THE WORLD BANK'S EXPERIENCE WITH LARGE DAMS

A PRELIMINARY REVIEW OF IMPACTS

PROFILES OF LARGE DAMS

(Background Document)

August 15, 1996

CONTENTS

AKOSOMBO HYDROELECTRIC PROJECT (GHANA)

The Project

The Akosombo Hydroelectric Project is located on Ghana's principal river, the Volta, about 120 km above the estuary at Ada where the river joins the Gulf of Guinea. Main project features are a 134 m high rockfill dam and a 793 MW power plant. The reservoir, known as Volta Lake, covers an area of 8,482 km^2 and has a live storage capacity of 62 billion m^3 or about twice the average annual river inflow. The project was developed in two stages. Stage I, appraised by the Bank in 1961 and completed ahead of schedule in 1966, consisted of the dam, the first four units, and related transmission lines. Total project costs at appraisal were US$190 million, financed in part by a Bank loan of US$47 million. Resettlement of the 80,000 people displaced by the reservoir was financed and managed by the Government under a separate project. Cost savings of 27 percent were applied to the Government's resettlement project which experienced a 168 percent cost overrun. In the 1969 the Bank financed Stage II, the addition of the final two units and further transmission lines. The project also created the potential for hydroelectric development downstream of Akosombo, and in 1977 the 160 MW Kpong Hydroelectric Plant was built with financing from the Bank. The owner of the Akosombo and Kpong plants is the Volta River Authority (VRA).

Project Rationale

After independence in 1957, the Government of Ghana sought financing for a project to build a large hydroelectric station on the Volta River to serve as the power source for a major aluminum smelting company to be built at Akosombo. Using the river's power potential to help exploit the country's rich bauxite reserves was viewed as the springboard to propel Ghana on a fast track to industrial growth. Country-wide total electricity generation was only about 65 MW in 1960, all supplied by locally-operated diesel plants. The country had no oil or gas reserves. Estimates for the period 1960-1966 showed demand for power growing at around 15 percent annually. Short of importing oil, the startup of any kind of industrial program required the parallel development of a hydroelectric facility on the Volta River.

Thus, the main objective of the project was to exploit the waters of the Volta River to accelerate industrial development, and provide power for an aluminum smelter to be constructed on the southeast coast. In a review of Ghana's economy in 1960, the Bank questioned the project, citing its large size relative to the economy as a reason for caution. A project preappraisal report issued later in the year showed greater optimism, stating that while the project would not be financially attractive in the initial ten years of operation, it would prove beneficial over a 50 year period. Ultimately, the project was justified in the longer term as a supplier of cheap energy for industrial development and the source of important secondary benefits including flood control, navigation improvement, and fisheries development.

Development Impacts

Power—VRA's main customers are the Volta Aluminum Company (VALCO), and Electricity Corporation of Ghana (ECG). In 1993 VRA sold 6,200 GWh, of which 2,800 GWh was to VALCO, 2,350 GWh to ECG, 650 GWh to mining companies in Ghana and 330 GWh was exported to Benin. Thus, the project has achieved the purposes for which it was built. Annual foreign exchange earnings have ranged between US$90-70 million in recent years.

However, the project, and inevitably its customers, are vulnerable to drought. In 1982-84 a drought caused VALCO's smelter to be shut down and supplies were curtailed to domestic customers, and at the present time river flows are below normal. Ghana is now installing thermal power plants to meet the growth in demand estimated at an annual rate of 8 percent. The first thermal plant, a 300 MW combined-cycle plant financed by the Bank, will be in service by 1997. A mixed thermal-hydro system will have advantages over a pure hydro system in managing periods of drought. In a pure hydro system a drought has two adverse effects. First, there is less water to generate energy. Second, the reservoir is drawn down to augment the water supply and this reduces the head and, hence, the energy produced per unit of water. In a mixed system, it becomes possible to maintain the head and the energy deficit is then made up by running the thermal plant.

Regional Economy—The Akosombo aluminum smelter has been a successful venture. The region of Akosombo, Kpong and Tema where the smelter is located has become a prosperous area as a result of the relatively high wage employment provided by the Volta River Authority and VALCO. The town of Akosombo has modern street lighting, a well-equipped hospital, an up-to-date water and sewage system, primary schools, a secondary boarding school, a market and several recreational facilities. Additional industries have been attracted to the area by the availability of modern infrastructure and well-qualified workers.

Flood Control—Prior to construction of the dam, floods occurred annually in the lower Volta valley. With the reservoir live storage capacity at twice the average yearly river inflow, severe floods are now only a remote possibility.

Fisheries—The development of lake fisheries has been an important secondary benefit of the project. It is estimated that in the mid-1950s around 1,000 people in the reservoir area were engaged in fisheries as their primary occupation for an annual catch of about 200 tons. In 1975, fisheries was the main activity of some 14,000 households in 1,500 villages around the lake and the annual catch was about 40,000 tons. Whether yields have been maintained at this level over the last twenty years is unknown.

Social and Environmental Impacts

Resettlement—Creation of the reservoir, an 8,482 km^2 man-made lake spreading 480 km north of Akosombo, required resettling some 80,000 people, mostly subsistence farmers, from 740 villages belonging to nine ethnic groups. Six different agencies were involved in the various aspects of the transfer which involved land valuation, provision of compensation, land clearing at new sites, and establishment of housing, infrastructure and community services for 52 resettlement villages, new units of 2,000–5,000 people consisting of several old villages. This complex operation was expected to be completed in two years when reservoir filling was scheduled to begin. There were inevitable delays; when the water began to rise, the VRA was brought in to coordinate the final evacuation.

People to be displaced were offered two options: (1) a one-time cash payment based on the value of their property, which they would use to "self-settle" and (2) full assistance from the Government to relocate in a new village, which meant some level of cash compensation, a supply of food until the next harvest, and basic housing. About 20 percent of the settlers chose the first option. The rest were moved to the resettlement villages where they were expected to engage in large-scale, mechanized farming, a departure from traditional practices that most, apparently, were ill-prepared to accept. Many also found the standardized housing provided—an unfinished two-room structure with concrete floor and aluminum roof—incompatible with traditional culture. Consolidating villages into new, larger settlements often led to rivalries and conflict, both inter- and intra-tribal, which made cooperative farming and communal activities difficult to achieve. After the first year, 59 percent of the settlers left the resettlement villages, convinced that the Government had reneged on its commitment to provide them better living conditions than they had in their previous locations. For all that, by project completion in 1966, the cost of the resettlement component had soared to US$26 million, 168 percent over the original budget. To complicate matters further, the new government that came into office in 1966 withdrew support for mechanized agriculture and sought to return the resettlement areas to smallholder, subsistence farming. Lack of consistent policy support, inadequate preparation, and unrealistic goals were all factors in the failure of Akosombo resettlement in its first phase. It is important to note also that the settlers were not alone in their complaints about living conditions in Ghana. Records from the mid-1960s show that more than a million Ghanaians left the country at this time in search of a better livelihood in nearby countries such as Nigeria and Cote d'Ivoire.

The resettlement sites have continued to undergo significant ecological and economic changes. Already by 1970 the climate had noticeably changed, becoming hotter and drier, a phenomenon that observers variously attribute to creation of the lake and to the VRA's extensive land clearing efforts in preparation for mechanized farming. Increased aridity not only adversely affected flora and fauna but also led to loss of soil cover and soil erosion, drastically lowering crop yields. This in turn set in motion a process of migration within the basin, particularly to fishing communities where income earning opportunities were high. A second major response to ecological change has been a shift into what is called drawdown irrigated farming, that is, planting the lakeside areas which are exposed as waters recede during the dry season. Like the fishing villages, the villages engaged in drawdown farming have enjoyed markedly higher incomes over the past decade. In neither case was the income potential from such activities taken into account by resettlement planners.

Health—At the time of appraisal in 1961, malaria, river blindness, and sleeping sickness were endemic to the project area. About 5 percent of the population living near the river suffered from schistosomiasis. After creation of the reservoir, the incidence of schistosomiasis increased from 5 to 90 percent among inhabitants of lake side villages; there are reports that this problem has been mitigated by drug therapy and molluscicides. The incidence of malaria remained at the same high level as before the project. Both river blindness and sleeping sickness reportedly declined significantly though no precise statistics are available. An increase in parasitic infections was reported in a survey conducted in the mid-1960s. Further research is needed for an up-to-date assessment of the project's health impacts.

Sedimentation—The reservoir has such a large volume compared to the annual inflow that it has a life measured in hundreds of years.

References

SAR, Report No. TO-249, June 1960.
SAR, Report No. TO-281a, August 1961.
SAR, Report No. PU-8a, May 1969.
SAR, Report No. 1299b-GH, March 1977.
PPAR , Report No. 1363, November 1976.
PPAR, Report No. 5731, June 1985.
PPAR, Report No. 12158, June 1993.
Bannerman, R.L.K. "Pre-and Post Impoundment Studies (1978-1982) in the Volta River Below the Akosombo Dam with Particular Emphasis on the Microbiology." Hydrobiologia 126, pp. 175-187, (1985).
Mills-Tetty, Ralph. "African Resettlement Housing." Habitat International (Vol. 13, No. 4), 1989.
Ofri-Cudjoe, Sam. "Environmental Impact Assessment in Ghana: An Ex Post Evaluation of the Volta Resettlement Scheme: The Case of the Kpong Hydro-Electric Project." The Environmentalist, Vol. 10, No. 2 (1990), pp. 115-126.
Tamakloe, Martha A. "Long-Term Impacts of Resettlement: The Akosombo Dam Experience." In Involuntary Resettlement: Africa, Ed. Cynthia C. Cook, pp. 99-111. Washington, D.C.: The World Bank, 1994.
"Was Ghana's Akosombo Dam the Best Option?" World Water (September 1989), pp. 35-36.

BACURATO IRRIGATION PROJECT (MEXICO)

The Project

The main features of the project are the 116 m high Bacurato Dam on the Sinaloa River, the Sinaloa Diversion Dam, irrigation systems to serve about 100,000 ha, and provision for future development of a 45 MW hydroelectric power station. A Bank loan of US$47 million was made for the project in May 1974. Cost overruns and shortage of local funds changed the scope of the project and the service area was cut back to 46,000 ha. However, after the Bank loan was closed in 1982, work continued and a service area of 90,000 ha has now been developed with further Bank financing.

The Sinaloa River rises in the Sierra Madre mountains and flows though the province of Sinaloa into the Pacific Ocean. Of the 100,000 ha planned for development by the project, some 50,000 ha had already been cleared and was being farmed on the left bank of the river. About 45,000 ha had some form of irrigation service, mostly from temporary diversion dams in the river but also from 160 wells. The area on the right bank was mostly undeveloped pasture. The supply of water to the irrigated areas was unreliable because the diversion dams were often washed out and the canals were poorly designed and constructed. Also, the flow in the river was subject to wide variations, with most of the flow coming in the form of floods in the summer months.

The Bacurato Dam forms a reservoir with a total capacity of 2.9 bcm which provides almost complete control of the annual flow of 1.2 bcm from a catchment area of 8,200 km^2. The volume of water available for irrigation each year is determined by the content of the reservoir in October. Water is diverted into the irrigation system at the Sinaloa de Leyva Diversion Dam, 46 km downstream from the Bacurato Dam.

Development Impact

The Bacurato dam was mainly designed to support the expansion and upgrading of the cultivated area in Mexico. Despite extensive delays in the implementation of irrigation infrastructure, the project has provided year-round irrigation to 78,380 ha. that had previously only had seasonal irrigation, and increased the irrigated area by about 27,000 ha. The availability of water facilitated a major shift in the cropping pattern, from crops such as cotton, rice, safflower and sugar cane, which faced unfavorable market conditions, to crops that responded to market demands, such as vegetables, maize, sorghum, soy beans, potatoes and wheat. Overall, the project promoted efficiency by encouraging the development of crops for which there was a strong market demand, which favored the growth of the more dynamic segment of farmers.

Land Tenure—There are two classes of land holders in the project area : private individual smallholders and ejidos. The ejidos are made up of individuals known as ejidatarios who have specific rights as members of an ejido. The ejido system was established as a land tenure system in the Agrarian Reform Law of 1915. The land is legally owned by an ejido but it cannot be transferred, rented or mortgaged. The ejido may operate as a communal farm, or individual ejidatarios may operate their share of land as private farms. In 1973, ejidos controlled 61,000 ha and private smallholders controlled 39,000 ha of the project area.

With the introduction of reliable irrigation, some changes in land tenure were expected to take place. Owners of presently irrigated land with water rights would be able to keep a maximum of 100 ha. Newly irrigated land would be reallocated under the Federal Water Law, and existing holders would be able to keep 20 ha units. The balance of the reallocated land would be used to form ejidos. Thus, the project was expected to have a favorable impact on income distribution. The project failed, however, to create mechanisms for improving the competitiveness of *ejido* farmers,[1] who ended up renting out part of their land to large farmers. This case illustrates the point that the pursuit of distributional objectives by means of irrigation projects is not inherent in the projects and needs to be planned in advance.

Agricultural—Mexico encountered some economic difficulties in the early stages of the project. As part of an economic stabilization program, there were cuts in funding of public projects. As a result, the scope of the Bank-financed project was reduced to 46,000 ha on the right bank only. By 1982, this scaled down version of the project was completed. Because of the delay in developing the whole area, the supply of water exceeded demand and, therefore, water was used to reclaim some areas with excessive salinity.

Prior to development, farmers in parts of the project area were growing a wide variety of crops, including high-value fruit and vegetables for export to the United States. This was reflected in the estimates of future cropping patterns which foresaw a mix of high-value crops and cereals, with some increase in cotton. The evidence in 1982 was that the areas of cotton and high-value crops had, indeed, increased and yields were generally above appraisal estimates.

Economic Evaluation—The ERR estimated at appraisal was 17 percent. In 1983, the return on the revised project was found to be 11 percent, and it was estimated that by the time the 100,000 ha was completed and in production the return would be 15 percent. These estimates are based only on irrigation benefits. The Bacurato Dam will greatly reduce the magnitude and frequency of floods in the Sinaloa, but the benefits of reduced flood damage were not estimated. In the 1984 audit report, the project was given a satisfactory rating.

Social and Environmental Impact

Resettlement—The reservoir inundated 5,600 ha of land owned by ejidos with a population of 2,900. These people were all resettled on irrigated land within the project area.

Environment—The project has had no adverse environmental impacts. Before the dam was built the flow downstream of Sinalao de Leyva was negligible throughout the dry season. During the hurricane season the river was in flood. The situation now is that the reservoir controls almost all of the flow at the dam site and virtually all of the reservoir releases are diverted at Sinaloa de Leyva. Now some water is released for downstream users in the dry season. In the hurricane season the river is in flood from the runoff below the dam, but floods are much less severe than in the past.

1. Ejido: settlement of small farmers on public lands, where the farmer has rights to use the land, but not property rights.

References:

SAR, Report No. 281 ME, November 1973.
SAR, Report No. 2454-ME, May 1979.
PAR, Report No. 5191, June 1984.
PCR, Report No. 13090, May 1994.
On-farm and Minor Irrigation Networks Improvement Project, January 1994.

BAYANO HYDROELECTRIC PROJECT (PANAMA)

The Project

The main features of the project are a 75 m high concrete gravity dam, and a powerhouse with space for four 75 MW units. The reservoir on the Bayano River has a capacity of 3.9 billion m^3 and covers an area of 350 km^2. The project was appraised in 1970 and completed in 1976. The estimated cost of the dam and the first two 75 MW units was US$58 million, and the Bank loan was US$42 million. The owner is Instituto de Recursos Hidráulicos y Electrificación (IRHE).

Project Rationale

In 1969, IRHE was given the exclusive right to construct and operate all new sources of electricity in Panama. At that time the total installed capacity in the country was 155 MW and demand was growing at an annual rate of 10 percent. The aims of the project were to meet the growth in demand and to replace numerous small diesel plants that were costly to operate.

According to the latest information received from the project agency (May 1996), project benefits include flood control and small-scale navigation (pirogues etc.).

Environmental and Social Impacts

Environment—The project flooded 35,000 ha of forest—the area was extremely diverse and many species were still unknown to science. The construction of the dam was a catalyst for completing the 250-mile Darien Gap—a part of the Pan American Highway penetrating tropical forests and swamps. The access roads (40 km) to the dam site opened the reservoir area and its surroundings to an influx of people and uncontrolled logging took place threatening the forests and the indigenous people which inhabited the area. Forests in the project area were clear-cut to the reservoir shoreline. Apparently lumber extracted from protected zones was conveyed to officially sanctioned lumber camps. The loss of the forest buffer zone around the reservoir has led to high siltation rates and has reduced the effectiveness of the reservoir (only 25–30 MW generated by the dam in 1988). There has been an extreme degradation of the watershed.

Laboratory studies on pre-and post-lake conditions indicate that there was an explosion in the population of disease vectors of yellow fever and encephalitis. By 1983 they had become highly eutrophied due to the decay of vegetation left in place before impounding. Numerous fish species were lost. The larger benthic invertebrate fauna (primarily Crustaceans) was almost completely eliminated. The lake adversely affected shrimp populations since the dam cut off sedimentation and reduced the food supply in Panama Bay (shrimp need to migrate to estuaries to reproduce). Also, many of the lost shrimp species depended on running, oxygenated waters—conditions which changed following impoundment. Native fish fauna was also seriously impacted. The eutrophication of the water was thought to be primarily responsible for the decline from 61 species from 26 families before closure to 13 species from 6 families after closure. The project agency notes that there was an initial decrease due to the change in water conditions (May 1996). Presently, however, the reservoir is being repopulated.

The large amounts of biomass left underwater resulted in fish kills which, however, recovered within 6–8 months and extremely contaminated water (as far away as El Llano the water was too contaminated to drink). Rapid growth of water lettuce, particularly in the upper reaches of the reservoir, led to navigation problems and also fostered mosquito breeding. Proliferation of aquatic vegetation is a problem and efforts continue to clear the reservoir. Approximately 1,400 ha of water lettuce were sprayed over a three year period, the impacts of which on human health and water quality have not been determined. The decay of the underwater biomass has also caused corrosion of equipment leading to maintenance costs. IHRE agreed (May 1996) that water quality is acidic because of decomposition of organic matter and suspended solids, and that proliferation of aquatic weeds is still a problem. This problem, however, disappears after some years of reservoir operation.

Resettlement—Reports on resettlement are not in agreement. The number of people affected appears to have been underestimated. An original estimate of 450 Indians was contradicted by later estimates of up to 1,900 indigenous peoples and 2,000–2,500 colonists. The project agency (in May 1996) noted that 4,123 people had been displaced. The Bank's PAR found the resettlement well-managed. However, other sources report conflicts remained, especially with respect to the indigenous peoples. Conflicts remained over the dislocation and resettlement of the Kuna and Emberá indigenous peoples who lost much of their ability to maintain their cultural traditions. Debates over land tenure arose as indigenous people claimed rights to land and the government attempted to limit their rights to newly settled areas. The Kuna were particularly affected, as 80 percent of their reserve was inundated by the dam. Seven villages containing the majority of the population were located along the affected Bayano tributaries. Compensation for the loss of fruit trees and other cultivation was promised. However, national policy dictated that any untitled land was owned by the state and did not have to be compensated. Few people had title to the land.

Resettlement teams pledged that villagers would be allowed to participate in the decision-making process, provided with health care, schools and technical and material assistance in agriculture. However, the teams were unable to meet the expectations that they had aroused. The most successful program was the establishment of schools, as many families took advantage of the improved educational opportunities. Programs to provide medical services were less successful, especially since the reservoir contained contaminated drinking-water supplies. The construction of aqueducts to provide potable water lagged far behind schedule. The medical centers were small, had inadequate supplies, and lacked functional equipment. Agriculture assistance included demonstrating techniques for managing crops but no follow-up efforts were made. Since the assistance programs were incompatible with existing modes of production, they failed and many of the young trees subsequently died.

Health—According to the project agency (May 1996) health conditions improved as a result of medical extension, infant nutrition and better sanitation which involved the construction of latrines. There were no outbreaks of disease associated with the project but there was an increase in vectors, namely, Culex mosquitoes.

References

SAR, Report No. PU-18a, February 1970.
PAR, Report No. 2508, May 1979.
LATEN Working Paper. "Good and Bad Dams: Ranking Hydroelectric Projects in Latin America Using Environmental and Social Criteria".

CERRON GRANDE HYDROELECTRIC PROJECT (EL SALVADOR)

The Project

The Sixth Power loan to El Salvador financed two operations: the larger of the projects consisted of the Cerrón Grande hydroelectric plant (the subject of this profile) financed jointly by the Inter-American Development Bank (IDB); which had the primary responsibility for project construction supervision; the, smaller project was a 30 MW geothermal unit at the Ahuachapán geothermal field. The Cerrón Grande hydroelectric development is located 40 km northeast of San Salvador at the headwaters of the Cinco de Noviembre reservoir along the Rio Lempa. It consists of an 76 m earth and rockfill dam across the Rio Lempa with an installed capacity of 135 MW, spillway, a surface powerhouse and a switchyard. The reservoir has a surface area of 135 km^2 with a storage capacity of 1,430 million m^3.

The hydroelectric component was completed virtually on schedule and generally as designed. The total cost of the hydro plant and related transmission was US$111.7 million. The final cost was 48 percent higher than the appraisal estimate in current prices and 3 percent higher in constant prices, mainly due to the underestimation of the costs of some items. Of the Bank's total loan amount of US$26.9[2] million, approximately US$11.3 million was allocated for the hydro component excluding transmission features. The re-calculated incremental financial rate of return on the whole project (Cerrón Grande and Ahuachapán) is 11.6 percent compared to the appraisal estimate of 16.7 percent, primarily due to the cost overrun and a decrease in tariffs in real terms. Project outcome was rated as satisfactory.

The Ahuachapán geothermal plant's main components are steam separators, a powerhouse, switchyard, and a canal to discharge geothermal effluent, into the ocean. Until the canal was completed, however, the Comisión Ejecutiva Hidroeléctrica del Rio Lempa (CEL) operated the plant and disposed the effluent partly by injection into the geothermal field and partly by discharge into the Paz River. This discharge into the Paz River had negative environmental implications on human health and animal and plant life, as well as the potential for serious conflict between Guatemala and El Salvador concerning riparian rights. The Bank recognized this and formally requested CEL to prepare a program for temporary, safe disposal of the wastewater. The Government of Guatemala had already made strong formal representations to El Salvador and the Bank against geothermal wastewater discharges into the Paz River. The Bank had the Pan American Health Organization (PAHO) evaluate the situation and make recommendations on permissible levels of contaminants in the river. CEL accepted PAHO's recommendations but did not always carry them out in a fully satisfactory manner. However, the problem was solved when the canal was completed.

