member countries draw up national plans and policies that will ensure as rapid and efficient exploitation of their energy resources as possible. The present program covers about 40 of the 60 countries that stand in need of help. The work will be expanded as rapidly as possible to the others, and additional work will be undertaken in countries where only some of the sub-sectors have been covered. Assistance will be given in resolving particular legal and administrative
problems, and in the training of local personnel. Provision for these activities will be made in technical assistance, engineering, and production loans and credits. Where a loan or credit is not immediately in prospect, every effort will be made to find a suitable expert and a source of finance.

Assistance in all the areas mentioned above is available from a variety of agencies. The U.N. system, for example, offers assistance through UNDP; the regional Economic Commissions; UNIDO; the Centre for Natural Resources, Energy and Transport; the Centre on Trans-National Corporations; and through such specialized agencies as FAO, IAEA, UNEP, and WMO. Bilateral agencies, including the national oil companies of some industrialized countries, are also in a position to help and several have done so. The Bank will work with these agencies in order to draw on their experience and specialized knowledge and to avoid duplication of effort.

I. Power

A. Bank Lending for Power

The Bank has supported the provision of adequate electricity supplies (centralized generation and grid distribution) in developing countries and the establishment of strong sector institutions in the course of nearly 350 loans totaling more than US$11 billion over three decades. In providing this sector assistance the Bank’s unchanging aims have been to utilize the most suitable technology in keeping with the country’s size and state of development, to promote the financial soundness of the sector through revenue and debt service covenants and sector supervision, and to ensure the selection of economically justified projects.

For the past several years, Bank lending for power has averaged about US$1 billion annually for 16 to 20 projects. In FY79 power lending was US$1.4 billion for 19 projects and within a year or two lending for power is expected to be US$1.5 billion annually. During the past five years, fuel price increases have required greater emphasis on hydro, geothermal, and other alternatives to thermal projects. The Bank is also increasing its emphasis on distribution and rural electrification projects to extend the benefits of electricity to a larger share of the population. It is expected that an additional 10 million rural dwellers will benefit from Bank-financed power projects in the next two years. Recently the first power loans were made in several of the least developed countries—including Afghanistan, Fiji, Nepal, Haiti, and the two Yemens.

B. Nature of Technology Used

1. Present Technologies

The development of power systems in developing countries is following the historic pattern established for the industrialized countries: small isolated diesel or hydro-supplied systems are gradually connected into regional systems and these are interconnected to form national power systems. For large countries such as Brazil and India these national systems permit
the economies of scale possible with large steam and nuclear units, foster
development of major hydro projects such as the 14,000 MW Itaipu project on
the Parana River, effect fuel savings through coordination of hydro and
thermal operations, and permit capacity savings through load diversity and
reduced reserve requirements.

Hydroelectric power technology is well proven in all types of dams
varying from earthfill to concrete arch, in generating unit sizes up to about
700 MW, and at heads up to about 1,500 meters. Recent hydro emphasis has
been on bulb and tube-type units for low-head applications, on mini-hydro
stations for rural supply, and on reversible pump-turbines for peaking
sources using steam or nuclear stations as the pumping source. Fuel price
increases have accentuated the advantages of hydro power but there has been
delay in the developing countries in exploiting available hydro potential
because of: (a) the time required to execute hydro resource surveys;
(b) inadequate load to warrant major project development; and (c) lack of
agreement on projects on international waterways.

The Bank has always emphasized the need for national hydro surveys
permitting the priority listing of economic projects. Such surveys usually
represent only about 1 percent of final investment costs and can permit
substantial savings as well as ensuring adequate power programs. The Bank
has acted as executing agency for UNDP-financed hydro resource surveys in
many countries including Brazil, Guyana, Surinam, and Togo/Benin.

Some developing countries have been too eager to attract elec-
tricity-intensive loads such as aluminum smelters to make large hydro projects
viable, with long term penalties if thermal projects are required for future
domestic load growth. The Bank tries to ensure appropriate economic analysis
in such cases. Where the interests of several countries are affected by a
hydro project, the Bank attempts to play the role of impartial advisor by
arranging equitable settlement of any international issues. For the prospec-
tive Karakaya project on the Euphrates River in Turkey, appropriate reservoir
filling procedures are being developed to avoid adverse downstream effects in
Syria and Iraq.

Steam unit design characteristics in the U.S.A. have stabilized
somewhat at a norm of 1,000 MW, single shaft, one stage of reheat, 2,400 p.s.i.
and 1,000°F, although several supercritical (above 3,500 p.s.i.) 1,300 MW
tandem units are in operation. In the developing countries maximum steam
unit sizes are about 500 MW. The Bank is financing units at or near this
capacity in India, Thailand, and Indonesia.

Steam station locations and designs are determined by the avail-
able fuels and fuel transport options. The Bank is playing a major role in
providing fuel supplies for steam stations in member developing countries
through oil, gas, and coal development projects. The Thailand unit will be
supplied from offshore gas fields via a pipeline under consideration for
Bank financing. In Indonesia, Bank-financed studies are preparing a coal
mine and sea transport project to supply the Java units by barge from Sumatra.
The coal-fired Indian unit near Bombay is designed to also burn associated
gas, if available from the Offshore Oil and Gas Project financed by the Bank.
Over the past 30 years nuclear power technology has developed using various fuel-moderator combinations and has settled on two proven commercial designs--enriched-uranium, light-water reactors, and natural-uranium, heavy-water reactors. In the developing world, nuclear commitments have been possible only in the larger countries including Argentina, Brazil, Iran, and India because the minimum economic size for nuclear units is about 500 MW. Due to the ready availability of export credit financing in the supplying countries, notably the U.S., the Bank has been directly involved in only one nuclear project (a small experimental installation in Italy in the 1950s); it has, however, financed studies for many system expansion programs which included consideration of nuclear power stations.

Jet-type gas turbines of about 20 MW are used for peaking and reserve purposes; industrial-type gas turbines up to about 90 MW are used for peaking, mid-range, or base-load capacity depending on the system size and the fuels available. Gas is the preferred fuel; light oil is commonly used, but gas turbines can be fueled with heavy oil if it is treated to stabilize the contaminants. Gas turbine financing by the Bank has included wellhead, gas-fueled peaking units in Iran, distillate-fueled peaking units in Tunisia, and distillate-fueled base-load units in Liberia to complement variable hydro station output. Combined cycle units (gas turbines and steam turbines) are being considered for prospective Bank projects in Nigeria and Thailand.

Diesel generating sets provide the mainstay for small systems lacking hydro. Small, distillate-fueled, high-speed sets serve in small towns; low or medium-speed, residual-fueled sets supply major towns and regional systems. Typical of Bank-financed diesel projects is one in Sierra Leone, that financed installation of a 9.3 MW low-speed diesel generator on the Freetown system and high-speed sets totaling 2.3 MW in 10 provincial towns.

The Bank has assisted the development of Brazil's 20,000 MW interconnected system covering the southcentral and southern regions by serving as the executing agency for UNDP-financed studies that inventoried hydro resources and prepared optimum power programs. The Bank has also financed national or regional interconnection projects in many countries including Colombia, Iran, Brazil, and Yugoslavia. For small countries, such as those in Central America and West Africa, significant economies can only be achieved by interconnecting national systems to form regional power pools. The Bank has promoted interconnection studies in these two regions, financed a 220-KV interconnection between Honduras and Nicaragua, and is processing a loan for the 300-MW El Cajon hydro project in Honduras, which will make some power available to neighboring countries.

Power transmission voltages in use range from 33 to 765 KV A.C. and up to +400 KV D.C. Conventional lattice-type towers are giving way to more expensive but aesthetically acceptable tubular construction in urban areas. The Bank has promoted consideration in planning studies of long-term voltage requirements and has financed projects introducing EHV levels in many countries, including Iran and India.
Primary distribution voltages range from 2.4 to 22 KV for urban areas and from 11 to 33 KV for rural areas. Final service supply conditions vary from country to country. Most countries in North, Central, and South America use 60 hertz, 115/230 volts single phase for domestic supply. Most countries in Europe, Africa, and Asia use 50 hertz, 230/400 volts three phase supply. In some countries (e.g., Guyana and Saudi Arabia) both systems exist because of earlier dual influences; therefore, unification programs are necessary. The Bank tries to effect economies through design improvements and standardization. The appraisal for a prospective urban distribution project in Colombia includes consideration of voltage standardization, increased distribution circuit loading levels, and simplification of metering.

2. **Alternative Technologies**

New technologies offer some hope for lower electricity costs (in real terms) in the developing countries.

(a) Demonstration tidal power stations are in operation. Prototype stations are under study to develop power from the sea using wave power or ocean thermal energy converters (exploiting temperature differentials). Besides high capital costs, one inherent disadvantage of such ocean sources is the need for some form of energy transfer system such as pumped storage plants to "even out" their outputs.

(b) Wind power plants were widely used 40 to 50 years ago in rural areas of the developed countries in conjunction with batteries to provide a continuous power supply. They offer some potential for isolated systems in the developing countries but, to date, are not practical for a major station supply.

(c) Solar photovoltaic cells are in use as power supplies for isolated loads such as buoy lights and telecommunication repeater stations but high unit costs have prohibited their widespread use. Central solar plants using mirrors to concentrate the sun's radiation are in the experimental stage.

(d) Fuel cells may offer the best potential for a large central power source. A 5-MW demonstration station is under construction on the Consolidated Edison System supplying New York City. Batteries offer potential for system economies through (a) permitting higher system load factor by shifting usage to off-peak hours, e.g., night recharging of electric car batteries, or (b) providing supplemental power at peak time at distribution substations or on the customers' premises, thus saving investment for transmission and distribution in addition to providing peaking capacity.
Only about one-third of the fuel input to thermal power stations (steam, nuclear, diesel, gas turbine) is converted into electricity for distribution to energy consumers. The remainder is given up as waste heat to the air, lake, river, or ocean, depending on the cooling system, as an inherent limitation of the thermal cycle. Much higher overall efficiencies are possible if power stations can be combined with steam supply stations to utilize some of the waste energy for heating (district heating stations) or process steam ( cogeneration schemes).

This idea is not new. Fifty years ago the U.S.S.R. had standardized combined power and heating system designs for urban centers, spurred by the high heating demands with the country's low temperatures. Many of the world's power systems started as electricity supplies to factories and mills as an adjunct to the production of process steam for the industries ( autoproducers). Since most of the developing countries have a (relatively) small or only moderate heating load, there is no major need for district heating systems. There undoubtedly is potential, however, for energy conservation through cogeneration schemes. In the past, their development has been restricted by the almost worldwide nationalization of power systems with accompanying restrictions on self-generation by industries. There is scope, therefore, in the developing countries for more effective energy utilization through generation schemes.

The Bank consistently endorses adopting the latest proven technology in its search for ways to reduce grid power costs. A recent loan for the binational (Argentina/Paraguay) 2,700-MW Yacyreta hydroelectric project includes a mini-hydro resource study. A rural electrification project under review for a loan to the Ivory Coast includes consideration of single-wire-earth-return systems which offer scope for savings but must be examined carefully because of hazards if grounds are not effective. A project in India includes a prototype single phase distribution component. In the design of distribution systems for low-income groups consideration is given to eliminating meters and using current limiting devices and flat rates. Geothermal projects are being prepared for Bank loans in several countries, including Kenya and the Philippines, with one under implementation in El Salvador. Prospective Bank loans to Jordan for regional transmission and phosphate plants include consideration of various cogeneration and central grid power supply arrangements.

 Criteria for Choosing Technologies

The alternative technologies considered for Bank-financed power projects are well established ones, and almost never experimental or untried. The principal criterion used in selecting among these technologies is the least-cost rule. Thus the Bank seeks to ensure that each project it finances is a part of the long-run, least-cost system expansion program. Because of so called "systems effects," especially in establishing a correct mix of technologies for generation, the emphasis is laid on minimizing the combined investment and operating costs of the program over some future period, typically 10-20 years, rather than the cost of the immediate project. For example, the dual oil/gas-fired 500-MW unit planned for Thailand was studied in conjunction with various alternative sequences of hydro, thermal,
and nuclear stations to meet Thailand's power needs through 1990. Recent studies have shown that present reliability standards in many countries may be too high. The future trend in analysis of alternative supply programs therefore will be to try to minimize the total power costs to society -- i.e., system costs plus outage costs.

There are several secondary considerations which help to discriminate between alternative technologies, particularly in cases where the cost differences are small. For example, the availability of trained personnel to operate and maintain equipment is important in certain countries. The performance of some types of plant under severe operating conditions, poor maintenance, and uncertain repair services and backup from the manufacturers, could also affect the choice of technology. For such reasons low-speed diesels were selected as power sources for Sierra Leone and Liberia, even though these units have a higher first cost than medium-speed diesels; their rugged construction results in lower maintenance costs and simpler operation. The environmental impact of various technologies is also becoming an increasingly important consideration. The design for the first 500-MW steam unit in India allows for subsequent installation of scrubbers should India's environmental regulations so require.

4. Project Studies and Research

The Bank routinely finances engineering studies by consultants and/or borrowers, usually as a part of the project loan, and sometimes as a separate engineering credit. These studies range from analytical computer modeling efforts, such as for system expansion planning, to practical exploratory work in the field (e.g., hydroelectric dam site investigations, including drilling for core samples). Project-related research studies are not usually required with established technologies, but are becoming increasingly important in new areas of lending, such as rural electrification. A study of switched capacitor power factor control will be conducted in conjunction with a rural electrification project in India.

The Bank has a continuing program of separately funded research which is aimed at improving the design and technical standards for rural electrification projects, and also identifying their benefits. One result was the derivation of a general approach to the issue of supplying low-income groups with basic services, whether in urban or rural areas. Because of its operational relevance, this research is closely linked with, but not financed through, ongoing lending operations in many countries. Other significant research areas include power pricing policy, optimum reliability and research margins, monitoring new technologies, auto-generation and cogeneration, and interfuel substitution.

C. Building Local Capabilities

Every Bank-financed power project involves some degree of technical assistance to the borrower through technology transfer and the institution-building efforts of engineering or management consultants and Bank missions.
In Syria, the Bank financed the introduction of 125-MW steam units on a system where existing steam units were only 30 MW, requiring a major upgrading of the borrower's technical capability through appropriate programs. In Thailand, during the execution of seven Bank lending operations consultants have improved local system planning expertise, established appropriate accounting systems, and implemented asset revaluation procedures. The Bank’s presence has shaped the development of some of the strongest power entities in the developing countries, including EGAT in Thailand and CFE in Mexico.

The Bank finances the training of the borrower’s personnel in a number of ways, depending on the circumstances. This assistance is geared to the total needs of the borrower, rather than the narrow requirements of a particular Bank project. Thus, if new equipment or techniques are to be introduced in the sector, the Bank will include as a part of the project loan a component to pay for the training of local staff abroad. A Bank-financed distribution project for the city of Tehran included training maintenance and operating personnel at facilities of the London Electricity Board in England. The Bank also pays for consultant services to train the borrower’s staff on-the-job in management and technical skills (e.g., cable splicing). Finally, the Bank organizes many services and courses on power. These meetings range from fairly comprehensive, relatively long, and large courses such as the EDI power projects course held in Washington, D.C., (25 participating countries, 3 months) to specific, shorter, and more restricted seminars such as lectures on pricing policy held in particular countries.

Bid evaluation procedures for most Bank-financed projects give local equipment manufacturers a 15 percent preference and, in the case of countries with per capita income less than US$200, domestic civil works contractors are given a 7 1/2 percent preference. Even in projects requiring a very high foreign exchange content, the Bank attempts to maximize the opportunity for local involvement. The civil works for a Bank project in Afghanistan comprising two 20-MW gas turbines were constructed by the Afghans.