Project Rationale

El Salvador has only two indigenous energy resources of any magnitude: the Rio Lempa and geothermal fields. Since the creation of CEL in the 1940s power development in the country has been concentrated on the Lempa river system. Future development focuses on the continued exploitation of the Rio Lempa and geothermal sources. During the ten-year period 1962–1971,

---

2. About US$0.38 million from the original loan amount of US$27.3 million was canceled as a result of less than expected disbursements on equipment purchases and engineering services at Cerron Grande, studies, training, and interest.

production of electricity in El Salvador increased by 168 percent, reaching a level of 711.8 GWh in 1971. A rate of growth of 11 percent per year for energy demand through 1984 was forecast. It was thought that CEL's installed generating capacity of 199 MW would be able to meet the demand only through 1973. Thus, CEL would have little or no surplus capacity until the completion of Cerrón Grande.

Both Cerrón Grande and Ahuachapán represented the least-cost solutions compared to the only other available alternative, namely, a conventional oil-fired thermal plant, in order to meet the growth in power demand. They also enabled the country to utilize its only known indigenous energy sources—hydroelectric and geothermal power.

Development Impacts

Actual energy sales were in line with appraisal estimates. The project, therefore, achieved the expected objective of meeting the forecast growth in energy demand. The combined energy generation of Cerrón Grande and Ahuachapán in 1978 amounted to almost 56 percent of total energy generation.[3]

Social and Environmental Impacts

Resettlement—The main implication of the reservoir involved the relocation and employment of approximately 65,000 people (according to the project agency, May 1996), mostly small landholders and landless farm workers and their families living in the area to be flooded. Because of the comparatively large size of the dam and reservoir, it was agreed that CEL would conduct periodic inspections of the dam and associated structures to ensure dam safety. According to the PCR, Bank staff devoted particular attention during appraisal to the resettlement and environmental problems associated with the project. Cerrón Grande had been a subject of political controversy in the country and Bank staff indicated a strong interest in CEL's preparing an acceptable resettlement and environmental program for the people who would be displaced by the project's reservoir. The Loan Agreement included provisions which obliged CEL to undertake the project "with due regard to ecological and environmental factors "(Section 3.04 [ii]) and "prepare and implement plans satisfactory to the Bank for the resettlement and employment of the population displaced by the Cerrón Grande reservoir" (Section 3.05). A program for resettlement was prepared and later executed to the satisfaction of the Bank.

Environment—The SAR estimated that the reservoir would flood 13,500 ha of land of which 4,400 ha was fertile farmland under intensive cultivation. Creation of the reservoir would necessitate the relocation of a sugar mill and reconstruction of portions of a roadway, including a bridge. The loss of net agricultural return from the loss of crops (mainly sugar cane and maize) was estimated at US$1.2 million annually. According to available information, there were no mineral resources, historical sites, or rare plant and animal species in the area to be inundated. An ecological survey carried out by a consultant for the previous Cinco de Noviembre reservoir (located immediately downstream from Cerrón Grande) and its subsequent operation for 20 years indicated no adverse ecological impacts. Thus, it was assumed that Cerrón Grande would not have any adverse impacts either apart from the resettlement aspect. There is a possibility of

3. The SAR had noted that the regulating capacity of the Cerrón Grande would provide additional downstream benefits such as reduction in flood losses, possibilities of increased agricultural production in the lower Lempa basin, and increased potential generation of future hydro projects. The PCR did not touch upon any of these issues.

significant sedimentation in the long run. The PCR notes that a reconnaissance of the project's environmental impact was carried out but does not provide any additional information on the subject.

References

The World Bank. Sixth Power Project (Loan 0889-ES). Staff Appraisal, Report, No. 69a-ES. April 11, 1973.

The World Bank. Sixth Power Project (Loan 0889-ES). Project Performance Audit Report, No. 3053. June 27, 1980.

The World Bank. Sixth Power Project (Loan 0889-ES). Project Completion Report.

Proceedings from the Workshop on Sectoral Environmental Assessment of the Power Sector in El Salvador. April 18, 1996.

CEYHAN ASLANTAS MULTIPURPOSE PROJECT (TURKEY)

The Project

The Ceyhan Aslantas Multipurpose Project is located in Southern Turkey on the Ceyhan River, 350 km southeast of Ankara, near the provincial capital town of Adana. Its principal features are the Aslantas Dam, a 95 m high earthfill dam, a 49 km^2 reservoir with a storage capacity of 1,190 cum plus flood control storage of 460 cum, a gated chute type spillway with a conventional spilling basin fitted with six gates, a power plant with an installed capacity of 138 MW and a switchyard. The project also financed land acquisition for the reservoir area and for distribution systems and project roads (6,250 ha), flood protection dikes, purchase of hydromechanical and electrical equipment, irrigation and drainage networks to serve 97,000 ha, on-farm development of 97,000 ha, and purchase of dairy cattle for mixed farming demonstrations.

The project was closed four years behind the original schedule mainly due to delays resulting from the difficult period Turkey went through in the late 1970s. Project implementation was also affected by insufficient early planning, poor designs, inadequate supervision of contractors and little involvement of project beneficiaries in project planning and implementation. The main technical problem encountered was the failure of one of the six spillway radial gates which cause flooding and the loss of US$3 million worth of crop but it did not affect irrigation or electricity generation. On-farm works were delayed by the late delivery of heavy equipment and the refusal of farmers to allow land leveling after the irrigation network had been constructed (currently, irrigation is proceeding as planned). The total project cost amounted to US$446.9 million which was 39 percent above appraisal estimates. Although the overall project ERR was estimated by the PCR at 12.4 percent (13.3 percent at appraisal), the PPAR had some doubts on the validity of the ERR for the irrigation component. The audit also found that the PCR did not provide sufficient base data to review the validity of the ERR expected for some other project components, such as power and flood control. The project outcome is rated as positive as general objectives were achieved, and there are good prospects of sustained future benefits.

Project Rationale

Agriculture in Turkey plays a key role in the economy representing 18 percent of GDP, about one-third of export earnings, and approximately half the employment of the civilian population. A major factor in increasing and stabilizing agricultural production has been irrigation. About 40 percent of all crop production is dependent on supplemental or full irrigation, including some 25 percent of all agricultural exports. The Seyhan Irrigation Project, which is similar to the Ceyhan Aslantas Multipurpose Project, was considered one of the country's most successful irrigation developments. An OED Impact Evaluation Review conducted ten years after completion of the project clearly demonstrated the improved socio-economic well-being of beneficiary farming communities. The Ceyhan Aslantas project proposed to attempt to capitalize on the success of the Seyhan project by constructing a multipurpose dam for flood control, power, and irrigation designed to develop the agricultural and related industrial potential of the Ceyhan plain in the East Mediterranean region and southern Turkey. The primary objectives of the Ceyhan Aslantas project were to increase crop production and cotton and textile exports, provide irrigation and drainage of 97,000 hectares, flood protection of 35,000 hectares, and generate 500 GWh of electricity annually.

An optimizing study investigated the economic justification of the project comparing costs at Aslantas with those of an alternative thermal power plant. Though most of the power generated by Aslantas would be utilized within the region, the project was examined because it would be operated as part of the Turkish Electricity Authority's (TEK) interconnected system and it was compared to alternative developments within this interconnected system.

Development Impacts

The power plant which is operated by TEK has been generating electricity since 1984. Currently, monthly electricity production is approximately 50 million kWh. Farm incomes have increased and the overall standard of living has improved considerably.[4] The project was successful in promoting second cropping thereby increasing production. The progress made in farmer adoption of a second crop of peanuts or soybeans following winter wheat has been much faster than anticipated. Project investments for improved livestock production and the effects of the integrated extension service have resulted in substantial increases in livestock production. The project is also supposed to result in substantially higher flood control benefits than estimated at appraisal.

Social and Environmental Impacts

Resettlement—The project required the expropriation of 6,500 ha of land, mostly arable, and the flooding of four village centers and 25 small neighborhood units resulting in the displacement of 5,000 people. The SAR noted, though, that in accordance with Turkish law no resettlement costs could be paid to the displaced people who would be able to purchase land elsewhere with the compensation they received. The Bank did discuss the possibility of a resettlement scheme with the Government but was told that in previous acquisitions for similar purposes this had not been done and that no exceptions could be made. Inadequate compensation proposals led to widespread protests and to a recalculation of land values, still far short of current values. The problem was further exacerbated by the high rates of inflation to which no solution appears to have been found. In addition, the project did not pay any special attention to the development of human resources, other than through extension. No data is available on the impact of the project on women, which has been indirect. For instance, better water supply and overall improved standards of living. The social components more particularly aimed at women such as laundries and bath houses, have failed to be adopted by the local population. No concerted effort was made in the orientation of extension to women, who are very active in the fields, but extension services do have women staff. However, reaching women farmers was not raised by anyone as a particular issue.

Environment—Thermal springs at the extreme upper limit of the Aslantas reservoir and Hittite sites of archaeological significance at Karatepe have remained 20 m above the maximum flood elevation.[5] Access to the Hittite stones has been improved by the construction of the dam access road. As forecast at appraisal, a small crusader castle already in poor condition and one of many in the region, was submerged. The SAR pointed out that the reservoir was supposed to greatly

4. The larger owner-operated farms have shown the greatest improvement but tenant farmers have not improved their income due, primarily, to the large increases in land rental prices.

5. Interestingly, the PCR states that one important cause of the higher generation cost at Aslantas is due to the fact that the reservoir level had to be kept at a level below the site of the Hittite stones at Karatepe.

expand recreational amenities in the area and possibly lead to the development of a fresh water fishery. The PCR, however, does not mention this. No other reference is made to the impact of the project on the environment.

Health—The SAR noted that an upsurge in the incidence of malaria was anticipated in the vicinity of the Aslantas reservoir once it became operational. Existing health services in the area were judged to be sufficiently capable in controlling the phenomenon. It also pointed out that there was no occurrence of schistosomiasis in the Province. The PCR, however, does not touch upon any impacts that the project had on the health of the population in the area.

References

The World Bank. Ceyhan Aslantas Multipurpose Project (Loan 0883-TU, Credit 0360-TU). Staff Appraisal Report No. 16a-TU. January 31, 1973.

The World Bank. Ceyhan Aslantas Multipurpose Project (Loan 0883-TU, Credit 0360-TU). Project Performance Audit Report, No. 6756. May 7, 1987.

The World Bank. Ceyhan Aslantas Multipurpose Project (Loan 0883-TU, Credit 0360-TU). Project Completion Report. June 20, 1985.

CHIEW LARN HYDROELECTRIC PROJECT (THAILAND)

The Project

The main features of the project are a 94 m high rockfill on the Khlong Saeng in Southern Thailand, and a 240 MW powerhouse. The project was a part of the Power Subsector Project appraised in 1981, which made a US$250 million loan to finance the Chiew Larn and Lang Suan hydroelectric projects and various transmission lines. The Lang Suan Project was subsequently dropped by the Government because of environmental and resettlement problems. Chiew Larn was constructed between 1983 and 1987, at a cost of US$180 million, close to the appraisal estimate for the base cost. The owner is the Electricity Generating and Transmission Authority of Thailand (EGAT).

Project Rationale

The project was part of EGAT's 1980-1986 program for system expansion to meet a demand growth at an annual rate of 14 percent. Thailand's policy is to diversify its sources of electricity. It has domestic resources of lignite and natural gas but these are already heavily exploited. Most of the hydroelectric sites have been developed and their reservoirs are increasingly managed in the interests of irrigation and water supply. At appraisal no analysis was made of Chiew Larn itself. Instead, the 1980-86 program was analyzed and found to have an IERR of 12 percent.

Development Impact

After some slackening for a few years in the 1980s, Thailand's electricity demands have continued to grow rapidly. When Chiew Larn was appraised, the demand was 2,500 MW and it is now 12,000 MW. Thus, it is evident that the output of the Chiew Larn Project is fully utilized. On completion of the project, EGAT estimated that Chiew Larn was the least-cost alternative at discount rates below 23 percent.

Other Benefits—The project has made available a reliable water supply which permits irrigation in the dry season and facilitates flood control in the wet season. The stored water from the Chiew Larn Reservoir is supplied to an agricultural area of approximately 92,000 rais. The reservoir has also developed significant fisheries. From January 1987 to April 1988, 433 tons of fish, equivalent to US$216,000 approximately, was caught in the reservoir. The reservoir has also become an important tourist attraction in the southern part of the country.

Social and Environmental Impacts

Resettlement—The performance of EGAT in resettlement has been good in other Bank-financed dams in Thailand. The reservoir displaced 385 families (2118 people) according to the project agency (June 1996) who were resettled satisfactorily by EGAT. Approximately US$580,000 was paid as compensation to the villagers from the four villages affected by the project. A new village was constructed and each family was provided with one rai (equivalent to 1,600 m^2) of land for the home plot and 19 rai for rubber plantation. The infrastructure provided included 37.8 km of asphalt road, 40 km of lateritic road for the rubber plantation area, a supply power line, domestic water supply system, a school, health center, etc. The PCR notes that the resettlers are satisfied after moving into the new village. The new location was not far away from the old villages. Family incomes were supposed to increase twofold after relocation. An agricultural cooperative society was established in the new village and several training and development programs were arranged to supplement people's livelihoods and increase their incomes.

EGAT successfully dealt with the few problems that cropped up. Initial mistrust on the part of the people who were skeptical about EGAT's commitment to implementing its announced plans had to be overcome. A Resettlement Committee was appointed to deal with the details of the resettlement program such as determining who was eligible for compensation, the exact number of each family's land holdings, etc.

Environment—The PCR does not mention any impacts that the project had on the environment. According to the project agency (June 1996) a reforestation program is under implementation and wood cutting is prohibited, but no other details were provided. Sedimentation does not appear to be a problem as the annual rate of sedimentation is 0.4 million cubic meters. The total reservoir volume is 5,639 million cubic meters and the estimated remaining useful life of the reservoir is 8,000 years.

References

SAR, Report No. 158-TH, April 1981.
PCR, Report No. 7887, June 1989.

CHILATAN IRRIGATION PROJECT (MEXICO)

The Project

The main project features are a 106 m high rockfill dam on the Tepalcatepec River, a 28 MW hydropower plant, and new and improved irrigation and drainage canals serving 67,750 ha. The project is located in the Apatzingan Valley about 400 km west of Mexico City. The project was appraised in 1979 and scheduled for completion in 1986. However, reductions in the project's scope and financing in 1984 and 1987, reflecting general cuts in public spending, resulted in long delays in project implementation. The project was expected to be completed in 1995. The total project cost was US$407 million, financed in part by a Bank loan of US$160 million.

Project Rationale

In the late 1960s Mexico's agricultural GDP growth began to decline from the 4 percent a year average over the previous 15 years to under 3 percent, below the rate of population growth. This decline was in response to the high cost of bringing marginal land into production, a slowdown in the expansion of irrigated areas, inefficient water use, and inadequate drainage of irrigated land. The result was a reduction in cropped areas and yields. Mexico moved from food self-sufficiency to dependence on import of basic foodstuffs. To reverse this trend, in the 1970s the Government launched a number of irrigation projects, some Bank-financed, to upgrade and expand the cultivated area.

The original aim of the project was to raise crop yields and incomes for some 9,800 farm families through improved water delivery to 109,000 ha in the Apatzingan Valley. In the amended project, the total service area was scaled back to 67,750 ha. Despite abundant water resources available from the Tepalcatepec River and its tributaries, existing irrigation suffered from the lack of a reservoir to conserve the river flows, poor water control, and the need for extensive land leveling.

At the time of appraisal in 1979, alternative designs were studied to improve the Chilatán system serving the Apatzingan Valley. The alternatives were: (a) tapping water from additional wells and pumping from the Tepalcatepec River, and (b) constructing a storage dam at Chilatán and building conveyance canals from the Tepalcatepec River. To compare alternatives, the net benefit was derived over a range of electricity prices, up to the economic price of electricity (estimated to be US$0.03 per kWh in 1979). Construction of the dam yielded in the 1970s the highest net present value. Since there was a trend towards electricity price increases in Mexico, this was the alternative chosen. The construction of the dam also offered the potential of power generation at some later date, and municipal water supply.

Development Impacts

Despite delays in implementation, the project's overall impact has been positive. In a study undertaken by the Bank in 1991 as part of the Irrigation and Drainage Sector Project, the economic rate of return for the Tepalcatepec area, the area served by the Chilatán system, was calculated at 15.9 percent, notably higher than the 13.5 percent estimated at the time of appraisal. As noted in the 1993 PCR, adequate and reliable water delivery, made possible by the Chilatán dam and its associated irrigation works, has stimulated entrepreneurial development of high value fruits and vegetables, thus raising farm incomes in the project area. Though this cropping pattern was unanticipated at the time of appraisal, which instead projected increases in a mix of grains, cotton, vegetables and pasture crops, it is well suited to market demand. The area planted with mango and limes has increased 76 percent and melon and vegetables increased 18 percent. The aforementioned crops constitute about 75 percent of the current cropping pattern. Yields have increased significantly: from 2.4 to 5.3 tons/ha for maize, from 12 to 15 tons/ha for papaya, from 25 to 40 tons/ha for pasture crops.

One of the positive and unanticipated benefits of the project has been the increase in employment in the produce-grading and packing industries in the Apatzingan Valley. There are about 50 small and medium-size packing houses for fruits and vegetables, two oil extraction plants, and 12 packing plants for mangos. New opportunities are expected to develop in the future. Other benefits of the project include power generation, improvements in flood control and municipal water supply. In 1990, a 28 MW power plant was added.

Social and Environmental Impacts

The project included a component to resettle about 80 farm families (about 400 people) living in the reservoir area. People were provided with housing, schools, and other infrastructure and were moved apparently without incident. A total of 7,900 families in the project area have directly benefited from increases in farm production, off-farm job opportunities, and overall income as a result of the project. On the environmental side, the only impact of any note has been a positive one: a reduction in flooding of lowland cultivated areas as a result of better water management and improved drainage.

References

SAR, Report No. 2915 ME, May 1980.
PCR, Report No. SecM93-863, August 1993.
Mexico: Irrigation and Drainage Sector Project (IDSP), Ln. 3419-ME, December 1992
Presa Constitución de Apatzingan...para una Nueva Agricultura. Mexico, DF: Comisión Nacional de Agua, 1994. pp. 1-73.

CHIVOR HYDROELECTRIC PROJECT (COLOMBIA)

The Project

The main features of the project are a 237 m high rockfill dam on the Bata River, a 5.7 km long power tunnel, a 2,000 m long penstock, and a powerhouse with space for eight 125 MW units. The reservoir has a storage capacity of 815 million m^3. The cost of the project was estimated at US$114 million at appraisal in 1970. Bank financing was US$52 million, and about US$23 million was supplied through supplier credits. The project is owned by Interconexión Eléctrica S.A. (ISA), formed in 1967 for the interconnection of the four main electric systems in central Colombia, comprising about two-thirds of Colombia's entire power sector.

Project Rationale

At the time of appraisal, the combined demand of the four utilities was 1,260 MW with future growth estimated at around 10 percent. Chivor was part of a least-cost power expansion plan developed by ISA to meet the rapid growth in demand expected in the 1970s.

Development Impact

The project met its objectives in the 1970s, and it was developed to its full capacity of 1,008 MW in 1982. By the late 1980s, Colombia had a considerable surplus of power generating capacity. This in part was due to over investment in capacity by the individual utilities, and also because of inadequate investment in transmission and distribution. The situation has now improved, but it seems that some of the projects could have been deferred. Chivor has been, and will continue to be, a valuable component of Colombia's power system.

Social and Environmental Impacts

Environment—The project agency implemented a program to improve watershed management for the Chivor reservoir, where sedimentation had accelerated as a result of deforestation and poor land use. The US$29 million, 10-year program involves reforesting 50,000 ha of land, soil conservation works, and protection of remaining natural forests. The program has been successful in promoting better land uses and increasing tree cover in critical areas. The program reforests 1,500 ha every year and is financed by a 2 percent tax on all hydroelectricity sold from the Chivor basin.

Resettlement—The project agency stated (May 1996) that the reservoir displaced 1,171 persons. The SAR noted that the project would involve the relocation of its access road but nothing further was intimated on resettlement. There was no mention anywhere of land acquisition either. The audit mentioned the relocation of 30 km of access road from Somodoco to Santa Maria and 8 km to works. However, like the SAR, the audit, too, there was nothing on land acquisition, resettlement or the environment in the cost estimate or elsewhere. It is assumed that the displaced were resettled in a satisfactory manner. Water from the reservoir and electricity was supplied to nearby communities. A reforestation program was carried out in the catchment area, and the reservoir has been stocked with fish.

In May 1996 the project agency provided OED with extracts from a report on the social impacts of the dam prepared by a sociologist. The report notes that the project had a major impact, both positive and adverse, on the physical and social environment in some municipalities of the Valle de Tenza. The reservoir flooded lands of low fertility which had been mostly occupied by low-income smallholders. The reservoir also separated five communities in Macanal from its urban center. It introduced a new transport form into the community and it reconnected a previously forgotten and neglected region to the rest of the province. The project also facilitated a more intense inter-community communication system and improved communications in the community and municipality. ISA (the utility) used funds that came from tax revenues to develop rural electricity, help the local communities undertake reforestation, etc.

References

SAR, Report No. PU-31a, May 1970.

PAR, Report No. 2720, October 1979.

Draft LATEN Working Paper. April 1995. "Good and Bad Dams: Ranking Hydroelectric Projects in Latin America Using Environmental and Social Criteria".

Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation: Feedback into Resettlement Planning".

CHIXOY HYDROELECTRIC PROJECT (GUATEMALA)

The Project

The project's main features are a 133 meter high rockfill dam on the Chixoy River, a 26 km power tunnel, and a surface powerhouse with five 60 MW generating units and associated transmission lines. The 13 km^2 reservoir stores about 424 million m^3. The Chixoy plant is located in a sparsely populated, mountainous region about 100 km north of Guatemala City. The project was appraised in 1978 at an estimated cost of US$372 million, financed in part by a Bank loan of US$72 million. At the time the plant was commissioned in 1985, about three and one half years behind schedule, costs were 67 percent above original estimates in real terms and benefits were severely reduced.

Project Rationale

Sector Background—A 1962 UNDP power sector survey and master plan recommended that Guatemala exploit its abundant hydroelectric resources. The Chixoy River area was identified as a promising site for hydroelectric development. However, over the next decade most of the modest increase in generating capacity came from development of small thermal plants. The only significant action taken to develop hydroelectric resources in these years was construction of the 60 MW Jurun-Marinala plant which, despite its limited size, represented half of the country's installed hydroelectric capacity when it was commissioned. The latter figure, 120 MW, was only 2.5 percent of Guatemala's estimated 4,300 MW of technically exploitable hydroelectric capacity. By the mid-1970s, Guatemala's shortage of electrical energy was becoming acute. Consumption estimated at about 188 kWh per capita (1975), was the lowest in Central America and well below the Latin American regional average. Shortages threatened to curb expansion of the industrial sector.

What lent particular urgency to solving Guatemala's energy problem was the escalating price of imported fuel after the oil crisis of 1973. Thermal development no longer seemed as attractive an option as it had ten years before. In 1974, the Government prepared a new plan for accelerated investments in hydroelectric development. Of some 120 hydroelectric sites under review, facilities on the Chixoy and Aguacapa rivers were identified as the most economically attractive investments and viable candidates for outside donor financing.

Objectives and Design—The aim of the project was to exploit the hydroelectric potential of the Chixoy River to provide Guatemala with an additional 300 MW of hydro generating capacity by 1982. Projections indicated that with the Chixoy plant in operation, Instituto Nacional de Electrificación (INDE), Guatemala's main electricity authority and the entity responsible for power expansion, would be able to maintain adequate service reliability in the face of rising power demands. Developing hydroelectric was also expected to make possible a substantial reduction in thermal generation, thus reducing the country's dependence on imported fuel. The Bank also viewed the project as a vehicle for continued assistance to the Government in power sector reforms, particularly strengthening INDE's management structure. Finally, components were included in the project to resettle the 1,500 people to be displaced by the reservoir and to initiate erosion control measures.

A series of feasibility studies and site investigations financed by the Inter-American Development Bank (IDB) and involving numerous engineering consultants were carried out prior to the Bank's appraisal of the project in 1977-78. Prepared on an accelerated schedule to respond to the urgency of Guatemala's energy crisis, these various reviews nonetheless highlighted the technical risks involved in construction of the Chixoy plant, especially problems in constructing hydraulic structures in a complex geologic area with karstic (cavernous) limestone.

Economic Justification—In 1976, during its appraisal of the Aguacapa power project, the Bank identified combined investments in the Aguacapa and Chixoy hydroelectric plants and a geothermal plant as the least-cost solution for sector expansion in the period 1979-1989. Changes in estimated costs in the next year led to an alternative program involving Chixoy followed by the Serchil hydroelectric plant which would be operated to handle peaking capacity. The Chixoy-Serchil sequence was compared with a combined thermal-hydro program which was the only feasible alternative capable of meeting demand by the 1982 target date. Chixoy-Serchil was found to be the least-cost solution at discount rates below 13 percent or below 21 percent if initial (1977) investment in Chixoy was treated as sunk cost. Chixoy-Serchil was further compared with an all thermal program and was found to be the least-cost solution at discount rates below 18 percent. The economic rate of return for the Chixoy project was estimated to be about 13 percent.

Development Impact

The Chixoy project encountered numerous problems. In part, these were due to an incomplete understanding of the geological complexities at the construction site, some of which would have been detected with more rigorous subsoil investigations (the fault line under the powerhouse), others more difficult to anticipate (the extent to which anhydrite would be eroded in the tunnel lining). The 130 percent cost overrun for the project was, therefore, attributable both to cost underestimates at the time of appraisal and a convergence of unlucky circumstances. Much of the discussion in subsequent Bank reviews of the project relates to construction risks and who bore responsibility for failing to take them adequately into account. Chixoy also suffered from macroeconomic events outside the control of project planners, including inflation, currency adjustments, and the fact that world oil prices, expected to continue rising, actually declined in the mid 1980s.

The Chixoy Project proved to be an uneconomic investment. INDE's own revised analysis, prepared in 1989, showed a return on investment of only 2.4 percent based on final cost data for the investment program of 1976-1990 and on benefits reflecting reduced incremental sales growth and reduced fuel savings. The Bank's 1992 PAR, which rated the project as unsatisfactory, showed a recalculated equalizing discount rate no higher than 8 percent, well below the opportunity cost of capital. On an even more alarming note, the report questioned the sustainability of any level of benefit at all from the project because new leaks had developed in a stretch of the tunnel. With benefit of hindsight, it seemed that installation of thermal plants followed by a well-prepared hydro plant might have been the best course of action.

On the other hand, even at generation levels well below those expected at appraisal (about 1,300 GWh annually for 1990-1994 compared to 1,540 at appraisal), Chixoy's output has contributed importantly to total national energy generation: 69 percent in 1990 and 34 percent in the drought year of 1994. Projections for 1996.show Chixoy contributing 33 percent or 1,289 GWh of

Guatemala's total electricity needs and over 70 percent of the country's hydro generation. An INDE report issued in 1995 maintains that given the recent high cost of thermal power, Chixoy has had, on balance, a positive economic impact. This report makes no further mention of leaks in the 26 km tunnel.

Social and Environmental Impacts

Resettlement—Like the civil works parts of the project, the social and environmental component was plagued by a combination of bad luck and bad planning. To begin with, insurgency in the project area delayed the startup date for these activities. An even more basic problem, and one that persisted, was that INDE considered such issues as environment and resettlement to be relatively unimportant. Situated in Guatemala's remote highlands, the project required resettlement of 2,500 Maya Indians. But what should have been a straightforward task became a problem in the absence of advanced planning. No provisions were made for baseline data collection, phased implementation, performance evaluation, or follow-up social services for displaced people.

While the resettlement program was submitted and approved in 1979, its design was later (1984) judged to be flawed in concept, and its implementation was delayed due to intensive insurgency activity in the project area during the years 1980–83. In 1984, a modified resettlement program was designed and adopted as one of the conditions for the 1985 supplemental loan. However, delays in implementation persisted not only because of continued difficulties in acquiring land, but also in transferring title to land and houses to those being resettled. While construction of new settlements was nearly complete by mid-1989, not all compensation payments had been made, some land and title transfers were still outstanding, and some families lacked potable water. Schools and clinics had been built but were not operating due to lack of teachers, doctors, and equipment. Many of the settlers were unhappy with their new farm sites which they felt were not suited to the type of agriculture they knew best. By the late 1980s reservoir fisheries was proving an economic boon for about 80 families in the area, but this was the result of their own ingenuity rather than part of a program sponsored by INDE.

Most recently, there have been reports of a massacre of about 400 indigenous people from Rio Negro, one of the communities in the reservoir area, within the context of a civil war that (from 1980-84) led to the death and disappearance of about 72,000 people nationwide. There are two reasons to believe that the killing was related to the civil unrest and not to the resettlement. First, massive killing (of about 5000 people or 14 percent of the population) occurred in all the villages of the Rabinal municipality even though only Rio Negro was to be resettled. Second, the killing took place after the resettlers from Rio Negro had already moved to temporary housing along with people from 20 other villages from other municipalities.

Environment—INDE's own ecologists, hired to review "human ecology, flora, fauna, hydrology, and archaeology" concluded that the project's environmental impact "would not be significant." As a result, though INDE arranged for survey work to be done as required by the Bank, there was no coordination among agencies and no comprehensive planning for basin protection. The only real success in the "socio-environmental" category was work carried out by the Institute of Anthropology and History to survey and excavate archaeological sites in the reservoir area. A 1989 Bank-financed environmental review of Chixoy noted that large areas near the dam site had been deforested, the result of years of construction and what it terms "makeshift agricultural arrangements." A reforestation plan to control erosion at the Chixoy construction site was then in its first year, but community support for the effort was uncertain. In 1995 INDE reported some damage to the ecology of the project area, citing the inadequacy of forest management. On the other hand, this same report concluded that because of unusually favorable natural conditions, the project's negative effects were minimal overall.

Health—According to a recently (1995) report issued by INDE, there has been no change to date in the health status of the population in the project area. Such diseases as schistosomiasis and dengue fever which are endemic to the region have occurred in the Chixoy area with no greater frequency than elsewhere. On the other hand, there is some concern about possible deterioration of reservoir water quality, particularly in the absence of routine monitoring by INDE.

References

SAR, Report No. 1709b-GU, June 1978.
PCR, Report No. 10258, December 1991.
PAR, Report No. 10830, June 1992.
Instituto Nacional de Electrificación (INDE), *Reportes de Generación* and *Comentarios Sobre Aspectos Sociales, Ecológicos y Financieros de la Planta Chixoy*, 1995.
Bryson, Christopher L. "Guatemala: A Development Dream Turns into Repayment Nightmare." Christian Science Monitor, 1985.
"Critics: Chixoy Tunnel Doomed to Collapse Again" *News In Brief*, Central America Report-375, 1985.
See "A People Dammed - The Impact of the World Bank Chixoy Hydroelectric Project in Guatemala", Witness for Peace, Washington, D.C., 1995.

CHUNGJU MULTIPURPOSE PROJECT (KOREA)

The Project

The main features of the project are a 98 meter high concrete dam on the South Han river, a power house with four 115 MW generating units, and a reregulating dam 20 km downstream of the main dam. The project involved relocation of 300 km of roads and 13 km of railroad. The project was appraised by the Bank in 1978 and completed on schedule in 1984. The cost was US$602 million, financed in part by a Bank Loan of US$125 million and a loan of Yen 14,000 million from the Overseas Cooperation Fund (OECF) of Japan.

Project Rationale

The project's primary purpose is to exploit the waters of the South Han River to meet the rapid growth in water demands for the capital city of Seoul and neighboring cities, including the port of Incheon.

The Han River has two main branches the North Han and the South Han which join together 35 km upstream of Seoul to form the Lower Han. The Han River Basin covers 26 percent of Korea's land area and contains one-third of its population. The Han River Basin Study, carried out in 1970 with assistance from USAID, formulated a long-range comprehensive plan for the Basin's development. Since the North Han was already developed by two existing dams, it was found that additional storage would be needed in the Basin by 1986 and that this requirement would be best satisfied by the Chungju Project. USAID subsequently financed a feasibility study of the project which contributed to the Bank's appraisal of the project.

In its appraisal of the project, the Bank conducted basin studies which confirmed the findings of the Han Basin Study. It found that the Chungju project was economically superior to other possible sources of water and power. The project was subjected to a least-cost analysis. The Chungju Project was compared to alternatives for meeting the water demands of the Basin. Ground water was already fully exploited, so the only alternative to Chungju was the construction of other dams on the North and South Han. In terms of power, the alternative was a gas-fired combined-cycle power plant. The alternative for flood control would, theoretically, be embankments, but these were found to be technically unfeasible. Thus, as a proxy for a flood control alternative, the estimated annual flood control benefits were used. These benefits included avoided flood damages and also enhancements in agricultural land use due to reduced flood risks. It was found that Chungju was justified as the least-cost alternative at discount rates as high as 19 percent.

More efficient use of water and electricity through conservation measures was not a viable alternative to the project. In regard to water supply for Seoul, conservation would have deferred the need for the project by only a year or two. In the case of power, Chungju's output is a very small part of the power system, so conservation would not have materially affected the project's timing. The economic rate of return was calculated as 12 percent. The economic benefits of water and electrical energy produced by the project were quantified by the current retail tariff for energy and the bulk water tariff for water. Flood control benefits were as described above.

Development Impact

Since its completion in 1984, the Chungju project has secured the water supply for the Seoul area (in Seoul-Incheon which contains 25 percent of Korea's population and 50 percent of its industry), reduced the frequency and magnitude of flooding along the Han river valley, and provided a valuable source of quick response peaking capacity for the national power system; it generates about 740 GWh per year of clean, renewable energy. The quantification of the economic benefits of water supply needs to take into account the multiple uses of water, including municipal, industrial and irrigation uses. Based on information provided by the owner, bulk sales of water for domestic and industrial uses were about $21.1 million (in 1995). The irrigation benefit, based on the value of incremental crops attributable to the project, is estimated at about $22.3 million. Finally, the PCR assessed the flood control benefit based on an estimate of the avoided damage, at about $24.4 million

Environmental Impact

Surveys carried out as a part of the feasibility study found no archeological, historical or cultural sites in the reservoir area, and concluded that there would be no detrimental or beneficial impacts on wildlife. Since the powerplant is used for peaking, the river flows below the dam would vary widely during the day. To safeguard downstream users, a reregulating dam, with a 12 MW power plant, was built to smooth out the river flows. After its completion, the shallow reservoir formed by the reregulating dam was found to attract migratory water fowl.

An important environmental benefit of the project was control of salinity intrusion. The Lower Han is affected by tides in the Yellow Sea and, at low flows in the river, the sea water intrudes upstream as far as Seoul. Although the main intake for Seoul's water supply was moved upstream in 1980, the intakes for some other users are within the zone affected by salinity during the periods of low river flows. A flow of 100-130 cubic meters per second is needed to prevent salinity intrusion and to dilute the industrial and municipal wastes discharged into the river. The effect of Chungju is to maintain this flow during the months of low runoff in the Han.

Social Impact

About 38,663 people were required to be relocated from the reservoir area, and 3,700 ha of land was acquired. The Governments policy was, and continues to be, to pay market prices for land and property together with removal expenses and subsistence payments during relocation. People displaced from their land make their own decisions as to where to relocate and whether or not to resume their former occupations. Compensation payments for land in the reservoir area averaged US$25,000 (in 1979 prices) for rice land and US$16,000 for cultivated upland. The details of the compensation program were worked out by a team of Korean sociologists with inputs from an expatriate sociologist fluent in Korean employed by the Bank. The relocation and compensation program was carried out successfully but at a much higher cost than originally estimated.

References

SAR, Report No. 1932a-KO, February 1979.

DAMS ON THE CITARUM RIVER (INDONESIA)

The Citarum River Basin

Three dams have been built to develop the Citarum River in Java. Two of these, the Saguling and Cirata dams were Bank-financed. A dam at Jatiluhur was financed in part by France. The Citarum river at Jatiluhur, the most downstream of the three dams, drains an area of 4,600 km^2. Below Jatiluhur, the river flows across a wide, flat, heavily cultivated area before it enters the Indian Ocean. The rainy season lasts from November to April and the rest of the year is dry. About 85 percent of the runoff occurs in the rainy season. The Basin has been developed to irrigate 260,000 ha, to provide water for Jakarta and other communities, and to generate power. The dams store the rainy season flows for use in the dry season. Without the dams, the irrigated area would have been smaller and limited to a single wet-season crop, the hydroelectric potential would have been unexploited, and a significant part of the water supply for Jakarta would not have been assured.

The Saguling and Cirata Dams

The main features of the two dams financed by the Bank are as follows:

	Saguling	*Cirata*
Height of Dam	99 m	125 m
Type of Dam	Earth and Rockfill	Concrete-faced Rockfill
Gross Storage	0.98 bcm	1.97 bcm
Live Storage	0.61 bcm	0.80 bcm
Avg. Annual Runoff	2.54 bcm	5.15 bcm
Installed Capacity	700 MW	500 MW (Stage 1) 1,000 MW (Stage 2) 1,300 MW (Stage 3)
Avg. Annual Energy	2,156 GWh	1,430 GWh
Bank Loan	US$250 million	US$279 million, Phase 1 US$104 million, Phase 2
Project Cost (inc. IDC)	US$727 million	US$745 million, Phase 1 US$400 million, Phase 2
Construction Period	1981-1986	1983- 1988, 1993-95

The two projects were found to be the least-cost solution to meeting the power needs of Java at discount rates up to 20 percent. The economic rates of return were calculated with benefits expressed as the energy produced times the tariff. Costs were composed of the project costs plus the cost of transmission and distribution needed to deliver energy to the consumers. The rate of return was 16 percent for Saguling and 14 percent for Cirata. These rates of return do not take into account irrigation and water supply benefits of the two projects. Calculation of these benefits would require a comprehensive basin study to separate the large irrigation and water supply benefits due to the Jatiluhur Project from the those accruing to the two dams; such a study has not been undertaken.

Development Impact

The Saguling and Cirata dams have the main function of power generation but also augment the flows for irrigation and water supply at the downstream Jatiluhur Dam. The projects came into service in the late 1980s when the Java system was suffering shortages of capacity. In 1988, the projects accounted for 30 percent of the capacity in Java. In 1994, 500 MW was added to Cirata to increase peaking capacity in the Java system. In 1995 the two projects account for of about 15 percent Java's capacity and have an important function in providing quick-response peaking capacity.

Social and Environmental Impact

Environment—Detailed environmental studies were carried out for both projects. The public health study found that vectors of the more serious parasitic diseases were not present in the projects areas. A plan was put in place to control aquatic weeds. When the plants operate for short duration peaking, there are wide variations in river flows which can be dangerous for people in the river channels. Therefore, a warning system was put in place. Fortunately, the reservoirs almost overlap each other and so the stretches of river exposed to these risks are quite short.

Sediment depletion of the reservoirs will be a slow process. The annual sediment inflow to Saguling was initially estimated to average about 4 million cubic meters (mcm), compared to 270 mcm of dead storage. Sediment surveys now indicate this to be high by about 25 percent, so their will be no significant infringement on live storage for 100 years. At Cirata, the average annual sediment inflow is 5.7 mcm compared to 1,177 mcm of dead storage, so the reservoir life will be longer than Saguling. The stretch of river between the reservoirs is short and there have been no significant changes in river morphology. The river below Jatiluhur will not be affected by the dams because Jatiluhur has for years intercepted all of the sediment in the Citarum River.

The reservoirs thermally stratify during the dry season, and the high organic loading causes anoxic conditions in the lower levels. With the onset of the wet season the reservoirs destratify causing some fish deaths. These are presently at an acceptable level, but this could change if reservoir pollution conditions worsen. The Ciratum River is subject to heavy industrial pollution from the Bandung area, and this is a threat to all users of the river's water. A study to investigate this problem and to find ways to protect the river was financed under the Bank loan for Cirata Phase 2.

Social—The Saguling Dam inundated 5,600 ha of land, most of which was cultivated. About 3,000 families lived in the reservoir area, and 6,500 families had some of their land holdings in the reservoir (16,700 in total according to project agency in June 1996). In the case of Cirata, the reservoir inundated 6,100 ha of land, most of which was cultivated, and there were 8,459 families living in the reservoir area and 2,593 families who had land or were dependent on work in the reservoir area (34,842 according to project agency in June 1996). Of these, 6,605 families accepted compensation in lieu of resettlement, 2,008 families joined the transmigration program, 1,735 settled on newly formed nucleus estates, the remainder were trained to engage in aquaculture in the reservoir and have enjoyed major increases in income from fisheries.

References

SAR, Report No. 4356-IND, May 1983.
SAR, Report No. 11544-IND, April 1993.
PCR, Report No. Sec M92-1192, September 1992.
PAR, Report No. 7902, June 1989.
Soemarwoto, Otto. "Minimizing the Social Impacts of Dam Construction." Waterlines, Vol. 10, No. 2 (October, 1991), pp. 6-8.

DAMS OF THE CHAO PHYA/MEKLONG BASINS (THAILAND)

Background

In the Chao Phya and Meklong Basins, the Bank financed the construction of four major multipurpose projects—Bhumibol, Sirikit, Srinagarind, and Khao Laem—and large parts of the downstream irrigation systems. These projects, and their impacts, are described below in the context of the overall development of the Chao Phya and Meklong Basins.

The Chao Phya and Meklong Basins account for 27 percent of Thailand's land area and 55 percent of its population, and contain its main commercial and industrial centers including the capital city of Bangkok. The Basins are the main source of rice and high-value fruits and vegetables, and in recent years there has been rapid growth in fish farming. The Chao Phya Basin covers 110,000 km^2 and extends from the far north of the country to the Gulf of Thailand. The Meklong Basin lies between the border with Burma and the lower part of the Chao Phya Basin and covers 29,000 km^2. The flows in the Chao Phya and Meklong and their tributaries are dependent on the monsoon rains and are highly seasonal. About 85 percent of the total runoff occurs in the months of July to December, and natural flows are small from January to June.

The Chao Phya Basin

Development of the Chao Phya Basin began in the 1890s in the Southern Chao Phya Plain. The area was subject to deep and prolonged flooding, and the approach then was to construct canals to provide access to large areas for the cultivation of flood-dependent rice. The canals also helped to spread the floods more evenly and to promote drainage at the end of the flood season. From 1904, when the Royal Irrigation Department (RID) was formed as the agency responsible for water resource development in Thailand, through the 1930s, this mode of development was applied to more than 500,000 ha. In 1950, following the wartime slow down in construction, RID began a program to develop gravity irrigation systems in the Northern Chao Phya Plain. An important component of this program, the Chainat Diversion Dam on the Chao Phya River was financed in 1950 by a Bank loan of US$18 million. Further development of the area served by the Chainat Dam was assisted by a loan for US$5.6 million for equipment to construct canals, drains and roads; this was known as the "Ditches and Dikes Project." In the 1970s, the Bank financed two projects covering 220,000 ha in the Northern Chao Phya for on-farm development, a term used to denote an improved system of distribution canals and drains suited to intensive year-round irrigation. This was followed by the 95,000 ha Phitsanulok Irrigation System financed by a US$95 million Bank loan in 1975 which was completed in 1980.

In the 1950s the Government decided to construct dams to store the monsoon flows for release in the dry-season. Without such dams it would be impossible to exploit the Chao Phya's vast agricultural potential and to meet the growing demands of its cities. Therefore, the Bhumibol and Sirikit Dams were built to control the flow of the Chao Phya's tributaries for power, irrigation, and water supply; together they control the runoff from 22 percent of the area of the entire basin.

Bhumibol Dam—In 1957 a Bank loan of US$66 million was made for the Bhumibol Dam (originally known as the Yanhee Dam) on the Ping River, the western-most tributary of the Chao Phya. The 154 m high concrete gravity dam has a live storage capacity of 9.7 billion cubic meters (bcm), compared to the average annual inflow of 6.6 bcm from a drainage basin of 26,400 km^2. The installed capacity is 710 MW. The dam was completed in 1963 and filled for the first time in 1970. The delay in filling was due to a combination of several factors. First, Thailand was facing a shortage of generating capacity and power releases were almost continuous, with the result that there was a limited quantity of surplus flow to fill the reservoir. Also, during the early years, flows were generally below normal.

Sirikit Dam—The Sirikit Dam (originally the Phasom Dam) on the Nan River, the Chao Phya's eastern-most tributary was financed by a loan of US$26 million in 1967 and completed in 1972. The 114 m high earth and rockfill dam has a live storage capacity of 6 bcm compared to the annual runoff of 5.9 bcm. The installed capacity is 500 MW.

The Meklong Basin

Irrigation development in the Basin began in the early 1960s with a Bank Loan for US$22 million for a project that included the Vajiralongkorn Diversion dam on the Meklong near the town of Kanchanaburi, a canal system to serve 175,000 ha, and flood protection and drainage works. The initial objective of this project was to supplement rainfall for a single wet-season crop of rice which grew over most of the project area. As in the case of the Chao Phya Basin, the exploitation of the Basin's agriculture required construction of dams to store surplus monsoon flows for use in the dry season.

Srinagarind Dam (originally the Ban Chao Nen Dam), the first dam to be built in the Meklong Basin, was financed by a US$75 million Bank loan in 1974 and completed in 1980. The 140 m high earth and rockfill dam, on the Quae Yai River 80 km upstream of the diversion dam, has a live storage of 7.5 bcm. The average annual inflow to the reservoir is 4.6 bcm. The installed capacity is 720 MW and annual energy generation is 1,388 GWh. The dam regulates the flow from an area of 12,000 km^2, 42 percent of the drainage basin above the Vajiralongkorn Diversion Dam.