D. Lessons Learned

There is scope for the development of more systematic procedures, based on rational economic criteria, for determination of reliability standards of power generation and transmission appropriate to different countries and areas. Increasing (decreasing) system reliability involves an essential tradeoff between increased (decreased) system costs and decreased (increased) costs of shortages suffered by customers. Although savings in power system costs are not hard to calculate, it is difficult to estimate the corresponding economic costs involved by changing standards of service. Many of the Bank’s borrowers of recent years have been suffering shortages of generating and bulk transmission capacity, and some may well be expected to continue to do so following the increase of oil prices with the resulting higher investment and operating costs. In some cases, systems in LDCs have been overdesigned using reliability criteria more appropriate to the industrialized countries. However, even with huge reserve margins, neglect and poor maintenance have led to supply shortages. Other systems have been underplanned, also resulting in power shortages.
Distribution standards should be subjected to the same treatment. The work done so far in this field suggests that there may be significant scope for savings in developing countries through improvements in system and plant design; further savings should be possible by correctly targeting the planning standards. Thus, outage-sensitive industries could be served at high reliability, while service to the urban poor would be at minimum standards, with each type of customer paying a price commensurate with the cost of service.

The Bank has found that a strong central institution in the power sector is, on balance, beneficial. Experience suggests that such an institution is essential in order to develop sound and well-coordinated investment planning, balanced implementation among regions, and effective and economical use of other sources of foreign financing, such as supplier credits. The Bank has continued to try to reinforce established institutions of this type (e.g., in Brazil), to assist the development of newly created ones (e.g., in Indonesia, Nigeria, Turkey, and Zambia), and to encourage their emergence in other countries (e.g., India, Yugoslavia, and Cameroon), largely for the improvements in electricity development planning and policy that this should make possible.

The Bank’s research and review of experience with rural electrification indicates that the application of electricity for agricultural and industrial purposes can bring substantial development benefits. Rural electrification can help increase the output and thereby the profitability of farms, agro-industries, and commerce by providing a superior and cheaper means of household uses, including those of low-income households. Rural electrification projects must be chosen to meet the social and economic aims of the country, and the projects must be carefully and thoroughly prepared—institutionally, technically, and financially.

Finally, the need for developing countries to compile basic data on hydrology and meteorology has become critical since the oil price increases of the 1970s. Many countries have significant untapped hydro potential which cannot be developed optimally without historical records to ensure the dependability of rainfall runoff and river flows. A few LDCs have records dating back for fifty years or so, but records are seriously deficient in many countries and steps should be taken immediately to set up, as a minimum, rainfall gauges and river level gauges. As time goes by, stage-discharge relationships can be established for stream flows, and rainfall-runoff correlations can be determined.

II. Petroleum

A. Bank Approach to Oil and Gas

1. Main Reasons for Bank Support

Oil importing developing countries’ consumption of oil is projected to be 7.2 million barrels per day (mbd) in 1985 compared with 4.3 in 1975,
whereas domestic production of oil in these countries, if there is no change in the rate of increase in production, is expected to be 2.9 mbd in 1985 compared with 1.2 mbd in 1975. Oil importing developing countries will, therefore, have to import 4.3 mbd in 1985 compared with 3.1 mbd in 1975, which will have a dramatic impact on their foreign exchange requirements. There is a strong case, therefore, for the oil importing developing countries to increase their domestic production and to accelerate exploration, wherever it is economic to do so, while also developing their non-oil energy sources.

Oil price increases since 1973 have changed the economics of oil production and exploration radically. The cost of imported oil is now sufficiently high to justify exploiting known reserves which were considered before 1973 to be uneconomic due to their small size and high cost of recovery and/or transportation, and to increase exploration for petroleum. A Bank-commissioned survey 1/ of 70 developing countries found that 23 of them have prospects of finding "high" (750-1,500 m barrels) or "very high" (over 1,500 m barrels) quantities of oil. Although costs of exploration are substantial (they may be in the range of US$10-30 million onshore and US$20-50 million offshore), the drastic changes in energy economics make it necessary to reconsider exploration projects which had been abandoned prior to 1973.

Private investors may be reluctant to invest in production and/or exploration in developing countries where costs of oil production are typically higher than in industrialized countries where seismic/geological work has already been achieved, and which are nearer to main markets. Furthermore, the oil deposits in most developing countries concerned are likely to be relatively small. The Bank's presence can be an incentive to private investors by helping to reach agreements satisfactory to both host countries and oil companies and by helping host countries take all or part of the risk involved in exploration and production development. The role of the Bank is therefore to act as a catalyst for private financing sources rather than as a substitute for them. 2/ The Bank is also prepared to support local, government-owned companies.

1/ By the Bureau d'Etudes Industrielles et de Coopération de l'Institut Français du Pétrole (BEICIP).

2/ The International Finance Corporation (IFC), an affiliate of the Bank that makes equity investments and loans unsupported by government guarantee, is also supporting petroleum projects. It has assigned priority to the development of existing discoveries which maximize increases of output at relatively modest risk and uncertainty. The Corporation is likely to be involved in three types of programming: past discoveries that for a variety of reasons have not yet been developed, a large number of fields in which primary recovery has been completed or is declining but which are now worth additional expenditures for more costly secondary recovery programs, and refining and distribution projects. The Corporation also expects to be able to support exploration activities in certain instances. Projects which require a larger investment than is prudent for IFC to make will be handled by the Bank; other situations may call for joint participation by IFC and the Bank.
2. **Critical Points in Sector**

The three main problems that hinder progress in the development of indigenous sources of energy in developing countries are:

(a) the weaknesses observed at the level of planning institutions. This includes the design of long-term development policies, as well as the ability to negotiate adequate contracts with foreign investors. Insufficient training of personnel in local institutions weighs heavily against their efficiency;

(b) poor pricing policies. It is essential that there be adequate analysis in order to make correct decisions on pricing matters; and

(c) inadequate analysis of data from exploration activities. The exploration activities themselves have also usually been insufficient in oil-importing developing countries.

The first task of the Bank in these problem areas is to help build local institutions through technical assistance and training in both management and technical matters related to the field. The Bank also recommends organization, procedures, etc. In the initial phase, the Bank will provide direct assistance on financial, technical, and legal matters, especially in connection with the negotiation of agreements with foreign companies.

Second, the Bank advises on the design of energy policies. These involve taxation and pricing, as well as the planning of the development of local energy resources. The Bank will also participate in the study of intersectoral relationships, and in the analysis of the integration of oil and gas development within the full energy development plan involving all commercial and non-commercial energy sources.

Third, in order to strengthen knowledge of developing countries' energy potential, the Bank has already begun major studies such as the survey of 70 developing countries. Bank participation in the design and financing of exploration projects will improve data collection and analysis within developing countries.

3. **Nature of Lending**

The Bank's priorities in lending for petroleum projects are for low to medium income developing countries where prospects of economic production are deemed to be good and, among these countries, those having the greatest dependence on imports. Of the 30 oil and gas projects to be prepared for Bank financing during FY79-81, approximately half will be located in countries with a per capita income below US$500.
a. Survey Work

The Bank will participate in geological and geophysical survey work, through technical assistance loans and credits. The funds required for this type of project typically range between US$500,000 and US$5 million. It is forecast that the Bank will participate in 8 to 10 such loans a year in the early 1980s.

b. Exploratory Drilling

The cost of exploratory drilling may range customarily from US$0.5 to US$10 million per well. The Bank will act as an advisor in the negotiations of agreement for exploration between host countries and private foreign investors, while stating its willingness to make a loan at the production stage in case exploration has a positive outcome. (For example, the Bank participated in negotiations between Pakistan Oil and Gas Development Corporation and Gulf Oil Corporation which led to the exploration agreement signed in November 1978.) In order to help finance exploration investments made by host countries, when private investment cannot be arranged, the Bank will consider helping developing countries finance the exploratory drilling phase, as long as risks are deemed sufficiently low. (For this purpose, adequate initial survey work should have been done and produced positive results.) However, the Bank encourages countries to seek private financing as much as possible for this phase of exploration. Overall, the Bank plans to make 8 to 10 loans amounting to US$100 million for exploration drilling programs costing in total US$100 to US$250 million.

c. Project Preparation

Appraisal drilling will be financed through engineering-type lending operations. These drilling programs are estimated to cost up to US$25 million. The Bank will consider financing some 10 projects of this kind a year by 1983, for a total amount of US$250 million.

d. Production Investment

The Bank began a lending program of an average of 8 loans a year for oil and gas production programs in FY79, which will reach US$500 to US$550 million a year in 1980 and 1981.

B. Nature of Technology Used

1. General Nature of Science and Technology Used in the Sector

a. Geological and Geophysical Surveys

Geology and geophysics are used essentially in the first phase of exploration for liquid or gaseous hydrocarbons. They involve, besides the current geological approaches, such techniques as photogeology that will produce a preliminary geologic map by interpretation of conventional air photographs or side-looking radar and ERTS imagery and geochemical surveys that aim at detecting minor amounts of hydrocarbons on the ground surface, and more recently surveys of source rocks.
Current geophysical methods include magnetometry, either ground or air-borne (airmag), which uses high sensitivity magnetometers to detect minor changes in magnetic susceptibility of rocks; gravity, which uses gravimeters to record the minor changes in rock gravities; and seismology, which essentially deals with recording reflections of waves created by a controlled surface explosion and permits the interpretation of the subsurface structures.

b. Drilling

Exploratory drilling is the next step. The first exploratory well in a region, which is called a rank wildcat well, may help discover a petroleum accumulation that will be confirmed by drilling a stepout well or confirmation well. About three to five delineation or appraisal wells are needed besides the discovery well to delineate the field or its reserves before development, if deemed economically warranted, is started.

Development of a field or a cluster of fields consists in drilling the producing wells and other wells technically required, installing the producing facilities, the gathering lines, tank farms, pipelines, and pump-stations as well as the terminal facilities to refineries or to overseas markets.

c. Oil Production

Oil production is often achieved naturally through the utilization of the inherent reservoir energy. The various mechanisms by which oil is recovered in this primary phase are classified as solution gas drive, gas cap drive, or water drive. This phase normally recovers from 5 to a maximum of 40 percent of the oil in place. Additional energy could be supplied to the reservoir through the injection of water or gas (secondary recovery), which greatly improves the oil recovery efficiency. Over the last two decades, more attention has been given to introducing more sophisticated technology known as tertiary or "enhanced oil" recovery. These methods promise a very high rate of oil recovery. Many of them, however, are under the pilot stage of development.

d. Pipelines

Improvement in submarine pipeline construction for use at greater depths has been the most important recent development.

2. Criteria Used in Selecting Suitable Technologies

The Bank's role at all stages of petroleum development projects is to help choose the most appropriate technology from a technical and an economic standpoint. In most cases, this is one of the objectives of the engineering loan granted at the exploration or preparation stage. Consultants are used to determine the most appropriate technologies. An example is the Bati Raman engineering project in Turkey, which includes consultant services for a comparative study of the various possible enhanced oil recovery methods, for the design of a pilot plant, and for a geological description of the reserves.
C. Building Local Capabilities

As noted above, strong local institutions are a prerequisite to the design and implementation of efficient energy policies. The Bank, therefore, supports the inclusion of project components designed to strengthen managerial and technical capabilities of local institutions. This is done through the use of foreign or local consultants, training programs, and cooperation with local research institutions.

The projects use consultants as a means to complement and strengthen local capabilities both in technical and managerial matters. Most engineering projects make an extensive use of foreign consultants; for example, in the Toot Drilling Project (Pakistan) a Canadian firm serves as a technical consultant to assist local institutions regarding production methods. In Thailand, the project provides for consultant services in the area of project management, engineering services, financial management services, and natural gas services study, besides general advisory services in order to help in the development of the pipeline. In Turkey, the Bati Raman engineering project provides that the feasibility study will be undertaken by the consultants in close collaboration with Turkish technical staff.

Engineering projects almost invariably provide for the technical and/or management training of the institution's staff. The Toot Drilling Project (Pakistan) includes the design of a training program for operating and technical staffs in collaboration with the Oil and Gas Institute. In the Thailand project, training in natural gas technology has been arranged for all staff, as well as specialized training abroad for some staff in the areas of corrosion, engineering, telecommunications, supervisory control systems, and measuring/metering. In the Turkish project, specialized training will be set up in enhanced oil recovery, geological evaluation, and petroleum reservoir techniques.

Transfer of petroleum technology is already being achieved in developing countries such as Thailand, Turkey, India, and Pakistan. In Turkey, for example, development of local capabilities to use secondary recovery methods was a prime objective of the Bank's loan. Although technology is now mostly imported through the use of consultants from Europe and the United States, it can be expected that the next years will see more local capacity to use advanced technologies. Training and institutional development, which are essential components of the Bank's loans for petroleum, will play a vital part in this improved situation.
III. Coal

A. Bank Approach to Fuel Minerals

According to the World Energy Conference, coal \(^3\) reserves (including coking, bituminous, and sub-bituminous coal as well as lignite) in developing countries are about 10 percent of the world total. The present distribution of world coal production in terms of heat content closely reflects the reserve situation: centrally planned economies account for 53 percent, developed market economies for 41 percent, and developing countries for only 6 percent.

Available information indicates that about 50 developing countries have known but only partially explored coal and lignite reserves. The problem in many developing countries is determining more reliably the extent and quality of existing resources. Furthermore, there are a number of factors which restrict the supply of coal (mining difficulties, poor quality, transport/handling, ecology) which are dissimilar to petroleum, and which in many countries are more important obstacles to production than the lack of knowledge of reserves.

The coal projects currently being executed or prepared in developing countries are mainly designed for new domestic, coal-fired power stations or for the export of coal to the developed world. The present expansion of coal production in developing countries partially substitutes coal for oil or gas in new installations and will thus help to slow down the growth in oil/gas demand. There has been very little switching from oil/gas to coal in existing installations in developing countries, because time is needed to build up coal production in line with the increase in demand, and more importantly, most existing power stations or other potential coal users lack dual-fired boilers, making the switch impossible without major new capital expenditures. Coal uses will therefore spread only gradually as existing installations become obsolete and new plants are added. A more rapid switch from oil/gas could only be expected if further major oil price increases were to offset the disadvantages of using coal in existing installations, or if financial incentives were established to stimulate this switch. Conversion to coal involves, in addition to incremental capital costs for burner modifications, coal handling and storage facilities, as well as ecological problems.

\(^3\) The two most widely used classifications of coal are by calorific value and ultimate economic use. In the first classification, distinctions are made between hard coal (including anthracite and bituminous coal, with a heating value of generally more than 5,700 kcal/kg of coal) and brown coal (sub-bituminous coal and lignite, with less than 5,700 kcal/kg). In the second category, one distinguishes between thermal coal for electric power generation, industrial use, and residential/commercial heating purposes, and metallurgical or coking coal, used primarily in steel-making.
The above discussion is related primarily to large coal mines and the use of coal for large-volume and concentrated consumption. There are other developing countries that have only relatively small and scattered coal deposits and their exploitation could possibly be economically attractive when made into coal briquettes and smokeless or semi-smokeless fuels for domestic and light industrial use. This could help to alleviate the shortage of firewood and thus counteract the deforestation that is occurring in some parts of the world. This potential use of coal and the related establishment of small and medium-sized mines have not been given enough attention, with a few exceptions such as China, Turkey, and Korea.

Necessary exploration work for known coal reserves in developing countries can be distinguished by different risk and cost factors into two main categories:

(1) in a number of cases, exploratory drilling and quality testing are needed to complete feasibility and preliminary engineering work prior to project appraisal. Cost ranges are wide, up to several million dollars for the exploration/quality testing component. In addition some projects may require transport engineering; and

(2) in the majority of developing countries, although some exploratory drilling has been undertaken, the size, quality, and mining characteristics of the coal field have not been sufficiently delineated to allow a meaningful economic evaluation of the reserve. Additional exploration is needed in these cases but the expenditures and risks involved are smaller than in petroleum exploration.

Developing countries with major coal reserves have welcomed Bank assistance in the expansion of existing coal mines or exploitation of new deposits. A project pipeline has been developed for FY79-83 which may allow lending for 2-4 coal/lignite projects a year at an annual lending of US$100-200 million. At this level of lending, the Bank would be associated with coal projects totaling US$3.3-3.6 billion, or some 17-35 percent of expected investments in coal mining and associated transport projects in developing countries until 1990.

In FY78 the Bank made one engineering loan to Indonesia for the Bukit Assam coal mining power project to exploit an open pit coal mine and is discussing involvement in a number of other projects. For fuel minerals the Bank is only likely to be involved with coal and lignite (a young form of coal, geologically speaking) for the foreseeable future. Bank involvement is not required for uranium, since adequate international financing is available for both exploration and exploitation. In the case of oil shale, the technology is still relatively new, and Bank involvement in any specific oil shale projects has not as yet been discussed.
Among the critical points in coal project preparation are the market analysis and transport considerations. The Bank examines the market for each project on a case by case basis. Two of the projects under consideration will contribute significantly to export earnings, and the others are expected to satisfy domestic energy needs in the countries concerned, with substantial benefits accruing from the substitution of coal for petroleum.