Khao Laem Dam, the second dam in the Basin, was financed by a Bank loan of US$80 million in 1980 and completed in 1985. The 92 m high rockfill dam, on the QuaeNoi has a live storage of 4.8 bcm. The installed capacity is 300 MW, and average annual energy generation is 760 GWh. The average annual inflow is 5.2 bcm. The dam regulates the flow from an area of 3,700 km^2 that has much higher rainfall than the Srinagarind catchment.

The Chao Phya/Meklong Basin Study

This study was carried out by consultants to the Government in 1977-78 and was financed by funds provided in the Phitsanulok Project. The purpose of the study was to develop an operating strategy and operating rules that would recognize the interests of the three agencies involved in the Basin: the Royal Irrigation Department, the Electricity Generating Authority of Thailand, and the Bangkok Municipality.

A stimulus for the study was the rapid growth in irrigation during the dry season in the early 1970s. The study weighed the merits of two irrigation strategies. One was simply to store the monsoon runoff and then deplete the reservoirs every year to meet dry-season demands. This approach would lead to wide year-to-year variations in the area that could be served. A second approach was to aim at a long-term average for the dry-season cropped area (about 600,000 ha) achievable without excessive draw-down of the reservoirs. The study developed operating procedures to implement the second strategy with provision to cut back on the target during periods of below-average flows. The advantage of this strategy, which is still in force, is that it virtually eliminates conflicts between power and irrigation, and allows for more equitable sharing of the dry season flows for irrigation. An overriding consideration in the operating strategy is to maintain a flow of 100 cubic meters per second at the Bangkok water supply intake.

Development Impacts

Agriculture in the Chao Phya Basin—Rice is the main crop in the irrigated areas of the Chao Phya Basin. The year-round water supply produced by the dams increased rice production from around 1.5 million tons (milled rice) in the 1950s to 5.5 million tons in the early 1990s. The effect of the dams was to provide a more reliable supply of water for the wet season crop, which often suffered from erratic rainfall in the monsoon season, and from the greatly increased flows provided for expansion of the dry-season crop. Many farmers switched from a low-yielding single crop to two high-yielding crops. Investments in irrigation system improvement were needed to realize these gains, but these investments would not have been made in the absence of a year -round water supply. In the areas extending from the two dams to the Gulf of Thailand the cropped area of rice in the wet season is now about 1,200,000 ha compared to about 1,100,000 million ha in 1950. But, in the dry season, the average cropped area is about 600,000 ha compared to a negligible area before the dams were built. Droughts in recent years have caused a significant reduction in the dry season area which has fallen to below 400,000 ha.

Originally, the Southern Chao Phya was largely devoted to a flood-dependent crop that was planted by broadcasting the seed in May and then was harvested in December. The Northern Chao Phya was mostly devoted to transplanted rice, with varieties that were tolerant to flooding and drought. The flood dependent rice yielded about 1.5 ton/ha and the transplanted rice yielded around 2 ton/ha (yields are in paddy or unmilled rice). Initially, yields in the flood dependent areas suffered because the dams interfered with the natural rise and fall of flood levels. But, in time, farmers with land close to the old navigation/drainage canals resorted to using low-lift pumps to irrigate a dry-season crop (yielding 3-4 ton/ha) in place of their flood- dependent crop.

In the Northern Chao Phya, there was a sharp increase in double cropping of rice soon after year-round water became available from Sirikit Dam. This trend was also helped by the wider availability of seeds for high-yielding, short-duration varieties (HYVs) suited to dry-season cultivation. Much of this growth took place in areas with the rudimentary distribution systems provided by the Ditches and Dikes project. A higher standard of on-farm development was introduced in several Bank projects which served about 220,000 ha. In the 1980, the Phitsanulok Project was constructed to bring double cropping to an area of 95,000 ha along the Nan River; this area had to some degree suffered from the loss of flood-dependent agriculture. A criticism of the Phitsanulok project was that it diverts dry-season water that could be used in downstream areas with existing infrastructure. In other words, the water used at Phitsanulok had an opportunity cost that had not been considered in its justification. A counter argument is that the benefits from a more reliable wet-season supply justified the project.

Agriculture in the Meklong Basin—Rice is the main irrigated crop in the Meklong Basin, but there is also a large area of rainfed sugar cane. The irrigation systems now served by the

Vajiralongkorn Diversion Dam cover 240,000 ha. The regulation of the Meklong's flow provided by the two dams on the Meklong have greatly increased the irrigated area of rice in the wet season and in the dry season.

When the first stage system was built in the early 1970, several problems stood in the way of irrigated agriculture. The main irrigation works had some design and construction defects which made them difficult to operate, and the distribution systems were lacking in most areas. Also, many farmers on the higher and better drained areas had switched from rice to sugar cane, which was a new and profitable crop in the area. In 1980 and 1981 two IDA-financed projects, Irrigation XI and Irrigation XII, were implemented to improve and extend the main canal systems and to provide on-farm distribution works on 90,000 ha. As a result of these projects the area was transformed from a single to a double cropped area within several years of their completion. For the Meklong system as a whole, the area of rice irrigated in the wet season has now reached 160,000 ha, and dry season cropping of rice is around 75,000 ha.

Power—When they were built, each of the dams was an important addition to Thailand's power system at a time when the country was largely dependent on imported oil. In 1985, the four projects provided 40 percent of Thailand's capacity and 15 percent of its energy. Since then, Thailand has developed its lignite and natural gas resources, and these have become the country's main sources of electrical energy. Thus, the projects have become valuable sources of peaking capacity that can respond quickly to changes in system demands. Between them the four dams have an installed capacity of 1745 MW, produce 3,500 GWh in an average year, and account for 13 percent of Thailand's 1994 demand and 5 percent of its energy. In recent years the trend has been to operate the reservoirs in the interests of irrigation and water supply, and this has tended to reduce annual energy production.

Economics—Dam construction and development of the irrigated areas took place over a period of more than 30 years. The required investments did not impose an unusual burden on Thailand's financial resources or have any adverse macroeconomic impact. When they were appraised by the Bank, the economic justification of the dams derived largely from their power benefits. These were measured as the equalizing discount rate obtained by comparing the project cost stream with the cost stream of the least-cost alternative. Rates of return in the Staff Appraisal Reports and as estimated in the Project Completion Reports are listed below; these rates of return do not include costs and benefits of downstream irrigation.

Dams	**Rates of Return (percent)**	
	SAR	**PCR**
Srinagarind	11	13
Khao Laem	16	16
Sirikit	14	14
Bhumibol	12	n/a

Environmental Impacts

Upstream Effects—The areas inundated by the reservoirs were mostly degraded forests. No wildlife surveys were undertaken for Bhumibol and Sirikit reservoirs so the impacts of these dams on flora and fauna are unknown. Detailed ecological surveys were carried out for the

Srinagarind and Khao Laem Dams which concluded that any impacts could be readily managed. Records of management plans are not available.

Downstream Effects—The main downstream effect of the dams has been to maintain a supply of surface water for the Greater Bangkok Metropolitan Area where ground water use has for some years exceeded the natural recharge. Some of the water from the Meklong Basin is diverted to the Chao Phya Basin and then to the Bangkok area. Virtually all of the lands in the flood plains of the Chao Phya and Meklong Basins have been disturbed by human activities since the turn of the century, but they continue to attract a wide range of birds.

Floods, caused by storms located downstream of the dams, continue to occur in the lower parts of the Basins. Common sources of floods are tropical depressions which sweep across Thailand from the northeast and cause flooding below the dams. The dams therefore have little effect on these types of floods. However, the dams have greatly reduced the frequency and magnitude of floods produced by storms over their catchment areas, and have considerably reduced flood damages in the upper parts of the rivers on which they are built.

Salinity and waterlogging have not been problems in the Chao Phya and Meklong Basins, mainly because much of the land is devoted to paddy rice cultivation, and there is no evidence that such problems have been introduced by the dams. Surface drainage is needed in some areas to allow better water control for growing high-yielding rice varieties, and Bank irrigation projects have normally provided for such drainage.

The interception of sediment by the dams has no downstream impact. The rivers are relatively low sediment producers and the small amount of sediment intercepted has no material impact on river morphology or agriculture. Sediment data for the Srinagarind and Khao Laem Dam show that depletion of storage is negligible: the ratio of gross storage to annual sediment inflow is 8,600 for Srinagarind and 6,200 for Khao Laem. Data are not available for Bhumibol and Sirikit Dams, but sediment yields are likely to be similar. Given the large storage volume in relation to annual water inflow for these two dams, sediment depletion of storage will be negligible.

The dams have had no effects which could lead to any increase or decrease in the incidence of waterborne diseases in the irrigated areas, or at the intakes for municipal supplies.

Social Impacts

The projects have improved the productivity, incomes and living standards of farmers living on several million ha in the two basins. An impact evaluation concluded in 1993 that on average the livelihood of the resettled population has been restored to its pre-project level, but that an indigenous group, the Karen (who were perceived as illegal aliens) appears to have been negatively affected. For the typical rice farmer, one hectare of land now produces 5-6 tons of unmilled rice (paddy) compared to 2 tons before the dams were built. The impact on flood-dependent agriculture in the Lower Chao Phya, in the early years of the project, may have caused some financial distress. But, the farmers affected were mostly the larger operators who tended to specialize in this extensive form of rice cultivation. Fortunately, many of these farmers now grow two crops by low-lift pump irrigation using return flows from upstream projects.

There are no records in the Bank of the magnitude of the resettlement needed for Bhumibol and Sirikit dams, or of the impact of the dams on the reservoir populations. The project agency in May 1996 put the figure for Sirikit at 1,650. It is unlikely that whatever was done to handle resettlement would satisfy current standards, because involuntary resettlement was not accorded high priority by the Bank or by the authorities in Thailand at that time. A more enlightened approach was taken in the cases of Srinagarind (1,600 families of about 5,280 people), and Khao Laem (1,800 families of approximately 7,672 people). There, the resettlement was handled by a special unit in the Electricity Generating Authority of Thailand (EGAT), the owners of the projects. EGAT as a semi-autonomous agency with its own sources of revenue was able to deploy the funds and the skills to resettlement planning and implementation and the outcome was generally satisfactory.

References

SAR, Report No. TO-137a, August 1957.
SAR, Report No. N977-TH, March 1974.
SAR, Report No. 2569a-TH, October 1979.
PCR, Report No. (Khao Laem) 6157, April 1986.
PAR, Report No. 2850, February 1980.
PAR, Report No. 3999, June 1982.
Impact Evaluation Report 12131, June 1993.
Takeuchi Kuniyoshi. "Analyses of the Flow Regime of the Chao Phraya River." Hydrology of Warm Humid Regions (Proceedings of the Yokohama Symposium, July 1993) IAHS Publ. no. 126, 1993, pp. 181-193.

DEZ MULTIPURPOSE PROJECT (IRAN)

The Project

The main features of the Dez Multipurpose Project are a 203 meter high concrete double arch dam (from lowest foundation), a 520 MW power station, and a reservoir with a storage capacity of 3.5 billion m^3 covering an area of 65 km^2. According to information received from the project agency in June 1996, Dez generates 2,500 GWh/year. The project also included a 20,000 ha pilot irrigation scheme to assess prospects for smallholder development on the approximately 100,000 ha of irrigable land commanded by the dam. The Dez Multipurpose Project, completed in 1978, was followed by Dez Irrigation Project Stage I which included a re-regulating dam and a diversion dam, a new irrigation and drainage system on about 37,000 ha, and on-farm works on 57,000 ha. The Dez Irrigation Stage II project, designed to extend the irrigation network by 27,000 ha and make full use of water resources available from the dam, was appraised in 1972 but suspended at negotiations due to differences between the Bank and the Government over the project concept. The Dez Multipurpose Project and Dez Irrigation Stage I were financed in part by Bank loans of US$42 million and US$23 million (reduced from an original US$30 million), respectively.

Project Rationale

The Dez Project was conceived as a program to expand the productive capacity of Khuzestan agriculture by providing assured water delivery to some 100,000 ha of irrigable land. Conversion of mostly dry-land farming to irrigated area was expected to lead to higher yields of traditional crops, introduction of new, high-value crops, and a tripling of farm incomes. The project, in addition, had flood control and power generation objectives.

At the time the Stage II Irrigation Project was being considered, differences between the Government and the Bank arose on the organization of agriculture. The Bank favored developing the new irrigation area through improved smallholder agriculture; that is, family farms based on traditional management and modern inputs and services. In the view of Bank staff, early returns from the Dez Multipurpose pilot scheme confirmed the soundness of the traditional family farming approach. The Government had a different view and argued for organizing the project area into large-scale, mechanized farms run by agribusiness. Government planners cited results from the Dez pilot project, which showed a rise in smallholder yields but much lower than expected cropping intensities, as evidence that the smallholder approach was too slow to meet the country's needs. This difference of opinion finally led to the Bank withdrawing from the Stage II Project.

Development Impact

The Bank's 1980 PAR rated the project unsatisfactory based on its finding that: "The economic return on the project, including dam and irrigation systems, is negative and remains negative even when the cost of the dam is treated as sunk cost." This failure was attributed to the Government's decision to support large-scale farming through agribusiness rather than smallholder development. By 1978, large-scale farms cropped only 44 percent of the irrigable area allocated to them, compared with an actual pre-project cropping intensity of 63 percent and a cropping intensity of 119 percent projected at full development. Crop yields were below pre-project levels and neither high value crops nor livestock production had reached output levels anticipated at appraisal.

Data on the present situation are not so far available. However, there are reports that the growth in power demands in the Khuzestan area justified the construction of the power facilities.

Social Impact

As agribusiness took hold in the project area, farmers were induced to sell their newly-acquired land under land reform. An estimated 70 percent of them chose to move out of their home villages to find work in towns and cities. Since no base line data were established at appraisal on employment, such as farm incomes, size of farm households, etc., and since no tracking was done on displaced farmers, including compensation received for their land and incomes in new jobs, it is impossible to quantify the project's impact on the original farm population. It seems safe to say, however, that neither the Bank nor the Government carried out adequate assessments of the human costs and benefits of the Dez projects. The SAR did not mention anything on resettlement, only that land redistribution was expected. The only mention of resettlement in the audit was with regard to the canceled Dez II.

In April 1969 the government sent letters of intent stating that it was going to develop agribusiness in 55,000 ha (of which 39,000 ha was in the project area). Bank staff recommended suspension of the project. In 1973 the Government increased farm corporations from 200 to 12,000 ha. Bank staff recommended suspension again but this was perceived to be too drastic by Bank management. The smallholder development project originally envisaged by the Bank was transformed into a large-scale mechanized farming project. Considerable effort which had gone towards building up traditional farming was destroyed. The Bank was disturbed by disruption of the social fabric, and the social upheaval that was caused.

In the first two decades after the project, the project area experienced major upheavals. There were continual labor shortages, and resentment of agribusiness among the population. In June 1972 the Bank terminated negotiations on the follow-on project (Dez II) when it was discovered that the borrower had changed the project design in favor of agribusiness and to the detriment of improved traditional farming. The Bank was concerned about the social and economic implications of agribusiness development which it believed would lead to eventual removal and resettlement of a large part of the local population. Data on issues such as the employment situation before and after resettlement, the amounts of compensation paid, number of people concerned, their employment during a transitional period, size of house lots assigned to new settlers are virtually non-existent. Figures quoted give no idea of the social costs involved in the destruction of traditional villages, removal of population, resettlement in unfamiliar surroundings, emigration, unemployment and new employment in urban centers. In resettlement villages resulting from the project, the social fabric of traditional villages was transformed and corrupted. The economic rate of return is not only below 11–14 percent but is negative.

All the benefits beginning to emerge from land reform and provision of irrigation, namely, the break-up of large estates, the settlement of smallholders, the emergence of a more prosperous peasant class and increased employment for the landless, were abruptly reversed when the development of this area was handed over to agribusiness. The result as has been noted earlier was social upheaval, depopulation, decreased incomes and employment, and a heavy drain on

Government budget, without any compensating gain in production or a more rapid pace of development. However, as of 1980, Khuzestan was reported to possess an excellent, modern irrigation system. Reports on agriculture, though sketchy, indicate that smallholder farming has become established and the area is productive

References

SAR, Report No. TO 234b, February 1960.
SAR, Report No. TO 687a, March 1969.
SAR, Report No. PA 130, April 1972.
PAR, Report No. 3061, June 1980.
Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation: Feedback into Resettlement Planning."

EL CHOCON MULTIPURPOSE PROJECT (ARGENTINA)

Project Description

The project consists of dams and powerplants on the two main tributaries of the Rio Negro about 1,000 km southwest of Buenos Aires. On the Rio Limay at El Chocon, the main project works are a 86 meter high earth fill dam, a powerhouse with six 200 MW units, and a 1,080 km, 500 kv transmission line. The reservoir has a storage capacity of 20 billion m⁻ and covers an area of 816 km^2 extending some 70 km upstream from the dam. On the Rio Neuquen at Cerros Colorados the project's main features are diversion works and a 450 MW power generating facility. The diversion works conduct water from the Rio Neuquen into natural basins which have a storage capacity of 43.4 billion m^3 and an area of 620 km^2. The project was built in two stages. Stage I, provided for civil works and equipment at the El Chocon site and was financed in part by a Bank loan of US$82 million 1968. In 1973 the closing date was extended to allow unspent proceeds from Stage I to be applied to the stage two construction of diversion works at Cerros Colorados.

Project Rationale

At the time of appraisal, the electric power sector in Argentina had a total installed capacity of 5,720 MW, including 1,670 MW in captive industrial capacity. Energy generation in 1967 was about 16,700 GWh, of which more than 90 percent was from thermal plants. Demand was expected to grow at 7 percent over 1970-1978, mostly in the region of Buenos Aires, the center of the country's population and industry. To meet this need, the Government launched a program to develop the El Chocon plant, extend the regional transmission network, install small thermal plants, and build the first nuclear power plant in Latin America. With the other projects in place, El Chocon was expected to supply about 20 percent of Buenos Aires' system requirements when it came on line in 1974.

El Chocon was first identified as a potential site for hydro development in a UN-sponsored power sector study carried out in 1959. Subsequent studies, including two Bank reviews in 1966 and two reports by consultants in 1967, evaluated various alternatives, the major issue being whether to proceed with the El Chocon and Cerros Colorados sequence or to pursue El Chocon alone at a higher installed capacity than originally planned. The Bank's position was (1) that either option was justified when compared with a thermal alternative, and (2) given the relatively small benefits to expect from flood control and irrigation, increasing El Chocon's capacity from 1200 MW to 1650 MW and eliminating Cerros Colorados entirely would be the preferred alternative. However, the Bank agreed to support the Government's proposal for the two stage construction of the El Chocon-Cerros Colorados complex with Stage I financed by the loan.

Thus, the project's objective was to develop the hydropower potential of the Rio Negro to supply the electricity needs of the Buenos Aires region. Two secondary objectives were to control flooding in the Rio Negro valley and to help irrigate agricultural land.

Development Impacts

Power System—The El Chocon power plant went into commercial operation in 1973. About 2,570 GWh were generated in 1974, 73 percent of which was sold to the Buenos Aires-Litoral system. Although sales were lower than expected, the project was justified (as of 1976) for much higher discount rates than those established at the time of appraisal since the capital costs of alternative thermal schemes had at least doubled and fuel costs were at least four times as high. The project was given a satisfactory rating in the Bank's 1976 PAR.

Flood Control—Flood control benefits from the project were realized in 1972 and again in 1975 when floods threatened crops in the Rio Negro valley. It was estimated that without the dam in place flood damages would have been US$24 million in the case of the 1972 flood alone.

Irrigation—In the arid region crossed by the Rio Negro and its tributaries, crop production is possible only with irrigation. The project has led to irrigation of 60,000 ha and, the reduction in flood flows has opened up for agriculture some land that had not previously been farmed because of the flood risk.

Social and Environmental Impacts

Resettlement—The SAR noted that a main highway (No. 237 running between Neuquen and Bariloche) would have to be relocated before the reservoir was filled. However, there was nothing on resettlement per se in the audit. According to the project agency (in June 1996), 700 people are reported to have been displaced mostly from one settlement. However, no further information was provided on how the resettlement process was managed, the extent of compensation (if any) provided to the displaced people, etc.

References

SAR, Report No. PU-1a, December 1968.
PAR, Report No. 1353, November 1976.
Energy Sector Study 7993-AR, February 1990.

FORTUNA HYDROELECTRIC PROJECT (PANAMA)

The Project

The main features of the project are a 110 m high rockfill dam, a 6 km long power tunnel, a 1,400 m pressure shaft, an 8 km long tailrace tunnel, and an installed capacity of 300 MW that produces about 1,450 GWh in an average year according to information received from the project agency in May 1996. The reservoir on the Rio Chiriquí has a capacity of 13 million m^3 and covers an area of 10 km^2. The project was built in two stages. Stage 1 was appraised in 1977 and completed in 1982. The estimated cost of the first stage US$220 million financed by the Bank, IDB and suppliers credits. The owner is Instituto de Recursos Hidraúlicos y Electrificación (IRHE).

Project Rationale

IRHE has the exclusive right to construct and operate all new sources of electricity in Panama. In 1978 the total installed capacity in the country was 280 MW and demand was growing at an annual rate of 12 percent. The aims of the project were to meet the growth in demand and to supply at least 50 percent from hydroelectric plants. These objectives have been satisfied. The alternative to Fortuna was a 300 MW coal-fired powerplant.

Development Impact

The PCR (1990) concluded that the project had successfully met its two key objectives which were to increase Panama's electricity supply in response to national needs and to reduce the country's heavy dependence on imported fuel. The project was expected to continue to make an important contribution to Panama's power system.

Environmental and Social Impacts

Environment—The Fortuna region is very rich in biodiversity: prior to dam construction, over 1,400 plant species were collected including 163 species of orchids. The project flooded only 1,050 ha of forest of which approximately 600 ha was second growth growing on abandoned pastures. The Fortuna Forest Reserve has minimized in-migration in the area near the reservoir but the potential for deforestation (the area protects the upper watershed of the Chiriquí River, which is the principal tributary supplying the Fortuna Reservoir) was considered to be high by the project agency. There may be some downstream impacts due to hydrologic changes induced by the reservoir. Sensitive areas include the Chiriquí estuary and extensive mangrove regions. Regions along the coast provide a substantial amount of the country's shrimp harvest. It is thought that the hydrograph peaks have been reduced but not the overall sedimentation rate. These changes in flow may affect species living in the estuary. There was no problem with aquatic weeds in the reservoir. The project agency notes that though natural fish populations declined after the creation of the reservoir, it has now been stocked with alevines.

Environmental impacts were considered from the beginning. To protect water quality, the entire submergence area was cleared prior to construction activities. Detailed environmental assessments helped sharpen the focus on preserving the watershed. Management plans for the reservoir and watershed were established five years before Fortuna was commissioned and they were implemented. In 1976 the project agency established a 5,000 ha forest reserve surrounding and protecting the Fortuna impoundment and it has been well managed. In 1983 a 22,000 ha protected area bordering the forest reserve was created. The Fortuna region is considered to be one of the best managed watersheds in Panama. The project's success is attributed to management efforts established five years prior to commission as well as increased community extension efforts based on lessons learned from the Bayano experience. Other factors that contributed to this success include the low density human settlement, the small area of good quality agricultural land and the steep topography, the feasibility of clearing basin vegetation due to its small size, reforestation efforts, and the ease of enforcing regulations in the small watershed.

Resettlement—The project's social impacts seem to be limited. The reservoir area was virtually uninhabited. A report by the project agency in 1980 estimated that about 600 people would be displaced or seriously affected by the project. Finally, 26 people residing in the basin area and the rest in the 5,000 ha forest reserve created around the reservoir were displaced as a result of project activities (project agency in May 1996). No relocation efforts were described in Bank documents. People were apparently simply compensated for lost property. Community development programs were established to improve education, living conditions, and agriculture production methods by constructing schools, water and sanitary systems, roads, housing improvement, health, agricultural and education programs.

Health—The project agency noted (May 1996) that there was an increase in mosquitoes, Simuladae, for which a control program was undertaken. This program also monitored infectious and contagious diseases in the area of influence of the project.

References

SAR, Report No. 1510b-PAN, June 1977.
PCR, Report No. 8376, February 1990.
Draft LATEN Working Paper. April 1995. "Good and Bad Dams: Ranking Hydroelectric Projects in Latin America Using Environmental and Social Criteria."

GAZIVODE MULTIPURPOSE PROJECT (YUGOSLAVIA)

The Project

The project is located on the Ibar River in Kosovo Province, a part of the former Yugoslavia. The main features of the project are a 108 meter high rock fill dam, a reservoir, with a storage capacity of 350 million m^3, a 34 MW power plant, a 147 km water conveyance system, and an irrigation system serving 20,000 ha. The project was appraised in 1971 and was scheduled for completion in 1976. It was not completed until 1984 because of contract failures and delays in carrying out a land consolidation program. The time overrun coupled with high inflation (30-60 percent) over the period led to an escalation of project costs 119 percent over the appraisal estimate of US$93 million. Total Bank financing for the project amounted to US$45 million.

Project Rationale

Sector Background—In the late 1960s at the time the project was conceived, Kosovo Province was the poorest region in Yugoslavia. Per capita income was about US$170 or one-third the national average. The population growth rate of 2.9 percent was more than double that countrywide, a factor contributing to growing unemployment. Health conditions were poor, with a high incidence of intestinal diseases, caused by polluted water supplies. Although agriculture was the mainstay of Kosovo's economy and 40 percent of the province's land area was under cultivation, it was a highly inefficient agriculture that lacked modern inputs and depended on rainfall and ineffective irrigation systems. As a result, Kosovo was a net food importer. In the project area itself, about 78 percent of the land was owned by some 11,800 private farmers, two-thirds of whom lived at the subsistence level, practicing rainfed agriculture on farms of less than 2 ha. In the industrial sector, expansion of mineral resource enterprises offered the greatest potential for provincial economic development. Industrial demand for water was expected to triple in the period 1970-1985 mainly because of the planned buildup of mineral-based complexes at Obilic and Kosovska Mitrovica.

To overcome the water constraint and thus to facilitate growth of agriculture and mineral-based industry, the Government in the 1960s carried out surveys of provincial water resources. These formed the basis of a master plan to develop the principal rivers in the region, the Ibar and the Lepenac, to provide water for industry, communities, irrigation and power generation. The project was the first attempt in Yugoslavia to undertake comprehensive water resource development for an entire region.

Objectives and Justification—The main objective of the project was to exploit the waters of the Ibar River to make available the higher volume of water required to expand industry, increase agricultural output, and improve health conditions in the Kosovo region. The Ibar is the largest river in the area, and its development through a multipurpose project was determined to be the most cost-effective way to meet the estimated demand.

At appraisal, the project's industrial water supply benefits were equated to the costs of alternative works that industries would have to construct and operate to meet their needs in the absence of Ibar. The benefits of municipal water supply were measured as equivalent to revenues from water sales. Public health benefits, including reduced sickness-related absenteeism from industrial jobs, were not included in the calculations. Agriculture benefits were equivalent to the incremental net production value of the area newly irrigated by the project. Power benefits from the small power plant (34 MW and 95 GWh) were estimated to be only US$1 million, but the operation was expected to be important for peaking purposes and to provide a reserve source of electricity for the industrial complex at Obilic. Finally, the appraisal analysis considered as a benefit the reduced costs of silt removal downstream as a result of sedimentation control provided by the reservoir. Flood control benefits were expected to be modest and were not quantified. Analyses were made of alternative schemes to supply the same amounts of water to the various sectors to determine if any components, or combination of components, might be excluded from the Ibar project. The analysis indicated that inclusion of all project components, as proposed, was justified. The rate of return for the entire project was calculated at 16 percent.

Development Impacts

Regional Economy—The project succeeded in overcoming the constraints on water availability that affected the growth of industry and agriculture in the Kosovo region. Although at the time of the Bank's audit in 1986 the financial results were lower than appraisal estimates, it was thought that the project's long-term benefits would be substantial, and the project therefore merited a rating of satisfactory. In its ex-post review of the project, the Government concluded that the project was justified on the basis of unanticipated benefits alone: about $220 million (in 1995 US$) worth of flood damages was averted in 1979 because the dam was in place, and crop yield was maintained during the drought of 1985 because irrigation works had been built. The rate of return of the project calculated at its completion was 13 percent including the value of flood damage averted; without this benefit, the rate of return would be about 8 percent.

Water Supply—Sales of water to industry, expected to absorb 70 percent of the water available from the Ibar system, stagnated as Kosovo's major mineral-based industries postponed expansion programs in response to a nationwide economic downturn. Sales in 1985 were a quarter of appraisal estimates. Demand was expected to grow, but slowly, reaching levels forecast for 1985 only by 1994. Sales of water for domestic use, a small proportion of the total, were higher than appraisal estimates by 1985 and were expected to markedly increase in 1987 with the installation of a new water treatment plant in the project area.

Irrigation—Sales of water for irrigation which did not begin until 1985 due to delays in carrying out civil works and land consolidation, were far below the volumes estimated at appraisal. However, revised projections for agriculture based on 1985 as the first year of irrigation and 1994 as full development, show the long-term impact of the project to be substantial. With the introduction of irrigation on 20,000 ha, the cropping pattern was expected to shift from traditional rainfed winter cereal crops to high-value summer crops including maize, vegetables, sugar beet and sunflower. Double cropping was planned, with maize for silage the predominant crop to be planted following the harvest of wheat, barley, and rape seed in early summer. Based on a total cropped area of 28,200 ha and substantial with-project yield increases, the total annual volume of agricultural production at full development was expected to be six times the 1985 level. Data on the present situation are not presently available.

Power—As of the 1986 PAR, the 34 MW power plant was producing electricity (70 GWh) as expected, providing valuable peak power.

Social and Environmental Impacts

The project involved the resettlement of approximately 230 people (42 families) according to information received from the project agency in June 1996. The agency noted, however, that they did not have any additional information on the displaced people—there was nothing in Bank documents either. A decrease in waterborne diseases was reported due to mitigation programs in the newly irrigated areas. Water quality was considered suitable for continuous irrigation with almost no salinity or sodium hazard. In urban areas, the project was expected to improve public health and the quality of life. At the time of appraisal, Kosovo Province had a high incidence of typhoid fever, bacillary dysentery and infectious hepatitis. The water supply systems used by about 90 percent of the population--springs, streams, and private shallow wells, most of them polluted—were determined to be the principal source of infection. An estimated 20,000 man/days per year were lost in absenteeism from jobs as a result of infectious disease. The Bank's PAR mentions improved health as an important but unquantifiable benefit of the project; at the time of writing (1986), it was too early to gauge the impact of increased water supplies from the Ibar River on general health conditions. A possible adverse effect indirectly related to the project derived from the increase in industrial wastes discharged into the Ibar as the two major mineral-based industries expanded operations. Already at the time of appraisal, the Government had issued water quality standards and requirements that industries install waste treatment facilities.

The Project Agreement required the Government to carry out erosion control and soil conservation measures in the watersheds in the project area. The PCR states that "appropriate measures, which included afforestation and terracing, were completed by end-1978." These measures in addition to storage of sediment in the reservoir were expected to reduce siltation in river channels downstream of the project. The reduced costs of silt removal in downstream reservoirs was included in the benefit stream in the appraisal analysis.

References

SAR, Report No. PU-58a, April 1971.
PAR, Report No. 6232, June 1986.

GURA APELOR HYDROELECTRIC PROJECT (ROMANIA)

Project Summary

The Gura Apelor Hydropower Project is located in west-central Romania. The main features of the project are a 168 m high earth and rockfill dam, an 18 km tunnel, the 335 MW Retezat hydro plant, and the 14 MW Clopotiva plant. The reservoir on the Mare River about 20 km downstream of its confluence with the Strei River has a storage capacity of 200 million m^3. The Bank appraised the project in 1976 and completion was planned for 1981. However, a series of geological problems delayed the project works. The total cost estimated at appraisal was US$250 million, financed in part by a Bank loan of US$50 million; cost overruns were about 16 percent.

Project Rationale

Sector Background—In response to the oil crisis of 1973, the Government refocused its energy policy to highlight (1) energy conservation through introduction of modern, less energy-intensive technology and reduction of transmission and distribution losses, and (2) maximum exploitation of domestic energy resources, particularly low-grade lignite and hydropower. Stringent economy measures slowed the growth of energy demand from the high 10-15 percent figures of the 1960s and early 1970s to 4.5 percent in 1974. Projections made in 1976 showed an annual growth rate of 7 percent for the period 1976-1980 followed by 6 percent for the years 1981-1985.

The site on the Riul Mare near its confluence with the Strei was considered the largest of the remaining sites which could be exploited at acceptable cost to supply the country with essential peaking capacity. The Riul Mare-Retezat Project was one of four Bank loans to Romania's power sector between 1974-1980, including two loans to construct a 1,320 MW lignite-fired power station and another to develop smaller hydro and thermal plants.

The main purpose of the project was to supply additional peaking capacity to the national power system. In addition, the water storage and regulation function of the project dam was expected to enhance the output of cascade power generating schemes on the Riul Mare downstream to the point where it meets the Strei River and from there along the Strei to its confluence with the Mures River. All together, the project was expected to contribute 469 MW and 739 GWh in an average water year or less than 2 percent of the system needs at full project development.

Bank appraisal staff accepted the conclusions of the Government's least-cost analysis that, first, the power system would need additional peaking capacity by 1985 of about 400 MW and that, second, the Riul Mare-Retezat Project with its associated downstream cascade development was the way to fill this need at least cost. The internal rate of return on the project based on current tariffs was calculated at 6.5 percent. The SAR states that this was "not an appropriate indicator" since Romania was a planned economy with artificially low power tariffs which would be expected to rise as the sector developed.

Development Impact

Implementation delays have greatly reduced the project's benefits to the national economy. What role Gura Apelor now plays in the power system in Romania's changed political and economic environment is a question that needs to be explored.

Social and Environmental Impacts

Construction of access roads apparently involved some land acquisition for which compensation in accordance with published scales was paid to farmers, cooperatives and others whose productive capacity or facilities were detrimentally affected according to the SAR. However, nothing further is said in either the PCR or the audit.

The Government made a study of the ecology of the project area which includes, as part of the national park, a special nature reserve. In the interests of leaving the nature reserve entirely untouched, the tunnel from the reservoir was relocated from the right bank of the river to the left. Although the SAR engineering design report cited indications of weakness in the left bank compared to the right, it was not thought that this would cause unusual tunneling problems. Unfortunately this assessment was wrong: a landslide which buried the entrance to the main tunnel in 1977 was followed by heavy water infiltration in 1980 and tunnel blockage in 1983, all of which caused major construction delays. In addition to recommending tunnel relocation, the Government's ecological report suggested a series of practical measures to mitigate any harmful effects of construction operations on the natural environment of the project area.

References

SAR, Report No. 1103-RO, March 1976.
PAR, Report No. 6861, June 1987.

GURI HYDROELECTRIC PROJECT (VENEZUELA)

Project Summary

The Guri Hydroelectric Project is on the Caroní River, 120 km upstream of its confluence with the Orinoco River. The development of Guri set the stage for exploiting one of the world's greatest hydroelectric power resources. The project, 500 km from the capital city of Caracas, was built in three stages. The purpose of staged construction was to avoid the large front-end cost for civil works that is a common feature of many hydroelectric projects. Stage I, begun in 1964 and completed in 1969, consisted of a 100 m high concrete dam and spillway, a power station with three 175 MW units and foundation works for future installation of seven more units. Stage II, begun in 1970 and completed in 1976, provided for the completion of civil works for the powerhouse, and the installation of Units 7-10. Stage III, begun in 1976 and completed in 1986, raised the height of the original dam by 62 m, and built a new concrete dam, two earth and rockfill dams, 26 saddle dams, and a second powerhouse for ten, 600 MW units. The Bank made four loans for the project which in total amounted to US$200 million.

Developmental Impact

Although, Venezuela has abundant resources of fossil fuels, the Government decided in the 1960s to make maximum use of its renewable energy resources. The Guri project, one of the world's largest hydroelectric plants, now consists of a powerhouse with an installed capacity of 8935 MW. The regulation provided by the reservoir also greatly increased the potential for power generation in the Caroní between the Guri power plant and Macagua, a power plant at the mouth of the Caroní built at the same time as Guri. Macagua 1 had an installed capacity of 390 MW. Macagua 2 which is under construction has a capacity of 2,600 MW. Also under construction is the 2,400 MW Caruachi Project, about 22 km upstream of Macagua, and the 2,100 MW Tocoma Project, 20 km downstream of Guri.

This is an example of a project having an impact extending beyond its own power generation. Guri laid the groundwork for the development of the Caroní river basin, one of the world's greatest hydroelectric resources. Since the completion of Stage I of the project 1969, with 525 MW, its capacity has been increased to 8,935 MW. The regulation provided by the Guri reservoir made it economical to develop the potential for power generation downstream on the Caroní river, leading to the construction of a cascade of additional hydropower projects at Macagua I, II & III, Caruachi and Tocoma. Macagua, with 2908 MW, is already fully developed, and adds 16,000 GWh to Guri's annual energy production of 50,000 GWh, which is equivalent to over 60 percent of Venezuela's total electric energy production. In 1994, Guri and Macagua accounted for over 50 percent of Venezuela's electric energy production. The annual energy output of Guri is equivalent to fuel oil costing about US$1.2 billion.

Economic Evaluation

The economic rate of return at each stage was estimated by comparison with the least-cost alternative, which was an oil-fired thermal plant. The rates of return were as follows: Stage I (8 percent), Stage II (17 percent), and Stage III (20 percent). The higher figures for Stages II and III reflect the large sunk cost incurred in Stage I.

Environmental Impacts

The Caroní River at the dam site drains an area of 85,000 km^2 and the average annual runoff is 156 billion cubic meters (bcm). The gross reservoir capacity is 135 bcm, and the active storage is 85 bcm. There are no downstream impacts of any note. The minimum flow of the Caroní has been increased by the dam and the floods have been greatly reduced in size and frequency. Sedimentation was occurring and seen as a possible problem, although studies in 1963 indicated a life of over 200 years for the full development, and this was confirmed by observations in the Stage I reservoir. Because of the relatively low sediment flow, the reservoir has had no appreciable effect on the morphology of the Caroní downstream of the dam.

Prior to filling of the reservoir for the Stage I project, an operation was undertaken to rescue animals and artifacts from the reservoir area. Over 18,000 mammals, reptiles, and birds were removed from the reservoir area. Most of these (75 percent) were released in appropriate habitat in other parts of south-east Venezuela. The remainder were placed with zoos or wildlife research establishments. The effectiveness of the wildlife rescue was difficult to evaluate, for data are lacking on survival rates in the receiving areas. Because of the questionable benefits of this operation, no rescue of animals took place when the reservoir level was raised in Stage III, but a thorough collection of artifacts took place. The land inundated by Stage III consisted of 2,200 km^2 of marginal grazing land and 1,200 km^2 of evergreen seasonal forest.

Social Impacts

There is no reference in Bank documents on the social impacts of the project. However, the project agency provided information in June 1996 which put the number of people (mostly indigenous) displaced by the project at 3,600. There is no further information though, on whether any resettlement was carried out or compensation paid and the extent to which their livelihood was restored.

References

SAR, Report No. PU-Ga, April 1969.
SAR, Report No. 801-VE, June 1975.
SAR, Report No. TO-373b, September 1963.
PAR, Report No. 1192, June 1976.
Caroní: Electrificación del Caroní Ca Edelca. Venezuela, 1993.
Evaluación del Impacto Ambiental del Proyecto Caruachi. Venezuela: Edelca, May 1993.
Principales Indicadores, Edelca, December 1994.

DAMS ON THE INDUS RIVER (PAKISTAN)

The Projects

The Tarbela and Mangla Dams form part of the Indus Basin Project, a system of dams and canals built to transfer water from the western rivers of the Indus Basin to the eastern rivers. This transfer became necessary as a result of the Indus Basin Treaty which allocated the waters of the eastern rivers to India.

The **Tarbela Dam** is located on the Indus near the village of Tarbela, about 70 km northwest of Islamabad, the capital of Pakistan. The dam is 143 m high and 2,750 m long at its crest. The power house was originally designed for 2,100 MW (12 units of 175 MW), but the installed capacity has now reached 3,478 MW. The gross storage capacity of the reservoir is 11.6 billion cubic meters (bcm), and the original active storage, after deducting dead storage of 2.2 bcm, was 9.4 bcm. The average annual runoff at the damsite is 80 bcm. Tarbela Dam contains 142 million cubic meters (mcm) of material and is the world's largest embankment dam. It is 50 percent larger than the Fort Peck Dam, the next largest fill dam, and three times larger than Aswan High Dam. It stands on 180 m of pervious alluvium. A vertical cut off wall was impracticable and it was necessary to resort to an upstream impermeable blanket. Tarbela was more than twice the height of the next largest embankment dam employing an upstream blanket. The main and auxiliary spillways are some of the largest ever built and, in contrast to others, must operate at high discharges for three months every year.

The **Mangla Dam** is an embankment dam with 130 million cubic meters of fill founded on sandstone. It occupies the only site for a storage dam on the Jhelum River. It is 138 m high with a crest length of 2,500 m. The powerhouse now contains 1,000 MW (10 units at 100 MW). Average annual inflow is 28 bcm, the gross storage capacity of the reservoir is 7.3 bcm, and the original active storage, after deducting dead storage of 0.7 bcm, was 6.7 bcm.

The Indus Water Treaty

The Indus River has six major tributaries. From west to east these are the Jhelum, Chenab, Ravi, Beas and Sutlej. Large scale development of irrigation on these rivers began over 100 years ago, and by the 1930s an area of some 9 million ha was irrigated from numerous barrages (diversion dams) on the Indus and its tributaries. The partition of the subcontinent in 1947 between India and Pakistan drew a line across this river system. India became the upstream riparian on the Indus and its tributaries and was in position to divert some of the water that formerly had been allocated to areas within Pakistan. The problem was particularly acute on the eastern rivers where there were numerous long-established schemes.

In 1952, India and Pakistan accepted the Bank's offer to help find a way to resolve this problem. After lengthy negotiations between the two countries, in which the Bank played the role of mediator, an agreement was reached. This was spelled out in the Indus Waters Treaty. Under the Treaty, India would have sole use of the waters of the eastern rivers (the Beas, Ravi and Sutlej) and Pakistan would have the use of the western rivers (the Indus, Jhelum and Chenab), and India would contribute to the cost of implementing what was known as the Indus Basin Settlement Plan.

The basic concept of this plan was to divert water from the western rivers to the eastern rivers by a system of link canals and barrages. However, the dry season flows (October through June) in the west would not be sufficient to allow replacement of water lost in the east. Therefore, the plan provided for monsoon flows to be stored on the Indus by Tarbela Dam, and on the Jhelum by Mangla Dam, and then released in the dry season.

The Indus Basin Development Fund

Financing for this plan was provided by the Indus Basin Development Fund. The Fund Agreement was executed at the same time as the signing of the Treaty, and the Bank agreed to be the Fund Administrator. The Fund included commitments from Australia, Canada, Germany, New Zealand, Pakistan, the United Kingdom, the USA, and the Bank to contribute in grants and loans (including a contribution from India) an amount equivalent at the time to US$895 million. The Bank's contribution was a loan of US$90 million.

As work proceeded it became apparent that the funds committed would not be sufficient to complete the full program of works. It was decided to give priority to Mangla, the barrages and the link canals. Any funds remaining would be made available to Pakistan to finance Tarbela Dam or another water development project, to be agreed by the Bank and Pakistan after a study of the water and power sector in the Indus Basin. These arrangements were embodied in 1964 in a Supplemental Agreement.

The study provided for in the Agreement was carried out by several firms of consultants directed by a group of Bank staff headed by Dr. Peter Lieftinck, who was at that time an Executive Director of the Bank. The study confirmed that the Tarbela Project was technically feasible and economically justified in terms of its agricultural and power benefits

The Tarbela Development Fund

In 1968 the Tarbela Development Fund was set up to finance the construction of the Tarbela Dam. The Fund was composed of a transfer of unused funds from the Indus Fund, and contributions equivalent to U$150 million from Canada, France, Italy, the UK and the USA, and a Bank loan of U$25 million. Pakistan agreed to meet all local currency costs. A contract for the main civil works was awarded in May 1968 to the Tarbela Joint Venture, a consortium of Italian and French firms later joined by German and Swiss firms., At the time, the contract for US$623 million was the largest in the history of civil engineering. The major works were constructed on schedule and the reservoir began to fill in July 1974, but water continued to flow through the four tunnels on the right bank. In late August 1974, damage occurred in the diversion tunnels which led to emptying of the reservoir and an emergency repair program. The draw down of the reservoir revealed some sink holes in the upstream impervious blanket, which were repaired, and the blanket thickness was increased. In 1978, works were necessary to repair extensive erosion in the spillway plunge pool. These problems raised the cost of the project and it became necessary to raise additional funds. This was done through a Supplemental Agreement which provided US$42 million from a number of donors, including an IDA Credit for $8 million.

Development Impacts

Agriculture—Of Pakistan's total area of 80 million ha (m ha), around 20 m ha is cultivable, and of this 12 m ha is irrigated by canal systems fed by the Indus and its tributaries. The surface water supply shows a pronounced seasonal variation. About 80 percent of the flow of the rivers occurs in the monsoon months of June through September. Since the 1960s there has been rapid growth in tubewells to supplement surface water irrigation; this has taken place mostly within the irrigated areas. Initially, tubewell projects were publicly owned and operated, but private farmer-owned tubewells now account for the bulk of groundwater use.