While there are regulations on environmental impacts in developed countries, these are usually much less substantial in developing countries. The Bank tries to play a useful role in developing reasonable standards—e.g., for mine drainage, dump stabilization, re-vegetation, reclamation, disposal of ashes and of washing plant tailings, etc. The Bank also insists that the coal mines it finances be executed and operated in accordance with acceptable safety and health standards appropriate to such operations.

B. Nature of Technology Used

There are two main coal mining methods—open pit and underground. Open pit mining methods employ such equipment as drag lines, trucks and shovels, mobile crushers and conveyor belts, stackers for coal and spoil, and highly specialized bucket wheel excavators. Different applications are used for different deposits. Underground mining methods include room and pillar; the long wall method, which often uses highly mechanized and sophisticated equipment (mainly used in Europe); and hydraulic methods, used in some mines in the U.S.S.R., North America, and Europe.

Large-scale coal mining is capital intensive and highly mechanized; it does not lend itself to labor intensive methods, although fairly large labor forces are also employed in some developing country operations, particularly in underground operations. Coal mining uses mainly well-established techniques. The criterion for selection of technologies for use in Bank-financed projects is the optimization of mining methods and equipment selection in view of the specific characteristics of the deposit concerned, with due regard to the specific conditions of the country—e.g., labor costs, availability of skilled labor, availability of after-sales support from suppliers, energy considerations, level of technological development, etc. Usually the geological configuration dictates the use of certain technology, and the equipment is selected accordingly, with due regard to the specific country factors.

In developing countries, proven mining methods and equipment are used for reasons of reliability and ease of maintenance. In addition, equipment unit prices are high (e.g., a 120-ton truck costs approximately US$500,000). In remote areas, where availability of trained maintenance personnel can be critical, breakdown of equipment can result in a considerable increase in operating costs.

Possible new technologies include:
(1) Improvement of coal quality for direct utilization through coal cleaning for sulphur removal; fluidized bed combustion, reducing sulphur and nitrogen oxide emission from plants and allowing utilization of a wider range of coals; and environmental control technologies such as flue-gas desulphurization; and

(2) Coal conversion into low-BTU gas or substitute natural gas (high-BTU gas); and liquid fuels as a direct oil substitute or for use in fuel cells.

Most of the environmental control technologies are by now sufficiently advanced to allow commercial application. Although they increase the cost of direct coal utilization in power generation and industrial fuel burner use, their introduction does not threaten the relative economic advantage of coal vs. oil in these applications. Extensive commercial use of coal in the conversion processes, on the other hand, is not expected before 1985-90 because of remaining technical problems and relatively high cost. According to the International Energy Agency, at that time, substitute natural gas (high-BTU gas) derived from coal and low caloric gas for burning at the site of conversion are expected to be competitive with oil, while liquid fuels production from coal may still remain 10-20 percent more expensive than the currently projected oil price.

C. Building Local Capabilities

The absorptive capacity of developing countries—in terms of managerial skills and technical know-how—to implement coal mining or integrated coal/transport/power projects is limited in the medium term. Inadequate supplies of skilled and experienced manpower and staff are pervasive constraints in all sectors of developing economies. In addition, as the lead time for coal projects in developing countries may be ten years or more at present, scarce technical and managerial skill may be tied up on projects from which benefits will flow only in the longer term.

A number of developing countries have made or are now initiating a major effort to increase coal-related skills by emphasizing training, technical assistance, and technology transfer in the coal mining sector. India has made use of Russian, Polish, U.K., and French expertise and technical assistance, building up impressive local coal mining capabilities over the years. Developing countries with more recent coal development policies, such as Colombia and Indonesia, are still evaluating and experimenting with available bilateral coal assistance, training, and project execution schemes most appropriate for specific country situations.

Coal projects in developing countries generally use foreign technical assistance in exploration, for feasibility studies and mine layout, equipment selection, etc. It is common for consultants to work closely with national institutions or firms or both. For example, a coal exploration and feasibility study would often be done in cooperation with a geological service of a country and its coal or energy authority (usually
a state-owned company or section within the Ministry of Mines). The Bank encourages the use of local engineering and management firms or institutions in the projects it supports in order to increase local skills and capabilities.

The use of foreign (usually resident) consultants or foreign sponsors is very important for transfer of operating technology to management and higher level professionals. The amount and length of consultant involvement are tailored to the situation. Most local people involved in projects have engineering degrees or experience as technicians—surveyors, sample men—or skills as electricians, mechanics, etc., but need to develop skills in practical applications. To develop these skills the Bank usually encourages an approach tailored to the project requirements, including on-the-job training and sending workers for overseas training. Mining operations, therefore, usually institute training programs, employing their own instructors and making use of equipment suppliers or local institutions.

Wherever it is possible, the Bank encourages the use and development of local contractors and supports the participation of local equipment manufacturers generally through a preference of 15 percent or the applicable tariff, whichever is less, in international competitive bidding. Generally at least half of project costs are for equipment, which is usually imported. Roads and civil works, however, can usually be built by local contractors.

D. The Coal Outlook

Coal production is not expanding in the developing countries as quickly as one might wish. The reasons are primarily supply oriented, so that even the recent major increase in oil prices will have no or only limited impact on developing country coal production in the short-term. Many coal bodies need additional drilling and proving before an investment decision can be made. Also, developing countries often lack the infrastructure to develop coal bodies that would be exploitable in industrial nations and, in other instances, risks and uncertainties regarding overall development costs and marketing opportunities have resulted in some prospects being only marginally attractive in economic terms. In some countries, the possibility of coal-fired thermal power plants is limited by the lack of an interconnecting electricity grid and in other cases, large-scale development may be delayed by insufficient financing or inadequate engineering skills and resources. Nevertheless, these constraints have primarily short- to medium-term importance; they are not insurmountable but call for a longer term outlook for coal and energy planning in developing countries.

IV. Renewable Energy Sources

A. Bank Approach to the Sector

The growing concern with the role of renewable energy in the developing world has arisen in response to three interrelated stimuli:
The international oil crisis and the impetus it has given to the search for alternative, indigenous energy resources everywhere. The impact of the oil crisis on the balance of payments and economic growth of many developing countries has been severe, and their relative economic and financial weakness makes them particularly vulnerable to further financial shocks and supply constraints. In addition, the oil situation has stimulated interest in the development of indigenous energy resources by underscoring the vulnerability of the developing economies to external forces beyond their control and, thus, heightening general concerns about "dependency."

Increasing recognition of the critical situation that has developed with respect to the supply of fuelwood, the renewable resource on which the developing countries presently depend so heavily for energy, particularly in rural areas. In contrast to the oil crisis, a highly visible modern sector phenomenon, this "second crisis" is a quiet one affecting the traditional sectors of the developing countries. Deforestation, particularly on steep hillsides, has contributed to soil erosion that has reduced upland water storage capacity and increased the siltation of reservoirs (shortening their lives), irrigation canals (raising maintenance costs), and river beds (increasing the danger of flooding). The search for fuelwood has also been an important factor in the destruction of covering vegetation in arid and semi-arid areas, thus contributing to desertification. As fuelwood supplies have become exhausted, people have been forced to turn increasingly to the burning of dung and agricultural residues, a practice which deprives the soil of valuable nutrients and organic conditioning materials.

Growing appreciation of the need to increase the access of the poor to energy as part of programs to alleviate poverty and meet basic needs. The human cost of the renewable energy crisis has been high, both in terms of its immediate impact on the lives of the poor, and on the long-term prospects for alleviating poverty. The severe fuelwood shortages that have emerged in many parts of the developing world have put a heavy burden on the labor and cash resources of low income groups.

The Bank's principal response to these problems insofar as "commercial" renewable energy sources are concerned has been to continue to lend for hydro-electric, fossil-fueled thermal, and geothermal projects. Insofar as non-commercial renewable energy is concerned, the Bank has so far concentrated its lending in the forestry sector, where the technological, institutional, and natural resource base has allowed a substantial flow of lending for projects meeting the Bank's economic and technical feasibility requirements.
Nonetheless, the Bank has financed a few projects involving other renewable energy technologies and is investigating possibilities for expanding this work. Projects financed to date include components covering resource surveys and feasibility studies for small-hydro and wind-electric schemes, pyrolytic conversion to gas of rice hulls in one case and sawmill wastes in another for use in electricity generation, feasibility studies for the use of ground nut shells and surplus bagasse in power generation, installation of solar water heaters, research on solar ponds, and the adaptation and development of a range of solar devices in a rural development area.

B. Renewable Energy Technologies

Most of the research and development being done on renewable energy is directed toward the major energy problem of developed countries: finding alternatives for limited oil and gas resources. Developing countries with growing urban-modern-industrial sectors stand to benefit from this research as new technologies are improved and commercialized in response to this problem. However, the ecological differences between the tropical and temperate zones give many developing countries significantly different possibilities than those being studied for developed country use. For example, the tropical latitudes have generally much lower windspeeds and much higher biomass productivity rates than are found in most developed countries. Also, much of the research and development on small-scale technologies for developing country environments is focussed on providing inanimate mechanical power and/or electricity for stationary applications. Much more emphasis should be placed on the problem of cooking, including fuels, stoves, utensils, and perhaps solar cookers. Improved use of draft animals is also a relatively neglected field.

This discussion deals primarily with technologies that are or appear to have the potential to become economic in more than a few isolated cases in the 1980s. There are many more renewable energy technologies that should be considered longer-term possibilities.

"Energy" is far from being a homogeneous commodity; in discussing renewable energy technologies it is necessary to distinguish among forms or kinds of energy because energy demands/resources differ in the kinds of energy they require/produce, energy forms differ markedly in the ease with which they are stored and transported, and some energy conversions are relatively inexpensive and efficient while others are generally expensive and inefficient. A classification which seems useful at this stage includes four groups: heat at temperatures above 100°C and fuels suitable for producing this heat in stationary applications, though not on vehicles; heat at lower temperatures; mechanical energy and electricity; and vehicle fuels.

The principal technologies in each of these groups are the following:
(1) Sources of high temperature heat not suitable for vehicle or tractor use. Technologies in this group are useful for applications ranging from cooking to industrial steam raising and metallurgy. The most suitable renewable sources of this kind of energy are biomass fuels and concentrating solar collectors. Some biomass fuels technologies in this group with at least potentially important applications are those involved in improving the yield of wooded areas, increasing the efficiency with which wood is burned in cooking stoves and converted to charcoal, production of biogas (methane produced by anaerobic digestion of dung and some other organic materials), generation of steam and electricity from wood, bagasse, rice hulls, and other processing plant wastes, and "densification." Densification includes physical processes such as chipping, briquetting, and pelletizing that improve the handling properties of solid fuels. Concentrating solar collectors have not yet been shown to be a viable alternative for meeting cooking needs, but have demonstrated potential in industrial applications.

(2) Low-temperature heat. Simple solar devices requiring neither focussing collectors nor photovoltaic materials can be used for a variety of low-temperature processes: water heating, heating and cooling of buildings, driers for crops and fish, and distillation of water are the principal applications.

(3) Mechanical and electrical energy. High temperature heat produced by concentrating solar energy, by burning fuels, or from some other source, can be converted to mechanical or electrical energy through the use of heat engines. Biogas can work in internal combustion engines and producer gas has been used in some situations. Wood and other solid fuels can be used by external combustion engines such as the steam engine. Well-developed technologies with substantial potentials limited more by the availability of the necessary natural resource and markets for power are micro-hydro turbines and waterwheels, and windmills. Photovoltaic cells are useful in some situations where small amounts of electricity are needed. (See also the discussion of alternative technologies under the part of this chapter that deals with power.)

(4) Vehicle and tractor fuels. Fuels other than petroleum are difficult to supply cheaply from other sources. The principal renewable-based candidate technologies are biogas, producer gas (generated on board the vehicle), and alcohol. Biogas is useable, but cannot be produced at adequate rates in any generator that can be carried about. Compression of the gas would be expensive and the containers bulky and heavy. Producer gas has been used but the difficulty of filtering
the gas sufficiently well to protect the engine, as well as its low overall efficiency, has limited the use of this alternative. Alcohol (from wood and plants) is a promising candidate in a number of countries and now appears a feasible alternative in Brazil.

C. Bank Support for Fuelwood Development 4/

As already noted, the bulk of the developing world's poor depend for energy on wood, a "renewable" resource that is, in fact, being critically depleted. In view of the magnitude of the need and the gravity of the situation, first priority clearly must be given to increasing the supply of fuelwood. Recognizing this, the Bank two years ago launched an expanded social forestry program under which eight forestry loans and credits and fourteen forestry components in rural development projects have already been made to finance about 400,000 hectares of fuelwood. Lending under this program now stands at about US$125 million.

Fuelwood production is being financed under forestry and rural development projects which included a wide variety of components. In some cases, they include establishment of plantations to be managed by a national forest service. In others, they aim to improve the government's ability to convince and assist villages or individual farmers to establish woodlots. Nurseries to provide seedlings and extension agents to provide technical assistance are typical of these projects.

Fuelwood projects are innovations for many of the borrowers involved, as well as for the Bank. Most of the projects financed thus far can be characterized as pilot projects in the sense that they are not scaled to meet total estimated fuelwood requirements but, rather, to build the institutions, train the manpower, and test the technical packages and extension techniques that can form the basis for larger subsequent projects. In parallel, many projects include research, survey, and study components aimed at resolving the questions that need to be answered before larger-scale projects are designed: quantifications and geographic distribution of future fuelwood shortages, land availability, local trials of alternative tree species, the consequence and costs of failure to get more trees grown, and potential for conserving wood through more efficient use.

The major obstacles to fuelwood projects appear to be: competition for land, development of adequate technical packages, and the need for strong local support and participation. Fuelwood shortages are most often found in areas where the pressure of population density on land resources is high and land that can be used for raising food cannot be spared for wood production. Fuelwood species do not require land as high in quality as that required for crop production, so most projects utilize marginal lands. While a tree species appropriate for a given area can often be identified without extensive trials, the best species and sub-species and the best combination of planting,

4/ See also the section on forestry in chapter 1.
fertilizing, and disease prevention techniques—the "technical package"—generally cannot be determined without local trials. Strong local support for fuelwood production is generally needed to obtain the land and labor required to establish a woodlot and to assure maintenance and protection of the woodlot while it is growing to maturity.

D. Development of National Renewable Energy Programs

There are serious financial, institutional, and social constraints, as well as technological problems, that need to be overcome if new energy alternatives are to play a role in the developing world. The Bank is encouraging countries to focus on these problems and attempts through its energy sector work program to assist member developing countries to draw up national energy plans and policies.

No one program for renewable energy resources can be recommended that will be uniformly appropriate for all development countries. A number of measures that could usefully be taken in a number of countries without a long R & D/survey/study process are: increasing forest cover and fuelwood production, exploiting small-scale hydro and wind resources, fuller use of currently unused or under-utilized milling waste, and improving the economics of alcohol production technology on both the agricultural and industrial sides.

A basic group of indicators that may prove useful to consider in attempting to realistically orient a traditional/non-conventional energy program towards the most important problems include: types of fuel commonly used by households and general pattern of variation geographically and by income level; cost of household fuels in money and/or time; ability to pay for electrification; apparent pace of deforestation, relative roles of fuelwood gathering, land-clearing and animal browsing in causing deforestation, and seriousness in terms of erosion; and types, scale, and location of processing plants for handling large quantities of wood and plant materials, including sugar, lumber, and pulp mills.

With even a general knowledge of these subjects, it should then be possible to judge the relative importance of potentially conflicting goals that might be set for a renewable energy program: preventing erosion, reducing the time spent gathering fuelwood, developing an inexpensive source of fuel for low-income urban households, bringing the amenities and development-boosting benefits of electrification to villages at an affordable cost, reducing the potential competitiveness for land use between food and biomass energy crops, and substituting domestic energy resources (e.g., alcohol production) for imported petroleum.
10. TECHNOLOGY IN INDUSTRIAL LENDING BY THE WORLD BANK GROUP
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TECHNOLOGY IN INDUSTRIAL LENDING BY THE WORLD BANK GROUP

Introduction

A. Nature of Industrial Development

The industrial sector is defined by the Bank to include manufacturing, mining, and production of intermediates such as steel, fertilizers, paper, and textiles. In most countries with which the Bank is concerned, manufacturing is by far the principal industrial activity. There are, however, a few resource-rich countries in which mining is of great importance.