Pakistani farmers cultivate their fields under a two-season cycle—kharif crops are grown from May to October, and rabi crops are grown in the period November to April. The main kharif crops are cotton, rice, sorghum, and millets. Rabi crops are mainly wheat and fodder. Oilseeds, pulses and fodder are grown in both seasons. Year-round crops include sugar cane and orchards. Irrigation provides 85 percent of Pakistan's food and virtually all of its fiber crops.

In the 1960s, around 4 m ha of land within the area commanded by canals had a water table within 3m of the surface, and by that definition was waterlogged, although most of the area was cultivated. Since then, tubewell development has largely eliminated waterlogging on about 3 m ha which is underlain by fresh groundwater. The remaining 1 m ha, underlain by saline groundwater, is still affected by waterlogging and soil salinity.

In an average year the total inflow to the Indus system within Pakistan is about 180 bcm. Operation studies, with Tarbela and Mangla in the system, produce a water balance as shown below.

Indus Basin Water Balance—Average Water Year (bcm)

	Rabi	Kharif	Total
River Inflow	52	128	180
From Storage	15	-15	0
River Losses	8	12	20
Surface Water to Canals	58	74	132
River Outflow	2	26	28

The reservoirs fill during the kharif season when there is ample water in the rivers, and then water is released in the rabi season to supplement dry-season flows. The stored water of 15 bcm adds to the natural river flow of 52 bcm. After deducting losses in the rivers, the reservoirs add about 12 bcm to the canal diversions of 58 bcm for the rabi crop. Thus, the reservoirs increase the flow to the irrigation systems from 46 bcm to 58 bcm, or by 26 percent thus allowing 400,000 ha of previously irrigated land to be double cropped, and 400,000 ha of previously rain-fed land to become irrigated. The reservoirs also ensure the availability of water at critical times in the cropping calendar outside of the rabi season. For example, if the rivers flows are below normal at the beginning or end of the monsoon season, the reservoir releases can be increased to offset a shortage.

Tubewells are used to supplement surface water in areas where the groundwater is usable. Annual use is on the order of 50 bcm of which 25 bcm is pumped in the rabi season. But groundwater is not a substitute for surface water storage for several reasons. First, areas with a right to a rabi water allocation have had that right for many years and cannot be expected to relinquish it simply because they have access to fresh groundwater. Second, many areas with a rabi allocation do not have useable groundwater and are therefore totally dependent on surface water.

A rough estimate of the benefit of the additional water provided by the reservoirs can be derived as follows. Measured at the canal head the requirement for a wheat crop is about 15,000 m^3/ha. Therefore, 12 bcm is sufficient to irrigate 800,000 ha of wheat. In present day prices the net return on wheat, assuming a yield of 4 ton/ha is about US$250/ha. Thus, the annual benefit would be on the order of US$200 million.

Power—Pakistan has fossil fuel resources which have been partly developed. Domestic natural gas provides the fuel for 3,000 MW of generating capacity, but prospects for expanding gas production are uncertain and 5,200 MW of thermal power depends on imported oil. Large coal deposits, mostly high-sulfur lignite, have been found in the south of Pakistan, but they consist mostly of thin seams with considerable overburden and their economic feasibility has yet to be established. Tarbela and Mangla together account for 4,800 MW, or 37 percent of Pakistan's installed generating capacity, and in an average year produce 19,000 GWh, or 30 percent of Pakistan's annual electric energy demand. The annual energy output of the two projects is the equivalent of US$600 million of imported oil.

Economic Considerations—The Indus Basin Project was never subjected to an economic analysis, because it was seen as an unavoidable investment to secure the future of Pakistan. A "without project" scenario would have envisioned vast areas of land along the eastern rivers reverting to the deserts which existed over a century ago. An economic analysis of the Tarbela Project was, however, undertaken in 1968 as part of the study called for in the Supplemental Agreement to the Indus Basin Fund. This study estimated the economic return of the project to be 9 percent , taking into account agriculture and power benefits. In 1986, a Bank study calculated the rate of return as 12.5 percent.

Most of the cost of Mangla was financed by the Indus Basin Fund, but the local currency requirements for construction of Tarbela imposed a major burden on the country's budgetary resources. There has been no detailed study of the effects of this on Pakistan's economy at the time. On the other hand, once the project was built and the power facilities completed, Tarbela became a major asset in its annual contribution to food and fiber production, and in its savings in foreign exchange expenditures for imported fuel.

Environmental Impact

The audit for the Tarbela project notes that the reservoir aggravated emerging salinity problems in the Indus Basin. The Indus Basin has a long history of waterlogging and salinity, and, in spite of continuing investments in drainage and salinity control, Pakistan continues to lose almost as much irrigated land each year as it gains from investments. This appears to be an unfortunate consequence of the priority given to irrigation, including barrages and adduction canals (since the later part of the 19th century) and large dams (since the 1960 Indus Waters Treaty) at the expense of the development of drainage, salinity control and reclamation projects, which have lagged far behind requirements. Thus the problem appears to be more a result of lags in complementary investments, rather than the effect of the Tarbela and Mangla dams.

A significant environmental effect in downstream areas is the increase in dry-season flows, which are needed in part to compensate for diversion of flows in India. Waterlogging has declined sharply since the 1960s, largely as a result of the rapid growth in groundwater exploitation. Much of the additional water made available by the dams is used in fresh groundwater areas where the water table has been declining for years. This imposes additional costs on the farmers through higher lifts and replacement of wells. The increased supply will help to arrest the fall in water tables, and this will lower farmers' costs for pumping and replacement of wells.

The areas inundated by the reservoirs were mostly degraded forest and, in the case of Mangla there was considerable soil erosion. No wildlife surveys were undertaken but judging from the surrounding areas, the reservoirs were not rich in flora and fauna, and the species present were probably widely represented in other areas. Barrages on the Indus and Jhelum Rivers had imposed numerous barriers to upstream movement of fish long before the dams were built. But the lakes formed by the barrages are among the most valuable inland fishery resources in Pakistan.

The dams have no effect on the flow conditions in the Indus Delta. For many years, upstream diversions have virtually eliminated the flow at the mouth of the Indus from the end of September until late June, and the regime that has been established is one in which appreciable flows occur only in the months of July, August and September.

The dams have had no effects which could lead to any increase or decrease in the incidence of waterborne diseases in the irrigated areas, or at the intakes for municipal supplies. Schistosomiasis is not present in Pakistan.

Tarbela's reservoir capacity of 11 bcm is small compared to the annual inflow of 80 bcm. Therefore, the reservoir will be subject to fairly rapid depletion by sediment deposits. By 1992 45 percent of the dead storage and 12 percent of the live storage had been lost to sediment deposition. In 20 years much of the live storage will be filled. There is a possibility for off-stream storage to offset this loss. At Mangla, the depletion rate will be less because the reservoir capacity of 7.2 bcm is a higher percentage (nearly 25 percent) of the annual flow of 28 bcm. It is expected that the Mangla reservoir will be depleted at a rate of 1.2 bcm every 20 years. Also, with the low setting of the spillway crest, a stable bed profile upstream of the dam will form before the reservoir is depleted. At Mangla there is the potential to raise the height of the dam and to develop off-stream storage.

Resettlement

Resettlement for both dams was well-managed and the terms were generous. For the Tarbela dam, resettlement was an audit report budget item (5 percent of total "PWOR"). There were no staff appraisal reports for the project. Basic data sheet shows only engineers and loan officer went on supervision missions. The economic analysis mentioned resettlement of affected persons as "incremental costs" incorporated into analysis. Costs shown in Rs M, 1968–1984 by year. The Tarbela reservoir displaced 96,000 people (project agency in June 1996), mostly from farm families. They farmed small plots of rainfed land of about 2 acres and raised sheep and goats.

Each family was resettled on 12.5 acres of irrigated land. The urban dwellers were resettled in new housing in the town of Ghazi near the dam. The population displaced by the Mangla reservoir was 82,000 of which about 20 percent were urban families living in the town of Mirpur. The farm families also cultivated land that was not irrigated and raised some livestock. The town of New Mirpur was built to take the urban families, and the farm families were resettled on 12.5 acres of irrigated land in existing irrigation schemes.

References

PCR, Report No. 6398, September 1986.
President's Report P-H74 PAK, June 1975.
Indus Waters Settlement Plan TO241, April 1960.
Power Sector Development Project, June 1994.
Pearce, Fred. The Dammed. London: The Bodley Head, 1992.
Lowe, John III and Ingo Fox. "Sediment Management Schemes for Tarbela Reservoir." TAMS, May 1995.

ITEZHITEZHI HYDROELECTRIC PROJECT (ZAMBIA)

The Project

The first step in the development of the Kafue River was Kafue I, which involved the construction of a dam and a 600 MW powerhouse in the Kafue Gorge. This project, placed in service in 1970, was financed by the Government of Zambia and by suppliers' credits. The second step, Kafue II financed by the Bank, involved the construction of the Itezhitezhi dam at a site 250 km upstream and the addition of 300 MW to the Kafue I powerhouse. The reservoir has a storage capacity of 6 billion m^3, and the annual inflow averages 9 billion m^3. This project was appraised in 1973 and completed in 1978.

Project Rationale

The Kafue River is a tributary of the Zambezi River. The hydroelectric resources of both rivers have been developed to supply electricity to Zimbabwe and Zambia. In 1956 a decision was taken to build the Kariba project on the Zambezi. Its aim was to meet the power demands of Zimbabwe (then Southern Rhodesia) and Zambia (then Northern Rhodesia). The demand in 1956 was only 400 MW, but by the time Kariba I was in full operation in the mid-1960s the combined demand of the two countries had grown to 800 MW and the only remaining capacity was in the form of old thermal plants with high fuel costs. The next logical step would have been to proceed as quickly as possible with a second powerhouse at Kariba (Kariba II), but relations were poor between the newly independent Zambia and what was still Rhodesia. Zambia therefore decided to build its own hydroelectric plant on the Kafue River, a northern tributary that joins the Zambezi just below Kariba. This 600 MW project, Kafue I, was completed in 1967. In the early 1970s, the Bank financed the Kafue II power project in Zambia. This was the Itezhitezhi dam on the Kafue River to regulate the flows for the existing Kafue I and to expand its capacity from 600 MW to 900 MW.

Development Impact

The load forecasts on which the Kariba and Kafue projects were planned were not realized due to a worldwide slump in the demand for copper. As a result, there was a surplus of capacity through the 1970s. The Bank's PCR (1985) found the ERR to be 6.5 percent and concluded that the project was premature by 11 years. However, the project's overall performance was judged to be satisfactory, most notably because already by the mid-1980s the original capacity surplus had shifted to a capacity deficit. Also, for the period 1980-1987, Zambia exported each year more than 3,000 GWh to Zimbabwe. In the early 1990s, southern Africa suffered a severe drought which greatly reduced the energy generation at Kariba and Kafue, and both Zambia and Zimbabwe suffered shortages. Both countries have constructed thermal power plants so they now have mixed thermal-hydro systems. This means they can use low cost hydro energy whenever it is available, and supplement this with thermal energy when necessary. The Kafue power plant is now, and will continue to be, a valuable source of power and energy for Zambia and neighboring countries.

Other Benefits—The project agency (May 1996) noted that though the project was not expected to have any great effects on irrigation, the demand for water for irrigation has grown with the setting up of the Zambia Sugar Company at Mazabuka which is able to meet the country's demand for sugar and export the surplus. The area has also become important as a tourist spot for water-based tourism as opposed to just being a game viewing attraction before the dam.

Social and Environmental Impact

Environment—Eighty percent of the reservoir area was on the Kafue National Park, one of the largest game sanctuaries in Africa. Covering an area of 22,500 sq km, it is as large as Wales, or one half of Switzerland. Loss of the park area to the reservoir was estimated to be less than one and one half percent. The SAR noted that ecological aspects were examined in detail by experts and no serious problems were expected. The project involving the inundation of about 370 sq km of virtually uninhabited area under the proposed reservoir was not perceived to be a matter of great concern. Recommendations were made that with respect to water quality the growth of hyacinths should be monitored. The most significant impact would be the elimination of flooding of the Kafue Flats (about 5,000 sq km) below the dam during dry years, since such flooding was responsible for much of the grass upon which a large number of animals survived. It was planned that to replace this natural flooding, the reservoir would include a volume of 750 million cubic meters additional to that required for power discharges. This would permit a discharge of 300 mcu/sec during March in dry years to induce a degree of flood which is expected to maintain the natural condition. An abundance of cattle and wild life existed in the Kafue Flats, particularly the lechwe, a small antelope unique to the area, whose future would be anxiously watched by wildlife conservation groups the world over, according to the SAR. The population of this antelope was estimated at some 90,000 at appraisal. It was also thought that the large fishing potential of the Flats would improve, though development was likely to be slow.

The audit notes that the Itezhitezhi reservoir was filled June 2, 1978. There was no monitoring of the flooding of Kafue Flats to see if it was successful. In May 1996 the project agency stated that the flooding has not happened in the last 10 years due to severe droughts. According to the project agency, due to uncontrolled migration into the area the watershed wetlands are under substantial population pressure and poaching has become a serious problem. Also, though there are no problems with aquatic weeds in the Itezhitezhi Reservoir, they are proliferating at Kafue Gorge (Stage I of the project) thus posing a major threat to the power station. The project agency notes (May 1996) that there were some instances of fish kill in the past when water was discharged through the low level outlet. Currently, in order to minimize any possible negative effects to downstream aquatic life because of low oxygen content in the water discharged through the low level outlet, the water is mixed with water from the main spillway for at least a week after opening the low level outlet. Also, though no conservation programs are in place now, an environment unit has been formed in Zesco and when it becomes operational such programs will be initiated. With regard to sedimentation, since 1963 records from the sediment sampling station indicate a very low silt content (in the order of 20 ppm) thus posing no risk of reduction in reservoir capacity for some time.

Resettlement—The SAR noted that the reservoir area to be inundated (370 sq km) was virtually uninhabited, and that pastoralists would be affected but did not provide any details and mentioned that the 250 occasional itinerant fishermen in the area would "adjust" to the rising/falling levels of water. Nothing was mentioned on compensation or otherwise for the fishermen, nor on resettlement or land acquisition. The project agency (May 1996) stated that there were very few people displaced by the project and did not provide details.

Health—The SAR mentioned that though bilharzia is present there was no population of people for it to be a problem. Protection measures for the workforce were to be undertaken and brush would be removed to prevent habitats for the tsetse fly from forming. The audit notes, though, that there was no specific follow-up on precautions against schistosomiasis and tsetse flies on the workforce. Also, the temporary housing constructed during works have now been permanently occupied and could potentially result in a serious outbreak of disease due to the lack of sanitation, poor hygiene, and communicable diseases due to overcrowding.

References

SAR, Report No. 86a-ZA, May 1973.

PCR, Report No. 5566, March 1985.

Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation: Feedback into Resettlement Planning".

ITUMBIARA HYDROELECTRIC PROJECT (BRAZIL)

The Project

The project is located on the Paranaiba River about 420 km south of the capital city of Brasilia. Main project works are a 7 km long dam with earthfill embankment sections rising to a maximum height of 106 m, and about 1,400 km of transmission lines linking Itumbiara with other major hydroelectric and thermal plants serving the Southeast Region. The project has an installed capacity of approximately 960 MW and generates 9,000 GWh/year. The reservoir has a gross capacity of 17 billion m^3 and covers 760 km^2 of land in an area sparsely populated and generally unsuited for agriculture. The project was appraised in 1973 and completed on schedule in 1982. The total project cost estimated at the time of appraisal was US$593 million, to be financed in part by a Bank loan of US$125 million. The actual cost at project completion was US$1,051 million, 77 percent more than the appraisal forecast.

Project Rationale

Sector Background—In 1965 a UNDP master plan prepared for Brazil's Southeast Region identified Itumbiara as one in a series of hydroelectric sites suitable for development over the next 15 years. At the time Itumbiara was appraised in 1973, the southeast region had an installed capacity of about 10,880 MW or 80 percent of the country's total capacity. About 90 percent of this was hydroelectric. Regional energy consumption had increased annually at about 11 percent from 1969-1971 and was projected to grow at 10 percent over the period 1972-1982.

Itumbiara opened a second phase of the region's power expansion program, designed not only to add capacity to each independent power utility, but to integrate operation of all utilities supplying the southeast. Furnas-Centrais Eletricas, S.A. (FURNAS), responsible for constructing and operating Itumbiara, was the largest of the regional utilities, and accounted for 28 percent of total installed capacity at the time of appraisal. As part of the regional expansion program, FURNAS had been authorized to develop three consecutive hydro sites on a reach of the Paranaiba River, including Itumbiara. But, following detailed studies, FURNAS found that the best approach was to increase the height of the dam and exploit the potential with a single project.

Objectives and Justification—The main objective of the Itumbiara project was to provide FURNAS with the least-cost solution to meet the expected demand for power in the southeast region. The project also aimed to promote integrated operation of the regional power system by constructing a transmission system which linked Itumbiara with hydroelectric plants operated by other major producers in the region. To determine the least-cost solution to the region's power needs, two projects well-advanced in the sequence, Itumbiara and Agua Vermelha, were compared singly or in combination with equivalent oil-fired thermal or nuclear stations supplemented with additional hydroelectric peaking capacity which could be installed at existing hydroelectric plants. Itumbiara was found to be part of the least-cost program at discount rates up to 15 percent. The rate of return on the project was calculated at 23 percent.

Development Impact

Power System—The rate of return on the project, recalculated in the 1986 PCR, was 9 percent compared with 23 percent estimated at the time of appraisal. This low return reflects lower than expected tariffs and higher costs as additional transmission lines and substations were added to the project to meet rising demands. Itumbiara had a major role in meeting the rapid demand growth in the Southeast in the early 1980s. As such, it was given a satisfactory rating in the Bank's 1986 review. Demand has continued to grow, albeit at a slower pace, and has now reached 160,000 GWh of which Itumbiara supplies 9,000 GWh.

Environmental and Social Impacts

Some 3,700 people were displaced by the Itumbiara reservoir. During negotiations FURNAS agreed to develop and carry out a resettlement plan which would enable the affected population to "earn a living under conditions at least equal to those existing..." The PCR offers no details on how the plan was executed and what were the results, but states that the Bank was satisfied with FURNAS' performance.

A consultant's report prepared at the time of appraisal (the Itumbiara Environmental Impact Reconnaissance Report-November 1972) pointed out certain existing problems in the project area that presumably required monitoring: over-grazing within the watershed and the presence of schistosomiasis and Chagas' disease. The PCR does not comment specifically on whether these conditions worsened or improved, but observes that FURNAS carried out its "environmental obligations" in a manner satisfactory to the Bank. Sedimentation was not expected to be a significant problem according to the appraisal estimates. Annual sediment deposition, estimated at 20 million cubic meters, is small compared to the capacity of the reservoir.

References

SAR, Report No. 150a-BR, May 1973.
PCR, Report No. 6099, March 1986.

KAINJI MULTIPURPOSE PROJECT (NIGERIA)

The Project

The main features of the project are a 68 m high concrete gravity dam on the Niger River, and a 760 MW power station. The project also has a navigation lock. The reservoir, Lake Kainji, covers 1,400 km^2 and has a life storage capacity of 12 billion m^3. The annual inflow to the reservoir averages 62 billion m^3. Total project costs were US$568 million, of which four Bank loans contributed US$218 million.

Project Rationale

At the time of appraisal in 1963, Nigeria had a population of 50 million, of which less than 10 percent had access to electricity. The installed capacity of the country was 217 MW, supplied by small, isolated thermal plants. Power demands were expected to grow by 10 percent. Adding to the existing thermal system was not considered cost effective. Production from small-scale, scattered facilities was limited and expensive, and their operation required a core of experienced technicians, then in short supply. Building a single hydroelectric station which could produce abundant, cheap electricity with a lower work force requirement appeared an attractive option. Damming the Niger was also expected to bring other benefits including flood control, improved river navigation, and the development of lake fisheries. Finally, creating a large hydro scheme capable of supplying all regions was seen as a means to promote national integration in a country ethnically diverse and newly independent.

Thus, the project's main objective was to provide additional generating capacity in time to avert an electricity crisis as the country moved ahead with major plans for economic expansion. Of three sites on the Niger which had been investigated in the late 1950s, the Kainji site was judged the most favorable. A feasibility study compared Kainji with a large gas-fired steam plant in the Niger delta. The analysis showed Kainji to be only marginally better in the short term but likely to prove decisively superior over the medium and long terms. Later studies confirmed that Kainji was the least-cost solution by a reasonable margin.

Development Impacts

Power—When Kainji came into service in 1969 its 320 MW in initial installed capacity represented about half of Nigeria's total available capacity. The figure for 1978 when Kainji registered its full 760 MW capacity was 48 percent, in 1985, 22 percent, as the country added more gas-fired plants to meet a level of demand that was higher than originally forecast. Over the period 1961-1979, for example, demand grew at an annual rate of 20 percent. With the exception of several years in the early 1980s when power generation from Kainji was down due to drought conditions, annual energy production from the Kainji plant has averaged 4,600 GWh. The project has clearly fulfilled its main objective of making energy available to a rapidly expanding system. Not only that, it has done so by establishing for the first time a national power grid which has served to promote balanced regional growth along with a sense of political and social unity. The associated 1000 km of high voltage transmission lines served to create an interconnected grid out of previously isolated local networks in Lagos, Ibadan and Port Harcourt and, in tandem with additional capacity increments at Kainji, served to meet the rapidly growing demand for power in a balanced manner throughout the 1970s. A further power benefit which must be credited to Kainji is the provision of power to land-locked Niger through the construction of the Kainji/Niamey interconnection, commissioned in 1976. At the height of the oil crisis, the new power network saved Niger about US$10 million a year in fuel savings alone.

Navigation—Benefits from improved river navigation have not materialized. Navigational locks constructed at great cost are barely used. The main reason for this—something that could not have been foreseen at the time of appraisal—was the interruption of river transport during the Biafra conflict which prompted development of rail and especially road transport as cheaper alternatives.

Fisheries—Fish yields reached a maximum of 28,000 tons immediately after impoundment, but declined to the 8,000-10,000 ton range by the late 1970s. What the situation is now, twenty years later, is unknown.

Irrigated Agriculture and Flood Control—Except for a successful sugar cane plantation which expanded its irrigated area using controlled water releases from the reservoir, benefits to irrigated agriculture have not materialized. However, evidence from a 1994 study indicates that farming in general and irrigated vegetable farming in particular have improved slightly over their pre-impoundment levels. In addition, though not quantified, there were water control benefits from Kainji during the severe droughts of the mid 1970s and 1980s. The large storage capacity of the reservoir has reduced damage from floods which were a common occurrence before the dam was built.