The manufacturing component of the sector is extremely complex; there are large differences in the scale and structure of enterprises, extensive variations in technology and large opportunities for technical change, complicated relationships between private and public decision-making, foreign participation in varying degree in ownership and management, and numerous institutions concerned with financial intermediation.

Above a certain relatively low level of per capita income, the industrial sector is normally the fastest growing sector of the economy.

On the demand side, the income elasticity of the domestic demand for foodstuffs and most raw materials tends to diminish and that for manufactured products to increase. The pattern of industrial demand will, of course, be affected by the size of the domestic market and the natural resource endowment of the country. It will also be affected by how seriously industrial policy is oriented toward import replacement as against an outward-looking strategy.

On the supply side, it is change in the structure of manufacturing, in manufacturing technology, in scale of enterprise operation, and in the quality of management that offers the principal explanation of increase in per capita incomes.

Differences in the size of enterprises in the industrial sector are very great. This is as true of mining (and construction) as it is of manufacture. At one end of the scale, there are in many developing countries large-scale organizations, which were often created by government or private interests after World War II. At the opposite end of the scale, there are thousands of small enterprises. Many of these are in service industries, but a host are in the area of manufactures. They exist to serve local communities, or they find a niche for themselves in urban areas and, frequently, they survive by acting as subcontractors to large-scale enterprises. In between the very large and very small are, of course, manufacturing enterprises of moderate size at various stages of growth and decay. These differences in the scale of firms set difficult problems for industrial strategy and policy and make the field of industrial lending a complex one for the Bank Group.
B. Bank Group Support for Industry

The World Bank Group provided in FY79 approximately US$1.96 billion in financing to support industrial activities in developing countries. It provided these funds through three channels:

First, the Bank provides direct loans, usually of US$50 million and up, for major industrial projects, which are often government-owned or sponsored. In FY79 the Bank lent US$843 million for such projects.

Second, the International Finance Corporation (IFC) provides loans and investments without government guarantee for private sector projects smaller than those financed directly by the Bank but relatively large in the country concerned. IFC invested US$425 million in FY79. It will be expanding greatly in the future.

Third, the Bank through lines of credit (and IFC through some equity investments) supports national and regional development finance companies (DFCs), which retail credits to local enterprises in accordance with terms and criteria agreed with the Bank and subject to the Bank's supervision and approval. In FY79 the Bank lent US$659 million for this purpose.

This third channel, which delegates the responsibility for day-to-day loan appraisal and subsequent administration to DFCs in the respective developing countries, enables the Bank to address the needs of a much greater number of smaller and more dispersed enterprises than it could possibly deal with directly. Nevertheless, even through these locally-based institutions, Bank financing has generally been accessible only to the larger, relatively capital-intensive segment of industry, perhaps the top 20 percent in number—firms that may be small by the standards of industrial countries but loom large in the local economy.

In 1975 the Bank began to look seriously at the case, and the potential, for assisting in the development of small enterprise. In FY79, one-fifth of its lending through DFCs (US$131 million) was for support of small enterprises (see part IV), with an estimated additional US$30 million provided for this purpose through urban project components.

C. Sector and Subsector Studies

The Bank conducts sector studies to acquire basic intelligence on which a developmental sector lending program can be based, including its technological components. Industrial sector studies have three principal aspects: (1) the provision of a basic data framework on the structure of the industry, its relevant factors of production, its growth, and, to the extent possible, its relationship to the rest of the economy; (2) an analysis of policies and problems relevant to the functioning and growth of industry; and (3) the identification and selection of projects for Bank lending.
Subsector studies are often used in identifying and preparing small enterprise projects. For example, a sector survey in Portugal examined both the present situations and growth prospects of six branches of industry, and of small and medium enterprises, in particular the relationship of the sector to problems of employment, regional dispersion, and exports. Other studies of small enterprise (including artisan) potential have been carried out in countries in every region.

These studies have also increasingly been used by governments in policy formulation. A detailed Bank review of the engineering industry in Korea, for example, formed the basis for an industrial strategy and program formulation for specific subsectors.

Bank initiatives have led as well to the carrying out of sub-sectoral work by local agencies. For example, two studies were completed by the Industrial Credit and Investment Corporation of India (on engineering industries and manufacturing exports), a major study of the textile industry in Pakistan has been recently completed by consultants working for the Government, and studies of six branches of industry in Egypt, initiated under an earlier Bank loan, were completed in FY78.

The Bank maintains a strong link between industrial sector and country economic studies. Economic reports give close attention to general industrial sector issues. Moreover, industrial sector work focuses on an export orientation of industrial development, export incentives, and exchange rate policies (recent sector work in Argentina, Bangladesh, India, the Philippines, Portugal, and Mexico exemplifies this orientation), but also deals with employment, more general incentive policies, appropriate sector pricing, tax structure, and other relevant issues.

D. Bank Research on Industrial Technology

The Bank conducts research on various aspects of industrial development, concentrating mainly on industrial strategy and policy (including research on incentive policies and domestic resource costs, export promotion, and employment and labor markets) and on comparative advantage, patterns of industrialization and trade, and economic growth. Among other topics studied, the following are most closely concerned with industrial technology.

1. Subsector investment analysis, with particular reference to the process industries. Much of this work has focussed on the fertilizer subsector, where a number of country- and region-specific programming exercises have been carried out. There has also been work on pulp and paper, steel, and mechanical engineering. Initial work in this area was the basic research needed to adapt specific tools of operations analysis to investment programming. Subsequent work, which still continues, seeks to apply the methods developed to operational investment decision-making.
(2) Industrial organization, with emphasis on the role of small and medium enterprises. While sector studies have addressed this question, research is being done to review the existing information and literature on small enterprises in developing countries; carry out case studies of patterns of small enterprises development in the Republic of China (Taiwan), Colombia, India, Japan, the Republic of Korea, Nigeria and the Philippines; and survey enterprises in urban areas of India and Colombia to investigate entrepreneurial history, markets, capital structure, and other aspects and problems of small enterprises.

(3) Industrial capacity utilization. Since rates of industrial capacity utilization appear typically to be lower in developing countries than in the industrially advanced countries, Bank research has explored whether it might be possible to secure increased output and employment in many developing countries without additional investment, simply by increasing capacity utilization. Some policy measures which can be taken to increase capacity utilization but typically are not related directly to this end deal with the terms of licensing and labor legislation. It should not be expected that increases are easily effected, however, due to such factors as shortage of skilled labor, inadequate provision of transportation, and individual preferences regarding work scheduling.

(4) Capital/labor substitution, with greatest attention to the non-process industries, specifically mechanical engineering. Increasing concern in the Bank with the prospects for employment generation through industrial development and the scope for capital/labor substitution in industry led to research to permit careful forecasting of the response of employment to possible changes in the economic environment—e.g., changes in relative factor prices. Exhaustive in-house research has been focused on mechanical engineering and has concluded that the scope for capital/labor substitution is quite wide at low levels of output, but that it narrows markedly at higher volumes of production owing to economics of specialization that strongly favor capital intensive techniques. Research has also been carried out on producers' choices of technology, focussing on understanding why textile manufacturers in Korea frequently have chosen more expensive imported looms rather than cheaper locally-produced weaving equipment. The research found that the labor intensive technology embodied in locally-produced looms was more appropriate on economic grounds than the capital intensive technologies embodied in the more highly automated, imported looms. The explanation for the choice of imported looms was typically found in government incentives that favored their selection.
E. Building Local Technological Capacity

Among the Bank's most important objectives in the field of industrial development is to build strong local institutions which can allocate resources efficiently and effectively. In the great majority of developing member countries the Bank has helped to develop the capabilities of at least one such intermediary to appraise, finance, supervise, and promote new industrial activity. The Bank's support of development finance companies generally extends over many years, in a process of gradual upgrading of staff, procedures, and financing capabilities.

In large industrial projects, the Bank helps its borrowers not only to obtain reasonable prices for the technologies procured, but also to ensure that adequate provision is made for efficient operation once the project is implemented. Technical assistance and training are often part of the services provided by the suppliers of the technology, whether it be a complete plant, specific pieces of equipment, or production processes. This assistance can include provision for experts to work for extended periods while training local personnel on the job and for special training programs, both local and overseas.

The Bank has taken a special interest in the needs of small entrepreneurs for technical assistance, which is often supplied by extension services separate from the intermediaries that provide financial support. The great number and diversity of small enterprises in developing countries (some 50,000 small and 500,000 cottage industries, for example, in Bangladesh) mean that careful research, setting of priorities, and new institutional arrangements are usually required.

Industrial projects have an impact on local capabilities in a number of related areas. Often Bank-supported projects serve as models for similar projects within the country and adjacent (or similarly situated) countries. They, therefore, set precedents and contribute to the capacity to design and implement other such projects in the future. Large industrial projects often require major investments in infrastructure—water, power, transportation, telecommunications, and even housing and health facilities for workers. The Bank is prepared to finance local suppliers of equipment and gives them a price preference of 15 percent (or the applicable duty, whichever is less). It also increasingly supports the use of local consultants for engineering and other technical services.

F. Development of Industrial Technology

Industrial innovation is a process by which technical ideas are implemented and new products and processes are successfully introduced into the market. Developing countries, whose industrial development is often based largely on imported technology, are increasingly interested in strategies for enlarging their own technological capabilities. Industrial innovation is both a measure of, and a means for, developing local technological mastery. It seems to require several elements: a potential demand in the form of a
market or social need, a base of scientific and technical knowledge, a source of creative effort, an attractive investment opportunity, the ability to assemble capital and other necessary resources, entrepreneurial and technical skills, and supportive government policies.

The Bank generally supports the use of proven technologies in the industrial projects it finances, since these are likely to meet the economic and financial criteria by which projects are appraised. The Bank has on occasion supported the development and use of innovative technologies through inclusion of research components, pilot projects, and engineering studies within projects and, recently, through funding of projects and project components devoted to the support of industrial innovation.

Bank Group staff are generally experienced in the industrial fields that may be supported. They stay aware of scientific and technological advances in each field through project work, the use of consultants, and special studies. In the case of fertilizers, an area in which the Bank plays a significant funding role for developing countries, a special unit has been established to study the sector on a worldwide as well as national basis.

When the Bank supports large industrial projects, most are sponsored by government. When a borrower wishes to use technologies which are new or have not been used before under conditions similar to those in that country, the Bank may support testing on a limited basis before financing their use in a project. It has done this, for example, in mineral projects in Egypt and Jordan. The Bank has also made loans for feasibility studies to India, Tanzania, Paraguay, Indonesia, and other countries.

IFC on occasion supports the development of new technologies. It did so in the case of a Mexican pilot company to prove the viability of producing newsprint from bagasse pulp. In addition, IFC has financed a venture capital operation directed toward innovative (mostly small) enterprises in Spain and is considering supporting a corporation which would participate in and assist small and medium enterprises in the Philippines.

The Bank is financing in several countries projects or project components which provide incentives and other supports for the development of indigenous industrial technology.

In Spain, industrial growth was fueled by large importations of foreign capital, technology, and expert assistance. The government recognized, however, that unless domestic capability in industrial innovation were substantially improved, Spain’s ability to compete in world markets would be seriously impaired. The Bank, as a result, is supporting research, development, and engineering to improve Spanish technology through indigenous efforts in product and process development. An autonomous Center for Development of Industrial Technology (CDTI) was created within the Ministry of Industry and Energy to receive and administer the Bank’s loan and government grants. CDTI’s staff includes about a dozen...
permanent experts in specific areas of technology and ad hoc task forces, which are independent bodies on contract with members drawn from industry, consulting firms, and universities. The task forces maintain close contact with industry and may help in identifying and promoting appropriate projects for CDTI financing or alternatively appraise and assist in formalizing proposals made directly by firms. Response in the first year of operation met expectations, with seven subprojects and several strategic and pre-feasibility studies supported in the electronic, food, and mechanical engineering industrial sectors.

Other such projects which the Bank supports include: (1) in Israel, a loan component administered by the Office of the Chief Scientist in the Ministry of Commerce and Industry to support a strategy for developing R & D-based industry and the promotion of such indigenously-developed, technology-intensive export products as a transverse section tomographic scanner, engines for on-site power generation in remote areas, a rural telephone system for communities of 100-400 subscribers, a non-convecting solar pond collector, and derivatives of jojoba bean oil; (2) funding for the Korea Institute of Electronics Technology, which through a research, development, and engineering program—including an innovation fund—is intended to advance the Korean electronics industry (semi-conductors and digital systems technologies) to state-of-the-art levels by the mid-1980s; (3) support for the Banco de la Republica and participating financieras to assist Colombian enterprises to upgrade their technology and improve product quality to make them internationally competitive through R & D, training, acquisition of equipment, etc.; (4) support of a Technology Improvement Fund in Turkey largely intended for technology adjustment and upgrading of R & D-oriented activities of textile firms; (5) financing through the National Laboratory of Engineering and Industrial Technology technological support and assistance activities to help small and medium Portuguese firms develop new products and improve the quality of export products; and (6) funding the development in Uruguay of the national Technological Laboratory from a testing and standards center to a multi-disciplinary R & D laboratory serving local industry.

I. Technology in Large Industrial Projects Financed by the World Bank

A. Bank Approach in Financing Large Industry

The World Bank lent during the period FY70 through FY79 a total of US$4.1 billion to finance 86 large industrial projects in some 27 developing member countries. Though the Bank staff make every effort to be realistic in their assessment of the technical, financial, and other aspects of a project, there are big risks associated with industrial plants, including managerial and other constraints affecting production, market assumptions, and even overall safety. In its lending the Bank closely follows worldwide technical and economic trends in major industries. Bank appraisals help borrowers focus on weaknesses in their market appraisals or in the technical, economic, managerial, and financial aspects of a project. Bank reports—in particular the care with which every element in the project is considered—have had a major educational impact on development agencies and financial
institutions in developing countries. Sometimes, the Bank's analyses serve as a catalyst to identify and modify government policies inimical to development. Routinely, they provide a basis for attracting co-lenders for a given project.

Large industrial projects typically require substantial investment in infrastructure such as ports, townships, rail and road connections, and power and water supply. The infrastructure total can approach or surpass the cost of the industrial installations proper. This is particularly the case of mining, but also in pulp and paper projects. Depreciation and interest on these investments will have to be covered through utility rates and local taxes paid by project and other users, or subsidized by governments; this may present a major obstacle to economic viability.

The scope for successful technology transfer in the various industries is affected by the level of industrial development in a given developing country, the project sponsor's capabilities to manage the adoption of new technology, and the government's policies toward technology transfer. The Bank only supports projects expected to provide sound economic and financial returns. As far as technologies are concerned, they must be both proven and "appropriate," meaning essentially that they should be properly adjusted to the relative scarcities of capital and labor in the country. In most of the industries considered here (with the partial exception of textiles), economies of scale are very important, dictating the use of massive equipment and militating against labor-intensive technology. Particularly as industrialization has proceeded to countries with little previous industrial experience, the Bank has become keenly interested in possibilities of using more labor-intensive or otherwise more appropriate yet economical technology in such countries.

As with the world in general, the Bank has become more aware of environmental considerations. No industrial project is approved without a careful study of its environmental impact, and appropriate and reasonable safeguards against possible environmental damage are negotiated with the government and the borrower.

B. Technology Transfer in Individual Industries

Some examples of specific Bank involvement in industrial technology transfer will be given in the accounts of individual industries which follow.

1. Minerals Industries

The Bank made its first loan for a mining venture in 1957. During FY70-79, it financed 10 mining projects (excluding coal, which is treated in chapter 9) for a total of US$342 million. While the Bank's own contribution has provided only about 1-1.5 percent of the total funds invested in mineral exploitation in developing countries, the additional funds mobilized bring total investment in which the Bank has participated to 6-8 percent of mineral sector expenditures in developing countries. Although this is not an overwhelming involvement, it is clearly significant and, in many cases, has been crucial to development of individual projects.
The location and the type of projects financed have varied widely. Four of the mining sector commitments were to African countries, 3 to Latin America, and 1 to Asia. Of the eight projects, four were for copper (of which one was combined with nickel), while the remainder were for iron ore, phosphate, and tin. Projects financed in earlier years included potash, manganese, and zinc/lead. In the future, there will be considerable growth in mineral lending.

Certain aspects of the mining industry distinguish it from other industrial activities. For example,

(a) **It involves a number of discrete stages, each requiring technical skills and specific technology.** Exploration is carried out by geologists. Planning open cast or underground mining facilities involves both geologists and mining engineers. Exploitation of deposits requires familiarity with mining techniques and of increasingly sophisticated large-scale equipment. In beneficiation of run-of-mine ores, advanced techniques have been introduced, particularly in flotation. Finally, the metallurgical processing stage calls for engineers skilled in pyro- and hydro-metallurgy.

(b) **Capital requirements of individual projects are high.** Total project costs may range from about US$200 million up to US$2-3 billion for a large-scale iron ore beneficiation project with associated infrastructure.

(c) **The mining industry is exceptionally risky due to implementation of complex engineering systems which must be adapted to differing ore bodies; unusually sharp fluctuations in prices for many minerals and metals; the political risk which foreign sponsors run of nationalization or punitive taxation; and the lengthy process of identifying and proving reserves and the need usually for extensive pilot plant testwork (it may often take up to 5 or 6 years between the time a mining project is first presented to the Bank and the start of the project implementation).** Because of the need for major rail links or other major infrastructure, the project construction period is also likely to be longer than for the normal industrial project.

Whereas most early Bank-financed mining projects were sponsored by major private mining companies, an increasing proportion will now be owned and operated by state corporations. At the same time there is a trend towards export of semi-finished products with a higher domestic added value. 1/ Thus,

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1/ In 1976, the value added in minerals processing in Western Europe was nearly three times the value of minerals mined; in developed market economies the corresponding ratio was roughly 0.3.
for example, iron ore which was formerly primarily exported as lump, is increasingly processed locally and exported as pellets, pellet feed, or sinter feed. Similarly, alumina and aluminum are exported rather than bauxite, phosphoric acid or superphosphate rather than phosphate rock. Though many projects will start by the export of unprocessed, or only marginally beneficiated product, the trend is likely to continue in the direction of more local processing. To the extent that this is in the interests of the host countries, the Bank will continue to support this development.

These changes have placed new demands on the Bank. Traditionally, the Bank's role was essentially catalytic. The Bank's presence was seen as providing a measure of political security enabling the borrower to mobilize additional funds from commercial, bilateral, and multilateral agencies that might not have participated in the absence of the Bank. This function, today, is more important than ever. But, in addition, the Bank's intervention now often occurs at an earlier stage of the project cycle and typically goes more deeply into the following activities:

(a) increased Bank assistance in the planning and administration of minerals sector development programs in developing countries;

(b) upgrading of the Bank's technical and economic intelligence on the minerals sector;

(c) increased emphasis on earlier stages of project preparation viewed as a critical area of technology transfer (i.e., financing of exploration, feasibility studies, and preliminary engineering);

(d) new methods of financing, particularly for exploration and development to counter the reduced flow of private venture capital into this area, including the mineral revolving fund, where exploration expenditures are financed from the revenues of projects reaching commercial exploitation, and the engineering credit which may be used to prove up preliminary reserves, to complete feasibility studies or to construct a pilot plant for metallurgical processing. A recent example of this approach is an engineering credit to perfect a scheme for iron ore beneficiation in Egypt. Engineering credits provide a vehicle for optimum adaptation of existing technology to the special characteristics of the mineral and the host country. More rarely, they may lead to a new technological departure, as in the Jordan phosphate project.

The Bank is greatly concerned with increasing employment opportunities in developing countries. Unfortunately, mining is typically a capital-intensive industry and the opportunities for labor-intensive technologies are limited. Even in countries where labor is cheap, their low labor productivity and the economic imperative, in most cases, of large-scale operations make
relatively capital-intensive mining inevitable. It is equally difficult to substitute labor for capital in downstream metallurgical processing. In fact, the problem is often the reverse: how to introduce modern mining and processing technology in replacement of traditional processes becoming increasingly obsolescent and sometimes causing huge financial losses and grave damage to the country's mineral wealth, i.e., where the best parts of the deposits have been extracted by wasteful methods and the bulk of the deposit can no longer be mined economically. In the exceptional case, however (say small and scattered deposits in difficult terrain), the small, labor-intensive operation will still be viable. Thus, in Bolivia, the Bank is currently financing a small-mines project through the intermediary of a development finance corporation.

2. Steel

In spite of the constraints imposed by market size, raw materials, ports and technology, quite a few developing countries have found steel production attractive. Since FY70, the Bank has lent US$753 million for 10 steel projects with an estimated total cost at the time of appraisal of US$8.6 billion. (IFC also invests in steel projects.) Apart from its lending activity, the Bank has advised on major steel projects in several developing countries.

Initial entry into the steel industry can be made with the rolling of bars and rods, particularly concrete reinforcing bars, a major construction material. This could be based on imported billets. Preferably, electric furnaces could be used to smelt local scrap to be transformed into steel billets by means of continuous casting. This is a relatively new technology—an alternative to the ingot casting/blooming and (or) billet mill route. Unlike the latter, which would generally call for a minimum capacity on the order of one million tons or 1-1/2 to two million tons if a blooming (or slabbing) mill is involved, continuous casting is well adapted to smaller volumes of output. A suitable size for a mill thus conceived might be 250,000 - 300,000 tons of finished product. The investments would be of the order of US$300 million and up.

In fully integrated steel production, where iron ore is used as the main raw material rather than scrap, two distinct steps are involved. First, iron ore is reduced to iron and, second, the iron is "converted" and refined into steel. Today's conventional process is the blast furnace and basic oxygen furnace (BF/BOF route). Because of economies of scale, integrated steel production based on the BF/BOF route is not feasible until a sizeable local market has developed, which some experts have suggested is at least one million metric tons of crude steel equivalent. Moreover, such a plant would be suited only to the production of non-flat products (including narrow strip for tube production). The minimum economic plant size for flat products is closer to three million tons.
Integrated steel mills are extremely expensive. A mill producing one million tons of crude steel equivalent per year, including finishing and supporting facilities, would cost over one billion dollars. Production is also highly capital-intensive, with a cost per job of about US$200,000. For these reasons, it is not advisable for a developing country to enter the steel industry on an important scale unless it has an adequate market or some special natural advantage, typically in transportation economics, low-cost iron ore, or low-cost energy resources (coal, natural gas, or hydro-electric power).

These parameters have been modified by a more recent route to steelmaking, namely, "direct reduction" of iron ore followed by electrical furnace steelmaking (DR/EF method). In this process combination, a gas potentially rich in hydrogen typically replaces coke as the reduction fuel. This is one of its major attractions, since metallurgical coking coals are becoming increasingly scarce. For capacities of up to two million tons of crude steel equivalent, capital costs per ton are somewhat lower than for the BF/BOF route. The DR/EF route, however, calls for a very high grade of ore or pellets and a high-grade fuel, namely, natural gas, both of which are also scarce.

A project recently appraised by the Bank for the Venezuelan Government, involving expansion by 3.6 million tons of crude steel equivalent, is based on natural gas. However, although Venezuela is one of the countries with the largest natural gas resources in the world, it is considered unlikely that natural gas would be available for future steel expansion. Only in the Middle East (where, again, the Bank has been involved in an advisory role) and a few other countries with a long-run surplus of cheap gas, can there be substantial expansion of direct reduction based on natural gas, but hardly on a scale having a major impact on world supply.

In steel, the transfer of industrial skills has proved more difficult than anticipated, but performance achieved in on-going expansion projects is improving and closer to forecasts. The efficiency of the transfer may be measured by the speed with which plants have been constructed and the time elapsed between start-up and attainment of a normal operating rate. The most efficient transfer seems to occur where the project sponsor is an experienced local private steel producer. This type of company tends to work relatively smoothly with foreign engineering consultants. In projects financed by the Bank Group this is illustrated by the Tata (India) two-million ton expansion project (1956) and the Dalmine-Siderca (Argentina) DR/EF plant (1977).

The economic viability of a greenfield steel project will depend on a combination of two or more of the following important factors: (a) the size of the natural (as defined by transportation advantage) or domestic market required for reasonable economies of scale; (b) the availability and cost of suitable iron ore; (c) the availability and cost of various forms of energy such as coking coal, natural gas, and electricity; (d) the availability of labor and technical expertise to implement and operate the project; and
(e) the availability of infrastructure facilities such as ports, railways, and water supply. Only a few developing countries have a mix of these factors that would justify a greenfield steel project. Even in these few cases, the sheer size of the investment, which would be about US$400 million for the smallest economic size integrated DR/EF plant, can pose a financing problem. One of the important roles of the Bank, therefore, has been to mobilize and put together international financing packages. In addition, a careful choice of technology and project scope (capacity and product mix) is crucial to the economic viability of a steel project. The timing of a project in relation to the overall trend of the world supply/demand balance is a further consideration.

Another important Bank activity, and one which appears to be increasing, is the modernization/rehabilitation/expansion/round-out of existing steel plants. The objective of this type of project is to improve the economic performance through elimination of bottlenecks or creation of a balanced plant; a product mix more closely related to market requirements; adoption of energy saving and/or more productive technologies; backward or forward integration; or improvement in process control, product quality, and management and operating systems. Thus, in countries with rolling mill facilities for bars and rods, for example, a backward integration into steel-making would be one option that may be explored. Some examples of the introduction of technological improvements are the use of continuous casting instead of ingot casting; the replacement of open-hearth steel-making by the BOP process; and computerized process, quality, and production control systems.

3. Fertilizers

The World Bank has been the largest funder of new fertilizer capacity in developing countries. Since FY70, it has lent US$1.7 billion for 29 projects costing about US$4.85 billion in 11 countries. In addition the Bank has been providing technical assistance to oil-rich Middle Eastern countries to develop fertilizer production capacity. It is estimated that more than 30 percent of all new nitrogen projects and about 20 percent of all new phosphate projects that come on stream between 1976 and 1982 in developing countries will have been financed in part by the Bank.

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Fertilizer has been an increasingly important factor in world food production, and is likely to be even more important in the future, especially in developing countries. As much as 40 percent of all new food crop production may be due to chemical fertilizers—nitrogen, phosphate, and potash. Fertilizer is used both to replenish nutrients to soil which has been depleted due to recurrent cropping, leaching, or other physical or chemical effects and to add nutrients required for specific crops—e.g., the new high yield varieties of grains.

In developing countries fertilizer requirements can be met in different ways as demand grows. The simplest needs can be met by fertilizer which is imported in bags and applied by hand. When several thousand tons annually are required, importation of semi-finished goods in bulk followed by mixing
and bagging near the port often becomes worthwhile. With only a few materials, such as DAP, urea, and potash, an appreciable range of mixed goods becomes possible. In the same process certain basics of fertilizer manufacture are introduced, such as storage of raw materials and finished goods, conveying, mixing, screening, bagging, and transportation. Sometimes granulation of fertilizers is undertaken in conjunction with mixing. Larger fertilizer users will eventually begin using tractors and spreaders. Similarly, the need for experienced soil testers and agronomists will expand, as well as requirements for seasonal financing, storage, and sales. Research on fertilizer application in relation to soils and cropping patterns is stimulated. The opportunities for economic investments in irrigation are greatly enhanced. Eventually domestic production instead of importation may become desirable, particularly for ammonia and its derivatives.

The general trend in the technology of fertilizer production has been toward large, capital intensive plants which afford economies of scale and low-cost products. The major advance in this direction for ammonia production came in the 1960s with the development of the centrifugal compressor, which permitted plant capacities to rise from about 300 mtpd to 900 mtpd per single stream. Recent proposals are for ammonia plants of 1300 to 1500 mtpd capacity, with further savings in production costs.

Production of phosphate and potash fertilizers is increasingly located near the site of the raw material. In phosphates, this is a break with the traditional pattern of transporting phosphate rock to plants in the consuming country where it was "digested" with sulfuric acid made alongside the phosphoric acid plant. This change, in large part, is attributable to the introduction of new technology for the bulk transport of phosphoric acid in specially built ships. Another important factor is the difficulty of mastering pollution problems in industrially congested areas of Western Europe and Japan. In both phosphate and potash production, the Bank has helped finance the partial migration of the industry from traditional production centers to developing countries which had become major exporters, and for which these industries are now principal foreign exchange earners.

In the production of phosphate fertilizers, the Bank's major assistance has been to Morocco and, more recently, to Brazil. Although phosphoric acid production was not new to Morocco, extensive technology transfer to local operators took place before and during the commissioning of the Bank-financed plant. The ordering of a second large plant shows that this training and transfer were successful. The Bank is also involved in planning for similar ventures in Togo and Senegal. In the latter country, it is hoped to develop procedures for the more complete recovery of phosphate from the raw materials, since today a very high proportion of the fertilizer component in the ore is wasted.

In addition to previously financing the expansion of Israel's Dead Sea potash plant, the Bank recently took part in a pilot project sponsored by the Jordanian Arab Potash Co. Results were successful and a large plant to produce over one million tons of high-grade potash annually from carnallite
reclaimed from Dead Sea brines through solar evaporation is now under construction, with the assistance of a US$35 million Bank loan. Although largely based on proven technology, new and modified methods had to be developed before a full-scale project could be considered. These included building permanent dikes on quakans and the provision of reliable carnallite harvesting methods, economic bulk road transportation, and adequate effluent disposal.

4. **Pulp and Paper**

More than 90 percent of the world's pulp and paper is produced and consumed in the industrialized world. Nevertheless, a number of developing countries with suitable fibrous resources have developed pulp and paper industries both to supply their own domestic needs and for export. Since its first loan in 1973, the Bank has loaned US$170 million for three pulp and paper projects (two in Turkey and one in Tanzania) with an estimated total cost of US$536 million. In addition, the IFC has invested about US$48 million in 5 such projects. The Bank also supports plantation forestry projects in a number of countries which are destined, wholly or in part, to provide the raw materials for pulp and paper plants. Other Bank activity includes advising on a major pulp project in Venezuela.

Paper can be produced from many different kinds of fiber and the type of fiber is a major determinant of the technology employed. At the simplest end of the scale is waste paper which can be slushed and re-formed into paper of various types. In the simplest mills, hand sheet-forming methods can be used and the sheets dried in the sun. Total investment in these cases may be only a few thousand dollars and production would only be of the order of a few tons a month. With high quality waste paper some specialty papers of high value can be produced in this way but, under normal circumstances, the product from such mills is of low quality and generally of higher cost than alternative supplies. Waste paper can also be processed in more sophisticated plants and this is very often the first step in introducing the paper industry to a developing country.

After waste paper, the next easiest fibers to deal with are agricultural residues such as straw, bagasse, and certain types of reeds and grasses (e.g., esparto). A mill producing printing and writing paper and based on agricultural residues might have a capacity of 70 tons per day, and require a capital investment of US$50 million (say about US$2,200 per tpy). Wide variations in both capacity and cost are possible, depending on the local situation. Because agricultural residues are often readily available in developing countries, and because the scale of production and investments involved are often more attainable, pulp and paper mills based on agricultural residues are most common in developing countries. Thus, while only 6 percent of the world's pulp for papermaking is produced from agricultural (as opposed to wood) fibers, in Asia (excluding Japan) the proportion is 63 percent.

By far the most important fiber resource for paper-making is wood. Traditional technology is based on long-fibered coniferous woods available from natural forests in northern regions. Gradually, this technology was
adapted to short-fibered species available in the same regions (birch, beech) and subsequently to sub-tropical and tropical species (eucalyptus, mixed tropical hardwoods). Used originally mainly for viscose pulp, hardwood pulps have been rapidly introduced into the production of printing and writing papers, to which they often supply elements of superior quality, surface smoothness, and opacity. The use of short-fibered pulp for the major bulk grades (newsprint, kraft paper) faces greater constraints. Although newsprint can be produced from short wood fiber (or from bagasse), these raw materials are not well adapted to mechanical pulping which, because of its cheapness (due to high yields and ease of production), is still the major form of pulping for use in newsprint. Standard quality industrial and packaging papers, where strength requirements are important, cannot be readily produced from short-fibered materials. The most promising entry by developing countries into the production of both newsprint and kraft paper is through plantations of long-fiber wood.