Social and Environmental Impacts

Resettlement—Creation of the 1,400 km^2 Kainji Lake required resettling 44,000 people from 239 settlements along with their household goods, farm tools, and food supplies. Although resettlement was not financed directly by the Bank loan, the Bank insisted that displaced persons be fully compensated and that all resettlement costs be covered by the project. Costs of this component estimated at the time of appraisal were US$8.6 million, but actual costs swelled to US$23 million.

Resettlement of the Kainji Lake population took place over the period 1963-1968. In the case of the first 17 villages, people were given a cash payment to use to reestablish themselves in designated locations which the Government provided with piped water, schools, and markets. People were responsible for constructing their own houses. When this proved unworkable, the Government took on the task of constructing replacement housing which consisted of sandcrete-block structures in traditional architectural styles. From this point on, the transfer proceeded smoothly. In the final tally, 150 villages with a population of 21,427 were moved as entire units while 89 villages with a population of 22,576 were consolidated into 52 new villages. Most villages were moved a relatively short distance to the shore of the lake. The project was responsible for constructing 4,320 housing compounds with 27,642 rooms in 141 new settlements.

The Kainji resettlement scheme was a success. There were several reasons for this. First, the Government was committed to ensuring that the displaced population would be provided a standard of living equivalent to what existed prior to the move. Second, resettlement planning started early (1961)–before construction work began on the dam–and a strategy was developed gradually based on several relocation experiments involving a limited number of villages. As a result of this early experience, for example, the cash compensation policy for housing was changed to payments in kind or "building compensation." Third, the Government carefully took into account the cultural sensitivities of the nine ethnic groups to be moved: village heads were consulted on resettlement activities and assured that traditional social and political patterns would be maintained; houses constructed in the new areas preserved traditional architectural forms. In a sample survey of 20 resettlement villages carried out in 1971, two-thirds of the respondents said they were better off than before and a quarter reported no change. Fully 95 percent had elected to stay in their new locations, testimony to the success of the operation. The town of New Bussa, replacement for the old town of Bussa inundated by the reservoir, is now a major trade and service center with a population of 16,000. In sum, the project has transformed the Kainji zone, a notably undeveloped, sparsely populated part of the country, into a viable economic region.

Such development has had some negative side effects. Creation of the reservoir and establishment of new farming villages reduced the amount of grazing land available to the nomadic Fulani pastoralists. A pre-resettlement survey projected a loss of 360 km^2 with 100,000 head of cattle. Special grazing reserves established by the Government in an attempt to offset such loss proved inadequate. In a succession of dry years in the 1980s, herds were driven south to exploit abundant lakeside grazing resources. This has resulted in an increase in livestock numbers, consequent overgrazing and deterioration of rangeland, and a continuation at a new level of intensity of the age-old competition for resources between farmer and herdsman. The project is also reported to have reduced yam and fisheries production for hundreds of thousands of people living downriver.

Health—The project's impact on the health of the local population has been mixed. Before the project, the Kainji region, like the rest of tropical Nigeria, was plagued by a host of infectious and parasitic diseases, most notably malaria, schistosomiasis, onchocerciasis (river blindness), and gastro-enteritis. Creation of the reservoir posed the risk of a marked increase in malaria and water-borne diseases. There is some evidence that this occurred, at least in the first years after impoundment. Sample surveys from the early 1970s showed a doubling in schistosomiasis cases in lake side village populations between 1970 and 1972. Likewise, some evidence suggests a higher incidence of infant mortality from malaria, already hyperendemic to the region. On the other hand, more recent studies suggest that the increase in schistosomiasis was small, and that the incidence of malaria, though still a serious problem, has remained stable. There is general agreement that in contrast to the other vector-borne diseases, river blindness has declined since the formation of the lake. At the time project construction began in the early 1960s, about 6 percent of the population of the southern Niger valley was blind and 49 percent were infected with the disease. Gastro-enteritis is still a major problem in the Kainji area due to water pollution in the lakeside villages.

Wildlife Protection—In the interests of wildlife protection, the project created the Kainji National Park consisting of the Borgu and Zuguruma Game Reserves which cover a total area of 5,300 km^2. The park, dam, and lake form an important tourist attraction, an unforeseen beneficial impact of the project. Research conducted in the park has contributed to an understanding of flora and fauna of the savanna environment of the entire Kainji Lake region. Along with animal life, the park supports over 130 bird species and a wide variety of aquatic plants, some of which are an important dry season grazing resource for livestock. While the park offers some protection against human encroachment, poaching by local people and outsiders is a continuing problem. This, in combination with disease, has resulted in an alarming decline in animal numbers over the past two decades. The park provides a habitat for the tsetse fly, which means an ever-present risk of an outbreak of animal trypanosomiasis and, presumably, human sleeping sickness should humans venture into the region unprotected.

Sedimentation—The annual sediment inflow was estimated at appraisal as averaging 6 million m^3. Even if this is a significant under estimate, the reservoir's life is measured in hundreds of years.

References

SAR, Report No. TO-380a, January 1964.
SAR, Report No. TO-679a, October 1968.
SAR, Report No. TO-3983, June 1964.
SAR, Report No. PU88, June 1972.
SAR, Report No. 3041-UNI, September 1981.
PAR, Report No. 5936, November 1985.
PAR, Report No. 8822, June 1990.
Power System Improvement Project 6923-UNI.
NEPA Kainji and Jebba Dam Operational Statistics, June 1995.
Ayeni, J.S.O., Wolf Roder, and J.O. Ayanda. "The Kainji Lake Experience in Nigeria." In Involuntary Resettlement: Africa, pp. 111-125. Washington D.C.: The World Bank, 1994.
Ayodele, A. Sesan. "The Technological Choice of Kainji Hydro-Electric Dam in Nigeria–A Blessing/Curse." Socio-Econ. Plan. Sci. Vol. 18 (1984), pp. 143-150.
Brightmer, Irene. "Kainji Twenty Years On: Human Health Developments Arising from the Damming of one of Africa's Major Rivers." Geography (1986), pp. 71-73.
Milla-Tettey, Ralph. "African Resettlement Housing." Habitat International. Vol. 13, No. 4 (1989), pp. 71-81.

KARAKAYA PROJECT (TURKEY)

The Project

The Karakaya Hydropower Project consists of a 178 m high concrete arch-gravity type dam on the Euphrates River in Turkey. Other features include a powerhouse at the toe of the dam containing six 300 MW turbine generators with an output of 1,800 MW, power intakes, steel penstocks, and a switchyard located 7.5 km from the dam. The project involved the relocation of 33 km of railway tracks, and construction of 35 km of new highways. Total project costs amounted to US$1,575 million of which the Bank financed US$120 million. The reservoir, with a storage capacity of 5,600 m^3, has a surface area of 298 km^2. Prior to the project, the project area had a low level economy based almost exclusively on primitive subsistence agriculture. About 17,000 people, living in 34 villages, required resettlement. Karakaya was built as a single-purpose power project, although the regulation effect on the flow of the river was expected to be useful on downstream dams for irrigation in addition to power.

The base cost estimate for Karakaya was adequate despite a cost increase of about 14 percent in real terms, which was mainly attributable to several unexpected events. The civil works contract had to be renegotiated in 1979, there was a construction delay of two years forcing, for instance, the installation of provisional storage facilities for equipment that was delivered early, and unanticipated extensive stabilization work was required in the dam abutment areas. Full commissioning of the power plant occurred in February 1989, some 27 months behind the schedule estimated at appraisal. The recalculated Internal Economic Rate of Return (IERR) was 12 percent (which fell short of the appraisal estimate of 15 percent), reflecting higher costs and assumed system losses, and increased allowances for transmission and distribution investments. This rate exceeds the Opportunity Cost of Capital (OCC) in Turkey and justifies the project as a good economic investment. Project life can be expected to be at least 50 years or more. Project outcome is satisfactory and the sustainability of benefits from the project is likely.

Project Rationale

Total power generation in Turkey during the period 1965–1978 increased from about 5,000 GWh to about 22,000 GWh. Hydro generation averaged about 37 percent of the total generation during that period. Between 1952 and 1980 the Bank had made nine loans and a technical assistance grant and IDA had extended three credits for the development of the power sector. At appraisal time the power system contained a large number of small, inefficient generating plants, used for covering peak demands as well as for prolonged base load requirements. Three large hydropower plants had become partially operable.

The principal objectives of the physical facilities of the project were to provide additional capacity for the Turkish power system (1,800 MW and 7,300 GWh yearly average), and to enable better utilization of the upstream Keban hydropower plant, already built. The output of Keban would increase by about 400 GWh in an average year. This would save on foreign expenditures by substituting less expensive hydropower energy for imported oil. Turkish Electricity Authority (TEK) studies investigated least-cost investments in the power sector for the period 1982–2002. All hydropower potential grouped in 26 basins and available fossil fuel resources were considered. Alternative investment programs were evaluated using a linear programming model. Practically all identified hydro and thermal plants were included (including one nuclear plant). In all cases considered, including sensitivity tests, the Karakaya project was found to be a part of the least-cost investment program, as well as the most promising new hydropower generation development.

Development Impact

Overall the project appears to have met its physical goals, and despite increased costs, was economically justified. The completed physical facilities have provided additional capacity to meet the power demand in the national power system and enable better use of the Keban hydropower system[6]. Other benefits, in terms of savings from imported fossil fuels for thermal power plants by their replacement with hydroelectric energy, and the financial revenue derived from the sale of energy generated by the project, have also been realized.

Social and Environmental Impacts

Resettlement—Resettlement of the 45,000 people in the reservoir area was organized by the State Hydraulics Agency (DSI) in close cooperation with the provincial authorities and the Ministry of Agriculture, Forestry and Rural Affairs (according to the project agency in June 1996). The loan agreement required the submission of a resettlement plan and a timetable of implementation, which was done. No significant difficulties were experienced in resettling the affected people of the 34 villages prior to the impounding of the reservoir. The Bank regularly monitored the progress of resettlement during supervision. A 1987 report by a consultant concluded that the existing Turkish legal and administrative system was basically sound and practices and procedures for resettlement, including those related to Karakaya, were satisfactory. The report recommended, however, that some improvements were required in relation to the collection of socio-economic data, follow up, and administration and coordination at the site level. DSI indicated that it would do the necessary follow up. A limited number of disputes concerning the compensation for land expropriated in the reservoir area did continue till the early 1990s in Turkish courts. The last settlement of compensation claims took place in 1992.

Environment—A study of the environmental consequences of the project including physical, biological and social impacts was prepared by consultants in 1977 based on terms of reference suggested by the Bank. Although the study was not considered entirely satisfactory, the Bank planned to arrange an ecological reconnaissance by its environmental staff to identify problems, if any, and to help the Government in formulating solutions, but this never came about. Intensive archaeological investigations made throughout Turkey during the 1970s with the assistance of numerous foreign scientific institutions, also covered the area to be flooded. Authorities from Turkish universities and overseas assisted in the salvage of archaeological artifacts in the dam and reservoir areas.

The project area and the surrounding countryside were generally bare and treeless, with practically no wildlife and restricted areas of agriculture. Loss of low-level agricultural and grazing land in the reservoir area was the main environmental impact for which compensation was made by the resettlement program. There was also some limited impact on archaeological and historical sites which was successfully mitigated. The Government also agreed to inform the

6. Optimum use, however, will only be reached after completion of a further southern transmission line which is a component of the Bank-financed Fourth TEK Transmission Project (Ln. 3586-TU).

Bank about the nature and frequency of monitoring procedures of the inspection of hydro works and dams in its territory. Internal Bank reports give no indication of any other significant environmental adverse effects. Fishing activities, upstream or downstream, were not mentioned nor were impacts on health discussed.

Riparian Issues—The project did not involve abstraction of water for irrigation or other consumptive purposes and was not expected to have, in itself, any major adverse effects on downstream Syria and Iraq as long as the "Rule of 500[7]" was followed. It turned out, however, that the one major failure of this project was the lack of consideration of the effects of future downstream projects in Turkey on downstream riparians. While the "Rule of 500" was adequate for Karakaya in 1991, TEK subsequently filled the reservoir of the Atatürk dam downstream from Karakaya drastically reducing river flow for some time and since mid-1992 has been operating the Atatürk complex which in contrast to Karakaya involves substantial abstractions from the river for irrigation. Turkey also refused to provide the Bank with hydrological data on the operation of the Keban reservoir upstream of Karakaya, thus preventing the Bank from updating the analysis of the adequacy of the arrangements concerning the use of the Euphrates waters. When in the mid 1980s, the Government sought supplemental financing for Karakaya and it was apparent that the "Rule of 500" could no longer be sustained, the Bank declined to help provide financing.

References

The World Bank. Karakaya Hydropower Project (Loan 1844). Staff Appraisal Report No. 2468-TU. April 8, 1977.

The World Bank. Karakaya Hydropower Project (Loan 1844). Staff Appraisal Report No. 2468-TU. April 25, 1980.

The World Bank. Karakaya Hydropower Project (Loan 1844). Project Completion Report No. 10243. December 27, 1991.

The World Bank. Elbistan Project (Loan 1023-TU), Second TEK Transmission Project (Loan 1194-TU), Karakaya Hydropower Project (Loan 1844), Third TEK Transmission Project (Loan 2322-TU), Elbistan Operation and Maintenance Project (Loan 2650-TU). Performance Audit Report No.12069. June 24, 1993.

7. From Turkey the Euphrates river flows down first to Syria and then to Iraq. A special study was prepared by Bank staff and consultants which revealed that the Karakaya reservoir could be filled within a period of three to seven months depending on actual water flows and the operation of Turkish power plants, and that the maximum energy output at Karakaya could still be attained while maintaining an average discharge of 500 m3/second at the Turkey-Syrian border. This operating rule called the "Rule of 500", would also ensure that the existing requirements of the downstream riparians for irrigation and power generation, as well as the anticipated growth in these requirements during the period 1974/75–1983/84, would be met.

KARIBA HYDROELECTRIC PROJECT (ZIMBABWE)

The Project

The Kariba Project consists of a 128 m high concrete arch dam and two power plants on the Zambezi River where it forms the border between Zimbabwe and Zambia. On the right bank, the Zimbabwe side, an underground powerhouse (Kariba 1) built in 1962 has an installed capacity of 700 MW. A second underground power plant (Kariba 2) with a capacity of 600 MW was completed in 1980 on the Zambia side. The reservoir has a capacity of 190 billion m^3 and covers an area of 5,577 km^2. The Bank contributed to the financing of the dam and both powerhouses.

Project Rationale

When a decision to build the project was made in 1956, its aim was to meet the power demands of Zimbabwe (then Southern Rhodesia) and Zambia (then Northern Rhodesia). The demand in 1956 was only 400 MW, but by the time Kariba 1 was in full operation in the mid-1960s the combined demand of the two countries had grown to 800 MW and the only remaining capacity was in the form of old thermal plants with high fuel costs. The next logical step would have been to proceed as quickly as possible with Kariba 2, but relations were poor between the newly independent Zambia and what was still Rhodesia. Zambia therefore decided to build its own hydroelectric plant on the Kafue River, a northern tributary that joins the Zambezi just below Kariba. This 600 MW project, Kafue 1, was completed in 1967. In the early 1970s, the Bank financed the Kafue II power project in Zambia. This was a dam on the Kafue River to regulate the flows for the existing Kafue 1 and to expand its capacity by 300 MW to 900 MW.

Development Impact

It turned out that the demand forecasts that justified the Kariba and Kafue projects were optimistic, and there was a surplus of capacity through the 1970s. However, by the mid 1980s, demand and supply came into a better balance and new capacity soon came to be needed. The project was given a satisfactory rating in the Bank's 1983 PAR.

In the early 1990s, southern Africa suffered a severe drought which greatly reduced the energy generation at Kariba and Kafue, and both Zambia and Zimbabwe suffered shortages. Despite this recent event, the Kariba power plant is a valuable source of energy and, under normal weather conditions, it supplies over 50 percent of the energy demand of Zimbabwe and Zambia.

At the time of appraisal, Kariba was compared with two alternatives solely on the basis of the cost of energy production. Compared with a large coal-fired thermal plant at Harare (then Salisbury) or hydroelectric development of the Kafue, Kariba was found to have the lowest cost per kilowatt hour. There have been no retrospective analyses of Kariba.

In May 1996 the project agency provided some information on other benefits from the project. The reservoir and its environs are being used for navigation, with navigation in the estuary having improved due to river regularization. Important fisheries have been developed which are highly lucrative, and flood control benefits have been realized. The area under irrigation is unknown, but 20 million cubic meters of water per year is abstracted for irrigation according to the project agency. Also due to improved access to the region tourism has flourished.

Social and Environmental Impact

Resettlement—The project required the resettlement of 23,000 people on the south side of the river, in Rhodesia and 34,000 people on the north side, in Zambia. The top-down approach of the authorities in Rhodesia in dealing with the resettlement issue is manifest in that village elders and chiefs were assembled and informed that they should be ready to move at given dates to sites that they might help select. Transportation and building materials were supplied, taxes were remitted for two years, and grain was issued free of charge until the new crop could be harvested. No cash compensation was made. Displaced people were forcibly resettled in most cases (6,000 Gwembe Tonga removed by force), away from the lake and were not adequately provided for. There was loss of fields and some livestock and separation from relatives across the Zambezi River. In one incident lives were lost (9 killed and 30 injured). People moved to higher land to escape sleeping sickness which existed in the area. The authorities did undertake a spraying program to rid the new settlements of the tsetse fly.

The Zambian authorities approached the resettlement in a different manner. They followed the old tradition of indirect rule; people were consulted through their official representatives, composed of chiefs and their councilors. They agreed to the resettlement plan submitted to them. People had a choice to move where they wanted, compensation was to be paid to cover general and personal losses, shrines were given proper care, customary law and agricultural methods were respected in the new settlements, food would be supplied until the new crops could be obtained, the authorities would exterminate the tsetse fly from the new settlement area, schools, health facilities, wells, etc., would be constructed in the new settlements and maintained, and finally the fishing in the lake would be restricted to the displaced people until 1963.

The impact of resettlement accelerated an existing trend of attracting the young men outside the rural area. The sleeping sickness forced people to move to higher ground wherever possible. However, there is evidence that there was an improvement in the standard of living.

Environment— At the time of construction, the project was the subject of a lot of criticism related to wildlife protection during the filling of the reservoir. The inundation of the valley submerged an area of more than 6,000 km^2 at high flood level. The reservoir area was rich in wildlife, especially large mammals such as elephants, rhinoceros, giraffes, and a wide variety of deer. It was anticipated that many animals would be stranded on islands as the lake level rose. The authorities organized a rescue operation that received worldwide attention. "Operation Noah" involved measures to lead animals to safety along pre-planned escape routes and to capture animals on the islands and transport them to reserves established along the shores of the reservoir. The government created a number of wildlife sanctuaries, albeit not enough to compensate for the original loss of natural habitat. In time, these sanctuaries have become a source of tourism-related employment, but encroaching agriculture, industries, etc. restrict free ranging wildlife.

According to the project agency (May 1996), downstream floodplains such as the Mana Pools are no longer recharged by the flooding that is necessary after the dam was built. The water quality is affected by erosion from deforestation and agricultural practices. Aquatic weeds and sewage effluents further compound the problem. There has been significant sedimentation in the last 20 years. In 1978, 1.8 million tons of sediments were deposited by the Gwai River alone. However, a study claims that most of the sediment is trapped in the upper flood plains.

Health—There was a significant decrease in sleeping sickness after the lake was created but on the other hand, an increase in river blindness appears to have been registered by local authorities. Bank documents do not provide any details.

References

SAR, Report No. TO-438a, September 1964.
SAR, Report No. PU-44, June 1970.
PAR, Report No. TO-116a, June 1966.
PAR, Report No. 4661, August 1983.
PAR, Report No. 158, June 1993.
PAR, Report No. SecM93-773, July 1993.
Zambia Energy Sector Strategy ESH 8894, December 1988.
Zimbabwe Power III Project 11963-ZIM, November 1993.
Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation: Feedback into Resettlement Planning".
Internal Bank Memo. April 8, 1996.

KEDUNG OMBO MULTIPURPOSE PROJECT (INDONESIA)

The Project

The main features of the project are a 66 m high rockfill on the Serang River, a 30 MW powerhouse, and irrigation works for 59,300 ha of land. The reservoir has a capacity of 635 million m^3 and the annual inflow averages 800 million m^3. Total project cost at appraisal in 1985 were estimated at US$283 million and the Bank loan was US$156 million. The project was completed in 1993 at a cost close to the appraisal estimate.

Project Rationale

Indonesia's food crop production forms 60 percent of agricultural GDP and 18 percent of total GDP. In recent years, gains in food crop production, especially rice, have had a marked effect on living standards in rural areas. The Kedung Ombo Project was assigned priority in view of its major irrigation benefits in an area without dry season water, and subject to damaging floods. The project is also needed to increase the municipal water supply to some large towns.

Development Impact

The aim of the project was to irrigate a large area of paddy rice in the wet and dry seasons. The pre-project situation was 27,300 ha (wet), 7,900 (dry). The PCR for the project reported that in 1994 the situation was 60,000 ha irrigated in both seasons. Thus, the agricultural objectives were achieved. The project increased water supplies to about 60,000 hectares, directly benefiting about 87,000 families (about 440,000 people) whose incomes increased by 35–150 percent. The water supply benefit will be achieved once the works outside of the project are completed to deliver water to the cities. The project had a major flood control benefit as it increased the flood protection level from 20 to 100 year return period. There was a major benefit in terms of fisheries. One thousand families are now involved in fishing activities and aquaculture. The project has also resulted in increased power generation and tourism. The PCR rated the project outcomes as satisfactory overall.

Social and Environmental Impact

Environment—Recent studies indicate that the project had no major environment al impact apart from those associated with resettlement. Despite the intensification of agriculture, water quality is generally good and there appears to be no increase in levels of nitrates in the water. Sediment deposition in the reservoir over the period 1989-1994 has been 11.5 million cubic meters compared with a total storage capacity of 723 million cubic meters and a dead storage capacity of 88 million cubic meters.

Resettlement—In the reservoir area, 9,500 ha were acquired. The project agency put the number of people who had to be compensated or resettled at approximately 27,000 (5,359 families) in a June 1996 communication to OED. By the time the work on the dam was complete and impounding had started (April 1989), the requisite amount of land (70 percent in the reservoir area and 30 percent in the irrigation area) had been acquired and compensation paid, usually in cash at the village itself. Though land acquisition was for the most part well implemented some

750 families refused to accept payment and the amounts due to them were deposited in local courts for collection by the persons concerned. Most of the affected families preferred to resettle locally and only a small proportion had transmigrated. Land prices in the nearby areas had increased and the compensation amounts proved to be insufficient to purchase land of equal productivity in those areas. In 1989-90, the project's resettlement plan was criticized in Indonesia and internationally. The Government's response was to make more efforts to improve the program. Additional and was acquired to provide land, housing and other facilities; facilities at the transmigration sites were improved and efforts were made to provide extension advice on alternative income-generating opportunities such as fishing and aquaculture. The amounts allocated for developing the resettlement and transmigration sites were increased three more times in subsequent years. In the end 1,161 families joined the transmigration program, 669 were locally resettled on sites developed by the project, and 3,131 resettled themselves in adjacent villages with the proceeds of compensation paid by the project. Some of the families living in the Greenbelt refused to move and 34 households have filed cases in courts.