Most technologies for processing wood into pulp and subsequently paper are capital intensive, and technological alternatives are few. Inevitably, therefore, the pulp and paper industry has turned to increasing scale to minimize capital charges and other fixed costs of production, and the average size of new plants has more than doubled in the past 10-15 years.

Once the choice of fiber and process have been made, technological choices affecting the complexity and cost of the plant include:

(a) Substitution of labor for capital in materials handling (both of raw materials and products) and in process control.

(b) Sacrifice of product quality.

(c) Toleration of higher pollution levels.

(d) Integration with other wood processing facilities. Substantial economies in wood growing, harvesting, and utilization may be realized if a pulp and paper mill is integrated with another wood-processing unit such as a sawmill or plywood mill.

Although many developing countries have a pulp and paper industry of some sort, for others the establishment of a pulp and paper mill may represent the introduction of a new technology to the country. In such cases, and when a new project extends technology (for example, when a wood-based pulp and paper mill is installed in a country where the only previously operating mills are based on agricultural residues), there is a need to provide technical assistance to ensure an efficient transfer of operating technology.

5. Textiles

The first Bank loan for a textile project was made in 1974. Since then, the total approved lending for four projects has amounted to US$119 million. The main objective has been rehabilitation and balancing of existing
facilities as well as transfer of technology and skills through training and technical assistance. Thus far, the Bank has financed textile projects in Egypt, Tanzania (2), and the Yemen Arab Republic; 2/ additional projects are under consideration in Egypt, Syria, Portugal, Tunisia, and Turkey—nearly all are in the public sector and are predominantly focussed on the local market. Many more projects have been financed by IFC or indirectly as subprojects under a Bank loan to a development finance company.

Manufacturing of textiles is, as a rule, carried out in integrated plants including spinning, weaving, dyeing, printing and finishing. The raw materials are natural and man-made fibers (mainly cotton and polyester) and output is in the form of gray, bleached, dyed, or printed fabrics. For manufacturing of the unsophisticated fabrics used in developing countries economy of scale is normally achieved in a plant producing about 20 million meters of fabric per year operating on three shifts.

Based on conventional technology, such a plant would comprise 30,000 spindles, 500 looms, and appropriate dyeing, printing, and finishing facilities, and would process about 3500 tons of fiber per year. The total financing required would be about US$100 million. The plant might employ 2500 people at an average investment of US$40,000 per job. For a smaller plant, investment and operating costs would be significantly higher; in a typical case, the total rate of return on the investment might be one-third lower in a 10 million meters per year plant. Since almost all equipment would be imported, the foreign exchange component would be close to 70 percent. The period of implementation is typically about three years, compared with only about one year in industrialized countries. The main reason for this difference is the slower pace of construction in developing countries; delivery and erection of machinery normally imposes no constraint.

Available technologies may be grouped under three main categories:

(a) pre-conventional technology (PCT) based on narrow, semi-automatic looms, direct or mule spinning, and auxiliary equipment operating at low production rates;

(b) conventional technology (CT) based on wide automatic shuttle looms, ring spinning, and auxiliary equipment with high rates of productivity; and

(c) advanced technology (AT) using devices such as automatic openings in blow rooms, chute-fed, high speed carding machines, open-end spinning, "unifils" and electronically operated shuttleless looms.

All textile equipment manufactured in developed countries is currently either CT or AT. Some PCT machinery is still manufactured in Korea, India, Columbia, and Brazil, mainly for local users. Historically,

2/ This project, though subsequently cancelled, is described here to give an additional example of the issues considered in the selection of a technology.
CT commenced to replace PCT machinery in the thirties while AT was introduced in the early sixties in response to rapidly rising textile wages in the developed countries. By 1977 about 60 percent of the weaving looms operating throughout the world were CT, 30 percent PCT, and 10 percent AT. Though accurate statistics are not available, it appears that there has been parallel replacement of PCT in other textile operations such as spinning and finishing. During the next decade, the share of PCT is expected to decline rapidly. No more than 1 percent of new textile machinery producing in 1977 was based on PCT.

The choice of technology was carefully considered for each project financed by the Bank.

(a) In the first Tanzania project and in the Egypt project, the existing mills are based on CT, and the same technology was used for rehabilitation and expansion. PCT was rejected because the low quality of fabrics produced on this type of equipment makes them virtually unsaleable in markets where fabrics converted on modern equipment are available. On the other hand, the Bank has also resisted occasional pressures by borrowers to provide AT equipment for spinning and weaving. Since wages in Egypt and Tanzania are about one-tenth of those in Western Europe and the USA, less capital-intensive CT equipment was found to be most appropriate for spinning and weaving, which account for 85 percent of the costs of the production machinery. For dyeing and printing, however, AT equipment was found most appropriate as it results in a better quality product and entails lower consumption of water, fuel, dyestuffs, and chemicals. (There is virtually no difference in labor costs between AT and CT.)

(b) For essentially the same reasons, CT was selected for spinning and weaving and AT for converting in the new fully integrated plant in the Morogoro Textile Project in Tanzania. This project will produce blended fabrics (polyester-cotton and polyester-rayon) for shirtings and suitings. An added argument against PCT in this case was that there is nowhere any operating experience in the production of blended fabrics on PCT machinery since such fabrics have only been introduced during the last 20 years.

(c) In case of the Textile Rehabilitation Project in Yemen Arab Republic (YAR), the existing mill was originally equipped predominantly with PCT machinery. There is also a considerable shortage of skilled labor in YAR, and industrial wages have been rising rapidly. Consequently, the rehabilitation of the labor-intensive equipment would not result in profitable operation, and CT equipment was selected.
According to conventional wisdom, CT has a definite edge over PCT in both spinning and weaving. However, textile technology cannot be described in terms of a simple dichotomy between the pre-conventional and the conventional form. There are many limitations, and the whole subject of optimum textile technologies in different industrial environments is being intensively studied in the Bank.

C. Building Local Capabilities

1. Manpower

The construction of large industrial projects in developing countries typically involves a number of diseconomies—e.g., smaller plant size, higher equipment costs, and higher cost of capital—when compared with construction of similar plants in developed countries. When delays in building a plant and bringing it to full operating efficiency are superimposed on those other diseconomies, total costs can be greatly increased and the financial return lowered. A critical element in the success of a Bank-supported project, therefore, is the transfer of human capabilities to build the plant and operate it properly.

Any major industrial project will have a significant impact upon those associated with it. This is particularly true if it is the first project of its kind in a developing country, as is very often the case with Bank-supported projects. The borrower, local consultants and suppliers of goods and services, national planning agencies and others all acquire experience and expertise in project management and operations, engineering, fabrication, marketing, and financial matters which can later be used for other projects.

Sector studies, for example, help the respective governments to gain an objective view about the performance of the sector, the costs, quality and efficiency of production, supply/demand balance, export prospects, appropriate technology, investment estimates for modernization and expansion and also provide elements for development strategy for the sector. The feasibility studies, as well as subsequent appraisal of the project by the Bank staff in close cooperation with the borrower, facilitate the transfer of project preparation and evaluation techniques, especially in areas such as market study, choice of appropriate technology, financial projections, evaluation of economic returns, ecological considerations, and occupational hazards. These disciplines in the initial stages of industrialization are, as a rule, often imperfectly understood by the borrowers.

The greatest impact, however, will come from the training of staff and workers to run the new plants. All recent Bank mining loans, for example, include covenants pertaining to training. Where foreign partners have the managerial responsibility, these will often include targets for indigenization of key management and technical positions. About 5 percent of the total project cost is typically set aside for training. In Bank-financed textile projects, strong local counterpart teams have been formed.
in the project implementation period to work closely with foreign consultants. The cost of such technical and management assistance has varied according to the competence available in the country and the nature of the borrower’s plant from a low of 1 percent of the basic cost estimate for technically advanced companies in Egypt to a high of 14 percent in Yemen.

At the operational level, staff and workers are not only taught operational skills, but also acquire the organization and discipline necessary for industrial efficiency. Each Bank-supported textile project, for example, normally includes provision for substantial skill development through training of mechanics and operators in using the new equipment at the plants of the machinery manufacturers, training of junior supervisory staff in textile colleges abroad, continuous on-the-job training for operators and supervisory staff, and installation of new training centers or expansion of existing centers in the country where the project is located. The cost of such training is estimated at about 1.5 percent of the basic cost estimate when rehabilitation and expansion of an existing plant is involved and about 3 percent of the basic cost estimate for a newly installed plant.

The starting up of a new pulp and paper mill typically involves the temporary importation of skilled workers from other countries who train locally recruited counterparts in their specific tasks. Such direct on-the-job training may be supplemented by classroom training, and by training selected key personnel in installations located in other countries. The costs may be substantial. In a project under review in Tanzania, for example, (where there is a shortage of skilled workers for any industry) technical assistance for training local staff to operate and manage the mill is expected to cost some US$40 million, compared with a total project cost of US$250 million.

Modern ammonia, urea, and other fertilizer plants are operated from a control-room where complex instrument integration makes continuous production virtually automatic. Associated power generation, feed water conditioning, cooling, and waste treatment units operate similarly. Operators of such plants (which perform at high temperatures and pressures) have great responsibilities. They are usually few in number per shift, yet are largely responsible for complexes costing US$200 million or more. In Bank-financed projects, senior operators are typically sent for extended training in overseas plants to learn how to maximize production and simultaneously minimize the dangers of explosions and costly shutdowns. On their return, these experienced operators take an active part in training others via lectures and simulated conditions prior to and throughout plant start-up. Managers and supervisors also receive training in the techniques required to run large new fertilizer complexes.

Industrial operations include many skills that are common to most or all industries. The availability and diversification of such skills is an index of the country’s industrial development. But there are other more specialized skills which have to be acquired when new industries are added. This is true, for example, of the skills required to operate a pulp and paper mill. A moderate-sized plant employing 500 persons might have 140 positions
for skilled employees, of which about 40 would need skills specific to the pulp and paper industry. Similarly, in large steel mill projects, there are special applications of logistics and of preventive maintenance of hydraulic, electric, or electronic equipment. The learning of such new skills is an important indirect benefit from that type of project.

2. Engineering and Equipment Supply Capabilities

Though the services of foreign consulting and engineering companies and the procurement of foreign equipment under international competitive bidding are typical features of Bank financing in the industrial field, every effort is made to build up local engineering capabilities and local supplier industries. Local suppliers normally benefit from a margin of preference in Bank-financed projects. Using local suppliers and consultants (and by the same token improving their capabilities for the future) involves some additional risk for delays or otherwise inadequate performance as contrasted with the proven quality and reliability of the better-known international suppliers. These contingencies must not be taken lightly, since deficient performance will seriously prejudice the success of the project. Yet, to take reasonable risks in this area is part of the Bank's development role.

Some developing countries are gaining the capability to supply their own engineering and equipment, especially via licensing agreements with established overseas manufacturers. A good example is the fertilizer industry. Indian equipment manufacturers recently began producing large centrifugal compressors under license from Italy. If the Indian equipment makers are able to attain competitive delivery times and prices, they should be able to supply entire ammonia and other fertilizer plants to both domestic and foreign users within a few years. Similar situations exist in Brazil and Romania. In other developing countries, such as Pakistan, Turkey, and Indonesia, the same degree of self-sufficiency and export capability is likely to be at least a decade away.

The promotion of local engineering and equipment supply capabilities creates the basis for development of local technology, whether essentially adaptive or, as in some cases, pioneering. In the pulp and paper industry, for example, the establishment of engineering industries that manufacture equipment for installation in new plants has occurred in those countries where there is a large and growing number of pulp and paper mills, such as Brazil, India, and, to some extent, Mexico. These industries have developed in response to a growth in the local demand for pulp and paper-making machinery, and because suppliers in the industrialized countries were generally developing their equipment along the lines dictated by conditions in their own countries: higher speed, greater capacity, and a higher degree of automation and sophistication. Typically, the manufacture of equipment in developing countries for use in domestic mills is based upon designs provided under license from European or North American manufacturers, but modified to suit their local requirements. This adaptation has been particularly successful for certain types of pulp-making machinery (e.g., chippers, washers, screens) and small paper-making machines. In many cases these modifications may be
just a simplification, or the return to a simpler design which may reflect the technology of the past in the industrialized countries. Nevertheless, the resultant equipment is often much better suited to the scale of production proposed and to other local conditions. For this reason, these sources of equipment may also be appropriate to the needs of other developing countries where there is no local engineering industry capable of producing pulp and paper equipment.

In conclusion, the capabilities which are created through large Bank-financed industrial projects—management, operating skills, engineering know-how, new supplier industries—do not benefit the project alone, but represent a capital that is available to the economy as a whole. The additional benefits come under the heading of what economists have termed the "external economies" of industrialization. 3/

II. Technology in Industrial Projects Financed by the International Finance Corporation

The International Finance Corporation (IFC), an affiliate of the World Bank, is the only international financial institution concerned solely with the provision of assistance to the private sector in developing countries. IFC attempts to stimulate the flow of capital in two ways. In the first place, it makes direct loan and equity investments in specific projects. For these, local government repayment guarantees are not required. In most cases, the contribution of IFC must not constitute more than 25 percent of the company's total share capital. In this way, the generation of additional capital, either domestic or foreign, is ensured. In the second place, IFC assists member governments to create domestic conditions conducive to investment in general, through the development of local financial intermediaries, capital markets, and appropriate policies. It is in its direct investment activities that IFC has its greatest impact on technology transfers.

As of June 30, 1979, IFC had paid in capital and accumulated reserves of US$348 million. The Corporation may legally borrow up to four times this total. In 1977, member nations decided to increase IFC's share capital by US$480 million over the period 1978-82. In response to this capital increase, an ambitious five-year plan has been generated encompassing several objectives, including a relative shift in the concentration of operations, both regionally in favor of the least developed areas, and sectorally in favor of natural resources and agro-industry, and an increased role in the provision of technical assistance (for project formulation, financial sector development, policy advice, and management training). The attainment of such objectives will necessitate the development and implementation of innovative appropriate technologies on an expanding scale, and IFC may therefore be expected to be increasingly involved in the transfer of such technologies in the future.

3/ They are called external because they are collected outside the project which generated them.
In addition, IFC will continue to fulfill the role that it has played in the past. The technological assistance provided to developing nations by IFC may be divided into four categories: (a) the identification of appropriate technological and managerial partners; (b) mediation in the identification of a production technology appropriate to the concern in question; (c) mediation in the development of licensing agreements, etc., to ensure that the conditions are reasonable in terms of the cost and transfers/training provided; and (d) assistance in the use and development of new technologies.

It should be noted that the establishment of virtually all IFC-financed projects in developing countries increases the technological base of these countries in a general sense through the addition of a manufacturing unit complete with management and labor skills.

A. Identification of Technical Partners

In numerous instances, particularly in the least developed areas, IFC has been approached by local entrepreneurs with viable project concepts, lacking only the requisite technological or managerial inputs. Natural imperfections of information and lack of exposure to new technologies frequently prevent such individuals from locating or even recognizing the need for technical partners. Such projects might either not proceed or be less successful but for the use by IFC of its knowledge and expertise to identify such partners, and place them in contact with the entrepreneurs concerned. At the same time, established corporations are frequently wary of investing or otherwise becoming involved in little known areas with completely unknown partners. The knowledge that IFC has fully investigated the situation, and deems the project worth pursuing, can be an important reassuring factor, both initially and throughout negotiations. Recently, for example, IFC assisted a small Egyptian company producing garments to identify a suitable foreign technical partner for an expansion and modernization program. Participation of IFC in the project was a prerequisite for the involvement of the foreign firm. Similarly, in Sudan IFC assisted a fully integrated cotton textile mill and an integrated meat producer to secure the cooperation of European firms as partners.

In many developing countries the main constraint on development is not so much a lack of finance, as a lack of administrative and managerial expertise. IFC is a financial institution and not a management corporation. However, in the light of past experience, it is often in a better position than the local sponsors to realistically evaluate the degree of managerial competence required to implement a given technology, and to compare this to the degree of managerial competence available locally—especially within the entity concerned. If deficiencies are identified, IFC may recommend that the entity go to the international market in search of a suitable individual. Alternatively, IFC may recommend that the company reach a management agreement with some corporation, experienced in the use of the machinery and technology selected, as it did in the case of a project in Turkey which involved the continuous casting of aluminum coils. Because of IFC's insistence, a suitable managerial partner was obtained.
With the passage of time, it is becoming increasingly possible for IFC to generate second stage transfer of operating technology and know-how through this process. For example, in the case of a packaging project in Zambia, IFC was able to introduce a technical partner from Pakistan. IFC had earlier assisted in financing and arranging the introduction of flexible packaging concepts to the operations of the Pakistani firm.

B. Selection of Appropriate Technology

IFC undertakes promotional work to analyze the needs and resources of a country, identify appropriate commercial activities, and to generate local private sector interest in such projects. Such promotional work is expected to play an increasing role in the generation of investment opportunities in the future. In the past, however, the majority of IFC's projects have been evolved from specific inquiries by interested entrepreneurs, and to this extent the concern of the Corporation with appropriate technologies has been largely project, rather than country, oriented.

The first contribution of IFC is to check that the equipment proposed can actually perform the functions required by the project. For example, a food processing firm in Yemen was guided away from the purchase of water treatment equipment which was unlikely to have been capable of producing a sufficiently purified product under local conditions.

As a second step, IFC ensures that the production process concerned is not only technically feasible, but is also appropriate to prevailing economic and market conditions. The relative availability and cost of inputs and market trends for both inputs and outputs are examined, and the proposed degree of product differentiation, project scale, and potential for expansion/diversification, etc., are assessed. For example, during appraisal of the Sudanese textile project mentioned earlier, IFC recommended the introduction of flexibility in the project-supporting facilities to permit relatively cheap expansion of the range and blend of fabrics produced when inevitable changes in market conditions should so dictate. In the case of a copra processing plant in the Philippines, IFC recommended the adoption of a crushing-extraction technology other than that originally proposed, on the grounds that at a marginally greater capital cost increased flexibility, yields, and economies of scale could be obtained.

C. Assistance in Licensing Technology

During recent years, international concern has been expressed over the restrictive practices included in commercial licensing agreements made with developing countries, and the formulation of an international code of conduct on the transfer of technology has been a major concern within UNCTAD since 1971/72.

The scope of direct influence of IFC in these areas is limited to advising entrepreneurs concerned in specific projects involving such agreements. IFC has generally been able to help sponsors of projects in which it invests
to avoid most of the restrictive features of licensing agreements that have been of major concern in the negotiation of a code of conduct. IFC has also helped sponsors to guard against excessive royalty fees. In the case of management contracts, IFC has attempted to ensure that remunerations are related to actual performance as measured by profits, rather than to sales or other gross indicators. Moreover, where IFC introduces technical or managerial partners to a project, it seeks to ensure that the technical partner provides the necessary expertise and has a financial stake in ensuring that the transfer is successfully implemented during the initial stages.

D. Introduction of New Technology

The use and development of new technologies in developing countries has two aspects. On the one hand, IFC engineers are able to ensure against the use of overly sophisticated or experimental machinery in the projects in which IFC invests. For example, in the case of an integrated pulp and paper mill in Iran, IFC found that the consulting engineer was proposing to use the mill as an experiment for the introduction of twin-wire paper machines. IFC was able to intervene on behalf of the sponsors and ensure that the well-known Fourdrinier type was purchased instead. The introduction of this method alone constituted a technological advance for Iran and had a much higher probability of success.

The second aspect relates to the introduction and development of techniques appropriate to the resources of developing rather than developed nations. Under normal circumstances, IFC acts as a financial institution, investing in viable commercial enterprises and is not, therefore, actively concerned with technological research. However, in 1972, the Corporation did become a shareholder in a Mexican pilot company to prove the viability of the production of newsprint from bagasse pulp. The pilot project demonstrated that, with modification, the technology was feasible, and two large-scale commercial enterprises employing bagasse are to commence operations shortly (in Peru and Mexico).

In addition, IFC has supported a number of commercial ventures involving the introduction of appropriate new technologies, particularly in the development of mineral resources. For example, a copper refinery in Chile involved the use of new refining technology, specifically developed by the local sponsors. A major nickel mine and refinery in the Philippines involved the implementation, for the first time, of a new process developed by the foreign technical partner. A steel project in Malaysia involved the first commercial introduction of the use of local rubberwood (formerly a waste product) charcoal as a fuel for blast furnaces.

To conclude, the contribution of IFC in the transfer of technology to developing nations has, to date, primarily been that of ensuring that effective and timely transfers of specific operating technology have occurred at a minimum cost to the local entities and hence, to the countries concerned. Sometimes this process has involved the introduction of new technology or technology specially adapted to the availability of labor and raw materials.
or to market requirements in the country. In many cases, however, it involves mainly a review by an IFC engineer with broad experience, to ensure that a well-established technology is obtained on acceptable terms, and that sufficient technical and managerial competence is available to the local firm to operate the technology profitably.

III. Technology and Development Finance Companies

A. Bank Approach to the Funding of DFCs

Since 1950, the World Bank has been funding development finance companies (DFCs) in developing member countries. The Bank has concerned itself actively in developing the design and improving the organization, staffing, and procedures of these institutions. The Bank works with governments of, and private entities within, member developing countries that want to create new DFCs or re-organize existing ones. It will analyze the need for a DFC; work out its financial structure, policies, and organization; and even help find participating investors.

While DFCs finance only a minor part of total industrial activity in most developing countries, they have had in many cases a catalytic impact on the nature and direction of industrial development in their country. For example, they have been able to significantly affect selected industrial subsectors, channel resources into particular geographic regions, influence government policies, and be a model for other financial institutions in their methods of operation. DFCs are frequently the only source of long-term credit suitable for financing new projects, while medium-term credit offered by commercial banks is generally utilized to finance expansions of on-going concerns. As a result, DFCs are often in a prime position to influence investments in new projects, even if their share of total credit to industry is modest.

DFCs have in some cases influenced government policies to encourage the import of technologies which are suited to the needs and conditions of the subsectors and regions where the DFC has the most impact. They have affected the structure of the financial sector and the terms on which credit is made available so that firms are able to increase the quality of their products and seek new markets. They have helped in some cases to build technological infrastructure in the country to provide the research, design, and engineering capabilities necessary for expansion of industrial activity.

The building of development finance institutions is important in itself because of the impact they can have on industrial development. By channeling its loans through these financial intermediaries—in effect a delegation of Bank funding decisions 4/—the Bank is also able to support

4/ Generally subject to: (1) agreed sectoral priorities, (2) ex ante review by the Bank of proposed loans above a pre-set "free limit," and (3) ex post monitoring of loans under the free limit.
industrial and other directly productive investment projects which would normally be too small (below about US$5 million) and too numerous for the Bank to appraise individually.

Through FY79, the Bank supported over 100 DFCs with total commitments of more than US$6 billion. In FY79, twenty operations were funded for US$659 million. (In FY79 IFC made commitments of US$7.7 million in 8 DFC and capital market operations.)

Much the largest proportion of Bank lending for DFCs has been devoted to manufacturing investment in developing countries. While many of the subprojects in which DFCs invest are comparatively large (having, for example, fixed assets after project completion of over US$300,000), the Bank has been directing increasing attention to small enterprises (see Part IV below). About 90 percent of lending by Bank-supported DFCs is directed to privately controlled enterprises at the subproject level.

The Bank has undertaken studies of the effects of the DFCs it has funded in several countries. It has found that the overall economic return of subprojects financed by DFCs has been generally attractive, though some economically weak subprojects have been financed. The Bank has been working with DFCs to develop and use analytic tools which will permit screening out such subprojects. Data from a few countries, though not conclusive, showed an average cost per direct job created by DFC subprojects of about US$15,000 (in 1976 prices); an in-depth study of lending by DFCs in Colombia found indirect employment generation to be about 50 percent of direct employment generation.

B. Institution Building

A primary objective of Bank support of DFCs is to build institutions that have the staff and procedures to adequately appraise, supervise, and in some cases promote and provide for the financing and management of subprojects. The Bank achieves this institution building objective mainly through training and technical assistance.

By far the largest proportion of training of DFC staff occurs informally as Bank and DFC staff interact. In preparing DFC projects and later in supervising them, Bank missions provide for a continuing relationship through which questions can be raised and guidance given in the performance of jobs, skills required and correct procedures to be followed. This interaction is also carried on through correspondence concerning subprojects sent to the Bank for approval or funds disbursement. Comments are made not only on the individual subprojects but on general issues of subproject appraisal, the type of subproject being funded, and technology.

5/ Agricultural credit is mainly handled as part of Bank Agriculture and Rural Development sector activities, which are described in the first chapter of this volume.
A frequent means of training DFC staff is by providing seminars, which usually concentrate on subproject appraisal and supervision, management control systems, accounting, and sometimes specialized subjects such as policy planning. Bank staff may give seminars when they are on mission. More often, provision is made in technical assistance agreements for in-service training by expatriate managers or advisers. In this case, it is left to the DFC and the technical assistance organization to make the arrangements and carry them out.

Frequently, DFC staff are enrolled in courses given by the Bank's Economic Development Institute (EDI). EDI gives two special courses in Washington—one on Development Banking and one on Industrial Projects—and helps in national/regional courses given abroad. When DFC staff take a course at the Bank, they can interact with Bank staff during the course. It is not unusual for DFC staff members to stay on at the Bank for two or three weeks after an EDI course to work with Bank staff responsible for DFC projects. This provides an opportunity to jointly review DFC-proposed subprojects. In some cases a DFC staff member has been brought to the Bank for as long as six months for this kind of experience. DFC staff are also included from time to time on Bank missions, which has proved to be an effective form of training. Finally, arrangements are sometimes made for a staff member of a relatively undeveloped DFC to spend a month or longer at a more sophisticated DFC in another developing country, frequently in South Asia.

Management capabilities are an important aspect of DFC functioning. When there are serious deficiencies in DFC management or related professional areas (e.g., senior accountant), provisions are made for experts to spend a year or more carrying out a particular responsibility while giving on-the-job training to one or more local individuals who will later take over the position. Fellowships may also be provided for foreign study.

In order for DFCs to be able to assess the feasibility and appropriateness of technologies proposed in subprojects, the Bank normally requires that they have technically qualified personnel on their staff. Usually these are industrial (production) engineers, since it is normally not practical to have engineers trained in each of the many specific industrial areas with which DFCs deal. These staff are expected to be knowledgeable about consultants on whom they can call for specialized assessments. Very small or very new DFCs, or those located in countries where there is a lack of technically trained people, may employ foreign experts for a year or more to perform this function. A senior expatriate engineer so employed may also be expected during this period to train a junior engineer who has just graduated from a local university to replace him when he leaves.

The Bank has acted in several instances as the executing agent for UNDP technical assistance grants when there was a special need for training. It did so with the Industrial Development Bank of Afghanistan.

When a DFC operates in an area where it is difficult for local sponsors to identify and develop projects which the DFC could support, the
Bank arranges for technical assistance for feasibility studies and project preparation. In Bolivia, for example, a Bank loan helped to strengthen a mining bank, one of the few specialized DFCs supported by the Bank, to aid the development of small mining enterprises in the country. Technical assistance was provided both to the DFC in management control systems and project evaluation and to the national geological institute in the preparation of prefeasibility and feasibility studies for mining projects to be supported by the DFC.

The Bank generally makes no special effort to encourage DFCs to aid the development of local equipment suppliers, though some advances have been through the provision of import credits in some South Asian countries. Most entrepreneurs seek modern equipment which usually can only be obtained abroad. While DFC subprojects are exempt from the Bank's international competitive bidding requirement, most DFCs supported by the Bank require their clients to solicit competitive bids. The bids are often made by and even sought from foreign firms. The policy statements of Bank-supported DFCs, however, usually include a provision that the proceeds of the loan can be used to pay for the percentage of subproject costs which is the foreign exchange component of the costs of equipment of foreign origin and local manufacturing and services (generally construction). Some DFC clients favor the use of local suppliers of equipment and services in cases where they have better control over quality and delivery times than for foreign firms. They may also choose them when there are possibilities of keeping costs down. As DFCs capture more domestic resources, they are also able to make more funds available to clients for local currency purchases.

C. Technological Aspects of Bank and DFC Activities

The Bank assists both governments and DFCs to formulate policies and programs for industrial development by conducting industrial sector surveys. These surveys analyze government policies, existing financial and institutional arrangements, and manufacturing capacities. The Bank has carried out sectoral and subsectoral studies for about a decade. In South Asia, for example, such surveys have focused on jute and textiles (with attention also given to paper, steel, and leather) in Bangladesh, on textiles and small-scale engineering industries in Pakistan, and on capital goods industries in India. The Bank is also surveying the capital goods industries and export-oriented industries in several Latin American countries. These surveys provide a basis for discussions with governments and for designing assistance programs which will enable DFCs in those countries to become more priority oriented and better able to meet priority subsector needs.

Sectoral and subsectoral surveys can identify the need for and set in motion government and private sector programs for industrial development which may not involve DFC participation or Bank support. They contribute to an overall development process which in part is intended to improve the capability of DFCs over time to capture domestic resources. This is one reason the Bank usually lends to a DFC only enough to cover its funding needs for about two years, reassessing the amount and terms for any additional
support during that period. Since most DFCs have not yet mobilized enough domestic resources to meet their needs, even though they may be institutionally mature, the Bank continues to lend in support of their operations. The Bank has, for example, made twelve successive loans to date both to the Turkiye Sinai Kalkinma Bankasi A.S. (TSKB) and to the Industrial Credit and Investment Corporation of India (ICICI).

The degree to which DFCs function as development institutions, promoting industrial activity to meet identified development needs, varies according to conditions within a given country and the nature of the DFC. There are some notable examples where DFCs have taken the initiative in this respect. The Industrial Development Bank of India, for example, in cooperation with ICICI and local financial institutions, has set up Technical Consultancy Organizations in less developed parts of the country for identifying and promoting viable small-medium industrial projects.

In Zambia, the development bank got support from various donors to establish a feasibility study fund to assess possible projects and identify potential sponsors. Once a sponsor adopts a project and financing is arranged for it, the sponsor reimburses the fund for the study costs. In Yugoslavia, where the Bank supports DFCs in the four least developed regions of the country, a DFC may assist a sponsor to obtain needed additional financing for a proposed project—as one did in working with the agricultural bank to establish a milk distributing company which in turn also set up a number of processing plants.

The Bank is also assisting DFCs to increase their capabilities for improving the technology used in certain industries or for specific purposes. For example, recent loans to the Banco de la Republica in Colombia have included a provision that up to US$5 million may be used for technology improvement and pollution control. In addition, the Bank is increasingly using the services of some of the more experienced DFCs to implement self-contained sector or subsector development projects conceived by the Bank, which are then administered by the DFC in parallel with their other operations. It has done this, for example, with a textiles project in Turkey.

In many cases, however, DFCs do not do much project promotion. They mainly respond to proposals brought to them by entrepreneurs. The entrepreneurs do their own pre-feasibility studies (sometimes with the encouragement of the DFC) or have them done by or in conjunction with a foreign technical partner. They usually wait to do full-scale feasibility studies until financial backing has been obtained for the project. By the time most proposals come to DFCs for funding, however, the choice of manufacturing process and often even of equipment has been made and in many cases orders already let. This leaves little room for change. Too much pressure for change can cause the entrepreneur simply to seek other sources of financing. As a consequence, the DFC is only able for the most part to review and ask questions—ensuring that in its opinion the proposed project is technically feasible, economically justified, and financially sound.
The project appraisal which the DFC performs is a key part of its role as a development institution. It affects the nature and quality of the projects which the DFC supports. While most DFCs make an effort in their appraisals to assess the technologies proposed by the entrepreneur for use in the project, many are not able to because adequate technical staff are not available to them, there are no specialized institutions in the country to which they can turn for advice, and the alternatives are not always known with any reasonable degree of validity. At a minimum, the technology must be judged sufficient for the project to have adequate economic benefits as calculated by the economic rate of return and be financially viable as calculated by the projected cash flow. For these reasons both the Bank and the DFC must in large part assume that the overall macroeconomic policies of the country lead the entrepreneur to select the technologies most appropriate to the conditions in, and the development needs of, the country.

The Bank's role is to upgrade the DFC's investment decision-making process by ensuring that the appraisal and all other considerations leading to an investment decision are properly taken. As a matter of policy and of practicality, given the large number of projects funded by DFCs, the Bank only appraises the appraisal carried out by DFCs. It does this in two ways. First, Bank supervision missions visit selected DFC-funded projects in the field, identifying specific problems and giving advice for improving appraisal methodologies. Second, Bank staff review a sample of appraisals performed by the DFC for subprojects above the "free limit." As a DFC's capabilities improve, the free limit is raised in successive loans. In some cases, the Bank has judged that DFC appraisal capabilities have reached the point where subproject approval by the Bank is no longer necessary.

Since the subproject loan proposals received by the Bank have already been approved by the management of the DFC, it is very difficult and quite unusual for the Bank to disapprove these loans. While the DFC may reconsider its funding decision in view of Bank questions about the appraisal, the final decision nearly always rests with the DFC.

Technical aspects of subprojects above the free limit are reviewed, but the possibilities for significant changes are severely constrained. The Bank reviews the justification for the technology selected, but leaves the actual decision to the DFC and the entrepreneur. The review mainly rests on the analysis of the financial and economic benefits of the technology, though the Bank encourages whenever possible the use of technologies which will minimize the capital costs per job created. Since Bank funds mostly cover the foreign exchange components of subproject costs, the Bank has little influence in reducing reliance on imported technologies that are capital intensive.

The Bank's review of the proposed technology is also limited in its detail because feasibility studies are normally not included when a subproject is sent to the Bank for approval. The Bank in any case would not be familiar with the specific conditions which exist in the field. In a couple of cases, however, the Bank has made suggestions about the capacity of a subproject—e.g., recommending phased expansion of production facilities as
the market is established or as raw materials become readily available. Occasionally, a Bank engineer has questioned a proposed technology as being too experimental or previously untried in a given country. The Bank has also recommended the purchase of used equipment, though government policies often do not encourage this. In general, the Bank's review is mainly to check that the various parts of the proposed manufacturing process (both concept and equipment) do not fit together in an obviously unworkable manner.

As a rule, DFC subprojects use proven technologies. Often entrepreneurs propose using the most modern and capital intensive technologies, even in labor surplus countries. This is due to many factors, including a desire to be as modern as possible, acting in response to government development policies, the influence of foreign equipment salesmen, the biases of expatriate and sometimes local engineering consultants, and the tying of foreign sources of capital to specific technologies.

The Bank carries on a dialogue with DFCs in which it tries to impress on them the need to consider technologies appropriate to the factor proportions of their country and to obtain local, untied resources which will enable them to support the use of such technologies when they are available. A DFC's ability to mobilize untied financial credit in foreign exchange is a major factor permitting project sponsors to make rational choices among alternative technologies.

IV. Technology and Small Enterprises

A. Bank Interest in Small Enterprises

Small enterprises have been found to be more labor intensive per unit of capital invested and to employ comparatively more unskilled workers than larger firms. As a result, creating small enterprise factories offers possibilities for increasing employment opportunities, especially for the poor.

Small enterprises can be beneficial to developing countries for such other reasons as: (1) they buy more domestic inputs, produced by indigenous labor, than do larger enterprises; (2) they provide opportunities for local entrepreneurs to gain experience and these entrepreneurs are highly motivated to save and invest, partly from their inability to obtain financing from institutional sources but also from their psychological commitment to the enterprise; (3) they are more likely than larger enterprises to use in their production processes simple, general-purpose machinery which is often manufactured locally; (4) they are often innovative in their use of technology, adapting it to changing situations and opportunities; and (5) the technologies they use tend to be labor-intensive.

For these reasons, the World Bank has made it a priority in its lending program over the past few years to support small enterprises. The Bank is committing increasing resources to support small enterprise development efforts. Funding for small enterprise-related activities amounted
to about US$131 million for operations in FY79, approximately one-fifth of total Bank lending to financial intermediaries, and is projected to reach about one-third of Bank lending to financial intermediaries in FY82. Additional support is being given to small enterprises through components of urban projects (for which funding is expected to rise from an estimated US$30 million to US$50 million per year during FY79-82) and rural development projects.

The Bank's support of projects which finance small enterprises is too recent to yield much data on poverty-oriented employment generation. In the Philippines, however, a Bank loan has financed over 7,200 new jobs in nearly 300 subprojects at an average cost per job in FY78 below US$3,600.

The definition of a small enterprise varies from country to country. The Bank uses as a guideline that a small enterprise has an upper limit of US$250,000 equivalent (in 1976 prices) for fixed assets excluding land. For convenience, a limit of 25 to 100 employees is also sometimes used, depending on the country and project.

Small enterprises generally fall into three categories:

(1) small manufacturing firms that are relatively modern;

(2) organized non-manufacturing firms, such as those engaged in construction, repair, transportation, and trading; and

(3) enterprises not organized or conducted in a "modern" manner—e.g., traditional artisans, petty traders, and transporters in the "informal" sector.

In most developing countries small enterprises in the formal sector fill market needs primarily for products or services which are not met by larger firms. Small enterprises frequently suffer, however, from many problems. For example, deficiencies in management and organization result in unreliable delivery times, insufficient technical know-how inhibits the upgrading of product quality, and lack of access to supply and credit facilities makes it difficult to gain wider markets.

Informal sector enterprises, especially artisans, have similar problems though usually on a smaller individual scale and with more intensity. Credit and access to supplies and markets, for example, are often only available from moneylenders at high rates of interest (up to 100 percent per annum). Those who work in their homes or live in their shops often face unhygienic conditions, high rents if they must have space in a central urban area, or excessive transport distances for obtaining their supplies or getting their products to market if they are located in outlying areas.

The number and importance of small enterprises in developing countries is varied but usually significant. In Bangladesh, for example, there are roughly 50,000 small and 500,000 cottage industries, which together
contribute about 35 percent of industrial added value and employ 80 percent of the total industrial labor force. In Egypt, small manufacturing establishments mostly employing fewer than 50 workers account for about one-third of total industrial value added and about one-half of total industrial employment. In Mexico, "medium" size firms, having up to 250 but on average 75 workers, contribute nearly 80 percent of value added and provide about 60 percent of industrial employment. In Korea, small and medium enterprises with up to 200 employees comprise 94 percent of all enterprises and produce 37 percent of total commodity exports.

B. Sector Work and Project Identification

While providing support for small enterprises is a relatively new area for the Bank, there is a knowledge base from other aid agencies and some developing countries which has been built in some cases over ten or twenty years or longer. The number and variety of factors which must be considered in designing a small enterprise project, however, make it a very complex and uncertain process. As a result, the Bank regards many of its projects in this area as experiments from which lessons can be learned for designing future projects. A practical problem which the Bank faces is that the preparation and administration of a loan to a financial intermediary that supports small enterprises are generally much more time consuming than those to DFCs for support of larger enterprises (see part III above). The Bank has been devoting extra resources to this area.

The Bank is learning about small enterprises and the conditions which affect them through sector studies in a number of countries. The depth and comprehensiveness of these studies depends on the staff resources available and the nature of the industrial sector in a country or region. When surveying the small enterprise sector, the Bank examines the structure of the sector in terms of patterns of ownership, size, location, and employment. It analyses the organizational and operating characteristics of the enterprises, including the nature of entrepreneurship, skill of the labor force, equipment usage, capacity utilization, type of workplaces, marketing, and quality of output. It also considers government policies on taxes, price controls, import and export incentives, and the existing framework of financial and technical assistance institutions.

The Bank attempts to identify specific industries and trades which have the potential for growth and long-term viability, especially those which could lead to efficient import substitution or export expansion and to employment generation. In doing so, it examines the subsector’s linkages with raw materials and other inputs, with user industries and other market outlets (e.g., by providing subcontracting services to existing local industry and by organizing subcontracting exchanges), and its horizontal integration with other small industries. In Bangladesh, for example, where 70 percent of small and cottage industries are located in rural areas and are closely tied with agricultural and livestock production, there is expansion potential in such fields as fish drying, fruit processing, and rice milling. In Niger, the expansion and up-grading of artisanal activity in leather-working through a Bank-financed project will permit better use of locally produced hides and skins.
Conditions affecting the long-term outlook for artisan products of both the utilitarian and art/crafts types are dependent on many considerations. Changes in income in the country or region and of personal taste can have important effects. Introduction of inexpensive plastic bowls in some countries, for example, has had adverse effects on local pottery production. In contrast a growing middle class in some urban areas had led to demand for consumer-oriented services, such as garages, restaurants, and radio and television repair. To the extent possible, the Bank tries to anticipate and create conditions which will contribute to stable demand for products or services. The small enterprise project in Upper Volta, for example, was prepared in conjunction with a Bank-supported urban development project in that country which would require trained artisans in the construction trades.

At times, support for small enterprises has been a political issue because of the social welfare aspects of large-scale employment generation. Sector studies offer the possibility for dialogue with governments and leading financial and technical assistance institutions of member developing countries about the nature and needs of small enterprises. The Bank advises governments to study and support small enterprises when conditions so warrant. In the small enterprise project in Upper Volta the Bank included funds for further study of the sector. The Bank may advise governments to purchase more equipment and services from local small enterprises--e.g., in letting contracts for the furnishing of schools and offices.

C. Financial Support Mechanisms

The Bank has been trying a number of approaches to the support of small enterprise projects, depending on the conditions within a particular country. In general, it has combined in different ways the provision of credit with technical assistance and training.

When a sector survey indicates there is a potential for development of small enterprises, the Bank seeks an institution which can act as a suitable intermediary for providing financial support. Since development finance companies (DFCs) are the principal financial intermediaries with which the Bank deals in member developing countries, the Bank has financed DFCs (including some specifically established) to support small enterprises. When appropriate, the Bank also seeks other existing financial intermediaries which can provide such support, rather than create new institutions. It has been increasingly supporting commercial bank activity in this area. Bank support of small enterprises has taken at least the following forms.

First, the Bank requires of some DFCs that a portion of their subproject loans be to enterprises which have a cost per job below a specified level. Since DFCs generally have limited influence on the choice of technology by the medium and large firms which are their usual clients, this "earmarking" provision means that they have to seek smaller enterprises (in terms of total assets) and finance more labor-intensive projects (as measured by the capital/labor ratio). In successive loans to a given DFC the Bank may require that a larger proportion of the loan proceeds be used for this purpose and/or that the cost per job criterion be set at a lower level. It has done this, for example, in loans to the Small and Medium Industry Bank in Korea.
Second, the Bank includes small enterprise components in some loans to DFCs. A separate unit with a specially trained staff may be created in the DFC to administer the project component, which may be directed to priority subsectors which have been identified by the sector survey.

Third, the Bank finances projects that are devoted solely to support of small enterprises. In these cases, the Bank may use a DFC (or other institution) in a two-tier system in which the DFC on-lends to other DFCs or to commercial banks. Among the advantages of using commercial banks are the larger number of branches they are likely to have, their greater experience in dealing with local entrepreneurs, their knowledge of market conditions, and the ability to combine their own short-term funds with longer term finance from the Bank.

Fourth, the Bank supports institutions concerned with constructing industrial estates which provide developed land, factory buildings, and services at reasonable cost to small enterprises.

Fifth, the Bank now includes business support components in many of its basic urbanization (sites and services and slum upgrading) projects.

Sixth, the Bank has begun to support small enterprises in rural areas.

The provision of credit to small enterprises in developing countries is a complicated matter and is not the preferred business of many financial intermediaries. Most small entrepreneurs do not meet the normal collateral requirements of commercial banks. In addition, development banks usually lend for the purchase of large equipment and construction of buildings, whereas the main financial bottleneck for small enterprises is working capital for the purchase of raw materials and the holding of inventories, especially during slack periods if the market is seasonal.

Beyond this, the administration of loans to small enterprises is expensive. Small entrepreneurs need help to do the feasibility studies, project preparation and loan application work normally done by large firms. Moreover, more supervision is required for loans to small enterprises. While their arrears rate has been found in some cases to be low or lower than for medium and large firms, it appears that repayment requires consistent follow-up by the lender. This can become especially burdensome when the clients include large numbers of artisans and adds to the banks' reluctance to support them (see below).

To deal with these problems, the Bank has included in the projects it supports such practices as:

(1) The use of credit guarantees.

(2) The allowance of larger margins in lending to small enterprises.
The use of equity investments.
The support of equipment leasing.
The use of local materials and equipment.
The use of credit-in-kind.
The use of simplified appraisal and disbursement procedures.

D. Technical Assistance and Training at the Enterprise Level

Most Bank-financed small enterprise projects and project components include provision of technical assistance and training for the firms involved. This assistance is usually provided by a public agency, which is often affiliated with the Ministry of Industry and generally receives an annual government allocation as well as foreign assistance (e.g., from ILO, UNIDO, and individual countries). A problem faced in small enterprise projects is coordination between or among technical assistance agencies and banks. When projects support artisans, as in West Africa, both services may be provided by the same agency both for ease of administration and because the technical assistance grant to the agency may be used to cover part of the costs of administering its loans. In most cases, however, the two functions are separated, with technical assistance provided by a specialized agency—not by a bank for which the provision of technical assistance is an important but costly and not necessarily appropriate side line.

The technical assistance provided to modern small enterprises usually includes help in preparing credit dossiers for consideration in loan applications and training in business skills. These skills may include accounting, financial planning, production forecasting, determining the prices of goods, and organization of the work floor. For artisans, the agency is more likely to give technological advice and training—e.g., in teaching a blacksmith or a weaver how to use standardized methods and to achieve certain levels of quality. The cost and institutional limitations in reaching large numbers of artisans are reasons for selecting and concentrating on sectors which have good potential for growth and improvement.

For most small enterprises the choice of technology is really a choice of a particular kind or make of equipment, though some technological choices are made in process design in such areas as food processing. Even when presented with alternatives, however, the entrepreneur may have no sound basis for comparison and thus may make his selection on the basis of such factors as how modern the equipment appears to be, its availability from a known equipment supplier, or a recommendation from a personal contact. The Bank is attempting to remedy this situation in the small enterprise projects it supports, as the following examples show.

The Bank-financed small and medium enterprise project in the Philippines has supported the establishment and initial operation of a
Small Business Advisory Center (SBAC) in each of the 12 regions of the country. The SBACs have used all local personnel in providing engineering, marketing, and financial analysis capabilities for diagnosing and suggesting remedies for problems encountered by small enterprises in their regions. Specialized problems are referred to the central office, which has access to the expertise of universities, research institutes, and other appropriate agencies within the country and abroad. Since their inception in July 1975, the SBACs have serviced approximately 1000 cases from over 550 clients.

In Egypt, where virtually no technical assistance has been available to small enterprises, the Bank-supported small enterprise project contains a pilot technical assistance program consisting of a technical extension service and three training components. The technical extension service will be provided by an existing industrial design and development center with appropriate additional resources. The center was originally set up with UNIDO assistance and currently services public sector and some larger private enterprises. The training components include skill upgrading for workers in engineering, metal-working, woodworking, and furniture trades—using the workshops and other facilities of the industrial development center; accelerated training over six months for about 1,000 unskilled and semi-skilled workers; and development of industrial management skills for about 300 owners and managers of small enterprises.

The Bank's funding of such pilot project components contributes to its ability not only to improve this project in the future but other small enterprise projects as well. The Bank is also seeking to improve the general climate in which efforts to design and implement such projects take place. It has been investigating, for example, various possibilities for creating an international mechanism for improving the flow of information on technology to technical assistance agencies and small enterprises in developing countries.

The Bank also funds research on various aspects of the promotion of small enterprise—e.g., the study on industrial organization described in the Introduction. Another current Bank research project has reviewed numerous studies that analyze the technologies used in nine important industrial product lines—shoes, cotton cloth, cotton yarn, bricks, cornmeal, sugar, beer, leather, and fertilizer. Its findings are that the most appropriate technologies (defined as those yielding the highest present discounted value relative to capital investment) were less capital-intensive than conventional plants, providing 1.1 to 20 times as many jobs per unit of capital invested, the ratios varying by industry but all strongly positive. Other indices also favored the less capital-intensive pattern.