A monitoring study of the resettled population conducted in 1993 indicates that 72 percent of the families are worse off following resettlement. Six years after resettlement, families who accepted the compensation and resettled themselves (50 percent of the resettled population) earn somewhat less than their neighbors who were not resettled, with a wide range. Families resettled to sites provided by the government earn nearly 25 percent less. Incomes have declined because productivity of the replacement lands is lower than land previously cultivated by these farmers. However, the government has spent considerable amounts of money on this group to improve soil fertility and to provide various services such as houses and other infrastructure. This corrective action program has begun to show signs of significant success in improving income and with improved farming practices, this group may have sufficient assets to restore incomes to their previous level. The families that joined the transmigration program (22 percent) and those who remained behind in the Greenbelt (6 percent) have done relatively well. After initial difficulties, current incomes of transmigrants is well above those of local residents and groups which have resettled in other ways. Many of those farming in the Greenbelt have good income earning possibilities through agriculture and fishing as they have access to the reservoir and soils are generally good. However, cultivation in the drawdown area may not be sustainable in the long-term.

References

PCR, Report No. 14636, December 1994.

KIAMBERE HYDROELECTRIC PROJECT (KENYA)

The Project

The project consists of a 112 m high earth fill dam on the Tana River, and a 150 MW powerhouse. The dam forms a 585 million m^3 capacity reservoir covering an area of 25 km^2. Construction began in 1983 and was completed in 1988. The project is the most downstream of six hydroelectric plants on the Tana River. The most upstream project is the Masinga Project with a reservoir of 1.5 billion m^3, and a 40 MW power plant. Masinga provides flow regulation for the downstream projects, including Kiambere.

Project Rationale

The aim of the project was to meet the rapid growth in electricity demand in Kenya. Kenya has some geothermal potential but no indigenous fossil fuel resources. In 1983 the demand was 240 MW and expected to reach 520 MW by 1990. Kiambere was compared to equivalent thermal power plants fueled by imported oil and was found to be the least-cost alternative at discount rates up to 15 percent.

Development Impact

Power—When the project was fully operational in 1990, it supplied 30 percent of Kenya's energy and peaking capacity. In 1994 prices, the annual energy produced was the equivalent of fuel oil worth US$25 million.

Environmental and Social Impact

Environment—The environment was a prominent issue in this project. An area of 132 km^2 was expropriated by the project agency TARDA. Of this, 25 km^2 represents the area inundated by the reservoir, and the remainder is a buffer zone around the lake and the project facilities where settlement and human activity are no longer permitted and where reforestation is being undertaken. The project indirectly affected other areas of undetermined size where the several thousand displaced people had to move in the administrative districts of Embu and Kitui which border on the Tana River at Kiambere. The Bank advised TARDA to pay special attention to the environmental aspects of the land adjacent to the reservoir such as destruction of the forest bushlands, and effects on water quality of soil erosion. The Bank was also concerned with issues associated with the opportunity to irrigate 1,000 ha of land downstream, effects on fisheries in the river, and on flora and fauna downstream. The Pre-Construction Environmental Impact Study commissioned by TARDA did not answer all these questions. The PAR concludes though that TARDA is committed to the environmental protection of the reservoir area and the basin as a whole. The project created no hydrologic and morphological changes other than those already imposed on the Tana River by prior developments. The relatively small reservoir did not contain flora or fauna not widely represented in the vicinity of the project.

Resettlement—Kiambere displaced more people than all the upstream dams combined. Resettlement was not adequately considered in the planning, appraisal and implementation of the project. The decision to implement a buffer zone greatly increased the number of people affected. In 1983 it was estimated that 1,778 would be affected but eventually 7,500 people were displaced or dispossessed. The people affected came from two ethnic groups, the Mbere and Kamba, and each group moved to areas where fellow ethnic members were living. However, compared to the host population, the resettlers fared poorly. Compensation was too little to buy land equivalent to their original holding. In their original surroundings they had diverse sources of income that were lost when they had to move. Moreover, in many cases the resettlers did not spend their compensation money on land, but on marriages, old debts and household items with the result that they became landless.

A resettlement survey completed in 1987 indicates that the impact of the project on the displaced population, even when compensated, was not favorable. On the basis of interviews with an estimated 15 percent of resettled households and an equal number of non-resettled households, results showed the resettlers averaged a loss of about half their land, had their livestock reduced by more than a third, and had less access to pasture, firewood, water and trees for building. The cash compensation for lost land was inadequate for buying land in the more densely populated resettlement area where land was scarce.

References

SAR, Report No. PU-70, May 1971.
SAR, Report No. 4336-KE, November 1983.
SAR, Report No. 7392-KE, December 1988.
PAR, Report No. 1230, July 1976.
PAR, Report No. 14804, September 1995.
Energy Sector Investment Project (draft SAR), November 1994.
Kipevu Project Environmental Assessment, 1994.
Electricity Tariff Study, Vol. II, London Economics Ltd., October 1993.

KULEKHANI HYDROELECTRIC PROJECT (NEPAL)

The Project

The main project features are a 114 meter high rock-fill dam on the Kulekhani River, an underground powerhouse with two 30 MW units, and associated transmission facilities. The reservoir covers an area of two km^2 and has a total storage capacity of 85 million m^3 and the average annual inflow is 123 million m^3. The project was appraised by the Bank in 1976 and completed in 1982, nearly two years after the target date and at a cost 80 percent above original estimates. The total project cost at the time of appraisal was US$68 million, financed in part by an IDA credit of US$26 million. Reflecting cost overruns, the total Bank commitment at the time of project closing in 1983 was US$40.8 million.

Project Rationale

Sector Background—Nepal has a large hydroelectric potential, with most of it in large projects of 1,000 MW or more. Yet in 1974, when the project was first proposed, Nepal's installed capacity amounted to only 54 MW and only about 3 percent of the population had access to electricity, almost all in Kathmandu. Over the previous decade, energy production had increased at an average annual growth rate of about 22 percent and demand was projected to grow at 14 percent per year during the decade to follow. In response to the severe shortage of electricity, a clear constraint on expansion of industrial and commercial enterprise, the Government accelerated plans to develop the country's hydroelectric resources.

Objectives and Justification—The project's primary purpose was to exploit the hydroelectric potential of the Kulekhani River to meet the rapidly growing demands of the Central Nepal Power System (CNPS) which serves the Kathmandu Valley. The project, located about 30 km from the capital of Kathmandu, was part of a development program for the power sector designed to support industrial and agricultural development while responding to the needs of individual consumers.

The Kulekhani site was first identified in the 1950s by a Swiss-Nepalese team, then investigated more systematically in the period 1967-1968. A feasibility study carried out as part of a master plan of hydroelectric development in Nepal found that the optimum sequence within the CNPS was construction of the Kulekhani No.1 Project (60 MW), followed by Kulekhani No. 2 (35 MW) and then Dev-Ghat (150 MW).

Kulekhani was found to be the least-cost solution for the CNPS, in part because no other hydro schemes of comparable size had been studied sufficiently to enable them to be commissioned by the required date (1980). Installation of different types of thermal generating units in different combinations would have been the only feasible alternative within the given time frame. To confirm that Kulekhani was the least-cost solution, five alternatives based on the installation of different types of thermal units were compared with the Kulekhani project. It was found that Kulekhani was the least-cost alternative at discount rates up to 12.9 percent.

An additional benefit from the Kulekhani scheme noted at appraisal was the fact that the proposed Kulekhani No. 2 and No. 3 power stations could be constructed downstream, utilizing the regulated flow from the Kulekhani reservoir. The project also created a potential for irrigation of about 10,000 ha in downstream areas.

The economic rate of return was calculated at 6 percent. Benefits were quantified using domestic tariffs of US¢1.9 per kWh and tariffs on energy exported to India of US¢1.5 per kWh. A projected tariff increase to US¢3.5 by 1980/81 was expected to raise the rate of return to about 10.7 percent in constant prices. Benefits to agriculture were not included in the analysis.

Development Impacts

The project has been successful in terms of its primary objective of expanding power supply to CNPS consumers. By 1984/85, Kulekhani was providing a third of the total power demand within the system. The project has enabled CNPS to meet the peak demand, particularly during the winter months when the combination of lighting, cooking, and heating causes the evening peak to rise about 20 percent above the summer peak. On a rate of return basis the project has not performed well. The 1986 PAR calculated the current rate of return at 3 percent without and 6 percent with the tariff increases required by the project. These rates are significantly below the comparable 6 percent and 10.7 percent rates forecast at the time of appraisal. Nevertheless, the PAR judged the project's outcome to be satisfactory overall.

Additional benefits which accrued from the project include, according to the project agency (May 1996), increase in employment, trade, cellar mills, cage fish farming, and tourism.

Environmental and Social Impacts

Environment—According to the project agency (May 1996) the project did not have much of an impact on the natural habitat because the area was not densely forested, but rather fertile agricultural land that was inundated. The initial project design did not take full cognizance of soil conservation and watershed management. A landslide occurred near the site of the intake while the reservoir was being filled. Repairs and protective works were carried out at a cost of US$2.6 million. Further landslides in areas surrounding the reservoir cannot be ruled out. The reservoir is large compared to the annual inflow and hence it should have a long life. However, according to a 1994 study on sediment control in the Kulekhani watershed, it was estimated that the incoming sediment volume was 355,000 m^3/year and the annual rate of sedimentation was 2,817 m^3/km^2/year. Reservoir volume lost up to the end of 1995 was put at 7.7 m^3 million. The project agency (May 1996) noted that the estimated remaining useful life of the reservoir is 20 years. With the provision of a sloping intake the useful life of the reservoir is expected to be about 50 years. Soil conservation efforts in the catchment area include the USAID-funded Kulekhani Watershed Soil Conservation Project carried out from 1978-1981 and the UNDP/FAO Watershed Management and Conservation Project (also funded by Danida and with technical support from JICA) completed in 1995.

The project had a serious impact on migratory fish species such as Asala (Schizothoraxspp). However cage fish farming was developed in the reservoir.

Resettlement—At appraisal it was estimated that about 1,200 people would have to be relocated from the reservoir area. The PAR reported that eventually more than 500 families or around 3,000 people were successfully moved, some of them downstream of the dam. According to the project agency in May 1996, 534 households (approximately 2,500 people) were displaced. A covenant for providing the Bank with a Resettlement Plan was never fulfilled. Land was offered to the population, but when the site in the Terai was rejected, no alternative areas were offered. Instead cash payment was accepted by all those affected. Studies indicate that while members of one of Nepal's more urbanized groups, the Newars, were able to invest the cash compensation productively, the majority subsistence-farming community, the Tamangs, were unable to do the same. Land price inflation, the necessity to spend the cash on subsistence, and inexperience in handling large sums of money all have been cited as factors for the alleged impoverishment of this community. Tamang women, according to some accounts, attempted a mass protest against cash being given only to male household heads, but to no avail. Another study made reference to the "proletarization" of a large segment of the displaced population.

The project did create a substantial amount of employment, equivalent to some 5,000 man-years which was not only income-generating but also enabled workers to learn new skills.

Health—The project agency (May 1996) mentioned that the spread of transmissible diseases such as tuberculosis, malaria, hepatitis, dysentery, and typhoid occurred during the project implementation period. Project authorities arranged for medical facilities during the construction period with the contractor. The average monthly medical treatment during the project period is as follows:

Ailment	**No. of Cases**
Injuries	367
Digestive	378
Respiratory	571
Other	379

References

SAR, Report No. 833a NEP, November 1975.

PAR, Report No. 177, May 1986.

Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation: Feedback into Resettlement Planning".

A. Molner and T. Ragsdale. January 30, 1991. Land Acquisition and Resettlement Issues and Procedures in Nepal. The World Bank.

LUBUGE HYDROELECTRIC PROJECT (CHINA)

The Project

The Lubuge project consists of a 100 m high rock-fill diversion dam on the Huang Ni in Yunnan Province, a 9.4 km long tunnel and a 600 MW powerhouse. The project was started in 1984 and completed in 1992. This was one of the first Bank loans to China. Bank financing of US$141 million accounted for 23 percent of the project cost of US$615 million. The project was built on time and within cost.

Development Impact

Power System—The aim of the project was to meet the rapidly growing electricity demands of Yunnan Province. In 1992 when the project was in full operation the peak demand had grown to 2,500 MW from 1,400 MW in 1984. Lubuge with 627 MW met 26 percent of the 1992 power demand, and produced 2,400 GWh or 21 percent of the energy demand.

Economic Evaluation—Lubuge was compared with alternative thermal power plants, and was found to be the least-cost alternative at discount rates below 14 percent. The economic rate of return, in which the energy output of the project was priced at the long-run marginal cost, was calculated at 12 percent at appraisal and at completion.

Environmental and Social Impact

Environment—The project has no adverse environmental effects. The small reservoir (it occupies only 4 km^2) had no real impacts on the biodiversity of the region. The project was the last stage of a basin development and needed only a small reservoir to operate efficiently. Perhaps the other stages had some impact on the forest cover of the watershed but this aspect is not documented. However, reforestation of the area surrounding the reservoir was of some concern to the local authorities and the Yunnan power bureau. The potential for land slides of the reservoir banks when the reservoir is flushed during the rainy season possibly prompted the comprehensive reforestation program. This program was to be financed by a Reservoir Management Fund.

Lubuge is the most downstream of a seven-project cascade in the Huang Ni Basin, in which the Agang Reservoir provides river regulation. Sediment flows will be captured by upstream reservoirs, and therefore sediment build up in the project's reservoir will be slow. As the reservoir's primary purpose is diversion, it will eventually develop a stable regime in which sediment outflow will equal inflow. The existing projects cause daily changes in flow as they respond to changes in power demand. Though the project will be operated as a peaking plant, it will not cause more rapid flow changes than at present.

Resettlement—A resettlement plan, reviewed and found acceptable by the Bank for the 2,320 people affected by the reservoir and the project works, was efficiently executed. The total cost for land acquisition, compensation and resettlement was estimated at US$8.6 million. The average cost for a displaced person at US$7,000 was considered acceptable, taking into account the annual income of a Chinese farmer. An interesting feature of the resettlement was the reclamation of land through irrigation using the water of the reservoir. A pumping station using the energy from the power plant supplies water to irrigate about 80 ha of land, an area equivalent to the submerged land. The resettlement plan offered a choice to the population between continuing to farm on new land or retraining in a new occupation. All the costs were charged to the project.

Of the 818 people in Yunnan province, 418 were engaged in farming in nearby areas above the reservoir level, 300 were resettled in a newly established village near Louping, and 100 were assigned to reservoir maintenance and other development activities by the local governments. Of 569 people in Guizhou province, most were engaged in farming in nearby high areas but some were resettled in another county. The affected people were adequately compensated. According to a report prepared by the project agency, the living standards of the resettled population improved considerably over pre-project times. People were provided with more living area, drinking water, electricity, and transportation and communication facilities. Also, new modern schools and health centers were built. Those engaged in farming were provided with more cultivated land. The water conservancy and irrigation facilities have already enhanced land productivity. The Young power bureau decided to set aside one yuan for every 1,000 kWh generated by the Lubuge plant to establish a Reservoir Maintenance Fund, 80 percent of which was used by the local governments for reforestation, fishery, and agricultural development activities; 20 percent was retained by the power station for reservoir cleaning, maintenance works, etc. Local institutions have been established to deal with such activities.

References

SAR, Report No. 4334-CHA, January 1984.
PCR, Report No. 12549, November 1993.
Cheng Xuemin. "China's First World Bank-Assisted Hydro Scheme." International Water Power in Dam Construction, Vol. 38, No. 2 (February 1986).
"Intensive Hydro Development of the Hongshui River." International Water Power in Dam Construction. Vol. 40, No. 8 (August 1988).

MAGAT MULTIPURPOSE PROJECT (PHILIPPINES)

The Project

The main features of the project are a 105 meter high (above lowest foundation elevation) dam on the Magat River with a 360 MW power plant and an irrigation system serving 80,000 ha. The reservoir has a storage capacity of 1.2 billion m^3 and covers an area of 45 km^2. The project was financed by the Bank in three stages. Stage I was designed to irrigate 75,000 ha, Stage II was the dam itself, and Stage III (Irrigation) was designed to irrigate a further 25,000 ha. The actual area served was eventually only 80,000 ha, as some areas were found to be already irrigated and other areas were excluded for various reasons such as soils, topography, and exposure to flooding. At appraisal the total cost of the project was estimated at US$552 million to be disbursed over seven years, from 1976 to 1982. Total Bank financing amounted to US$254 million. The powerhouse equipment was financed by suppliers' credits. The project was completed in 1986, four years behind schedule, but at costs close to appraisal estimates.

Project Rationale

In the mid 1970s, at the time the project was appraised, agriculture accounted for about one third of the Philippine GDP, over half of total employment, and nearly three-quarters of export earnings. Agriculture was growing at over 4 percent per annum in real terms, slightly faster than the overall growth rate for GDP. While current performance was good, there were two major causes for concern: first, incomes of farm families remained very low, and, second, with the population rising fast, demand for food grains was threatening to outstrip domestic supply. To increase farm incomes and achieve food grain self-sufficiency, the Government set as its long-range target an increase in the irrigated area from 960,000 ha in 1975 to about 1.6 million ha by 1990. The availability of reliable, year-round irrigation was expected to induce Philippine farmers to raise cropping intensities and yields on lands newly acquired under agrarian reform (as owner operators or leaseholders). The project was part of a series of 15 Bank loans to the irrigation sector, which together were designed to irrigate about 490,000 ha and benefit 290,000 families by 1990.

The main objectives of the project were to increase the production and incomes of some 32,000 farm families in one of the Philippine's major rice growing regions and to develop the hydroelectric potential of the Magat river. The project area, about 350 km northeast of Manila, was endowed with good soil and water resources. Rice was the predominant crop and in irrigated areas most farmers had already adopted high-yielding varieties. Of the total 80,000 ha developed by the project, about 60 percent was rainfed and 40 percent served by run-of-river diversion or small pump irrigation systems, generally poorly operated and maintained. Even under these conditions, the region produced 13 percent of the Philippines' total rice output with yields 10 percent above the national average. With water flow regulation and improved canals and drains, output could reasonably be expected to more than double.

The project was compared to alternative irrigation and power combinations. This involved substituting for the Magat hydroelectric facility a thermal system consisting of a 100 MW steam power plant supported by a 200 MW gas turbine plant. Magat was the least-cost alternative at discount rates below 10 percent.

Development Impact

Both the Pantabangan (see the project profile) and Magat projects were designed to support the government objective of rice self-sufficiency, using high yielding varieties, and its agrarian reform. The effect of the two dams was to provide a more reliable supply of water for the wet season crop, which often suffered from erratic rainfall in the monsoon season, and to greatly increase flows to expand the dry season crop. Many farmers switched from a low-yielding single crop to double crops using high-yielding varieties that require substantial and dependable irrigation to grow successfully. Overall, the projects provided year-round irrigation to about 296,000 ha, of which about 53 percent had previously been rain-fed. A follow-up socio-economic survey carried out 10 years after the completion of Magat found that family incomes of the intended beneficiaries, mostly small farmers, had increased from 39 percent to 75 percent, and were higher than in other rural areas of the Philippines. Such income increases facilitated the government's implementation of an agrarian reform program that reduced average farm size, abolished share tenancy and stabilized rural populations.

In recent years, the cropping intensity on the 80,000 ha actually developed has been close to 200 percent, which is double cropping over almost the entire service area. Yields of unmilled rice are close to the appraisal target of 4.2 tons/ha in the dry season and 4.0 ton/ha in the wet season. The PAR recalculated the ERR for the project and found it to be 9.5 percent (exclusive of power benefits) compared to PCR and appraisal estimates of 13 percent and 12 percent, respectively. The PCR computed current incomes of 2 ha family farms at around P26,000, considerably higher than what was projected at appraisal. The PAR estimated that at full development farm incomes would be 60 percent above the without-project scenario. Overall project performance was judged to be satisfactory.

Although the main benefit of the project was to raise farm production and incomes, there were important additional benefits, including power generation, flood control, reservoir fisheries and recreation, and increased water supply for household and industrial use.

The project provided two major bridges over the Magat River and about 1,800 km of O&M, farm-to-market, and access roads. By 1986 it was apparent that these components had helped develop marketing and processing, and general economic development in the area to a greater extent than was anticipated at appraisal.

Environmental and Social Impacts

Resettlement—The Magat resettlement component was carefully prepared and successfully implemented. The approach taken was based largely on lessons learned from the Upper Pampanga River Irrigation Project (Pantabangan dam) in which failure to plan for resettlement at appraisal resulted in a ten-fold increase in resettlement costs and considerable hardship for the farmers eventually forced to move. In the case of the Magat project, a special division within the project organization was created to handle resettlement of the 308 families in the reservoir area. Affected families were consulted about relocation plans which involved placing people at three sites, all close to the original site and equipped with year-round irrigation and village infrastructure. The project also financed start-up production costs for new settlers to tide them over until the first harvest. Resettlement was carried out in an orderly fashion with none of the prolonged disputes that marked the Upper Pampanga case. Early indications were that Magat farmers considered themselves better off than before removal. Moreover, the 308 displaced families were not the only ones assisted by the resettlement program. The project also took measures to ensure that some 200 families already living in the new areas were provided with an equivalent amount of land and new housing.

The success of the project resulted in a level of migration into the project area not anticipated at appraisal. The population of the area increased by about 60 percent between 1972 and 1988, and average farm size declined by about half, from 3.3 to 1.7 ha. Reduction in farm size would appear to be a negative effect except that incomes of farmers were rising substantially and at full development were expected to be about 60 percent above the without-project scenario. The project also resulted in employment opportunities not considered at appraisal: temporary employment during implementation, permanent employment on O&M, and employment in related activities such as milling, storage, marketing and manufacturing of farm inputs. The project, in other words, was touching far more farm families in a positive way—through improved income levels and living standards—than anticipated at the time of appraisal.

Environment—Approximately 4,500 ha of agricultural lands upstream of the dam along the Magat River and its tributaries was submerged by the reservoir. The project agency in June 1996 stated that out of the established watershed area of 7,550 ha, only 2,685 ha is in existence to date. The decrease in the established watershed area is due to forest fires, insect infestation, encroachment of upland farmers into the plantation area, and inadequate maintenance. The project agency notes that the National Irrigation Administration has worked out plans and programs for the development and protection of the Magat watershed. Nurseries are being maintained to raise seedlings for reforestation purposes, etc. As of 1995, the rate of sedimentation is 12.8 m^3 million per year. Approximately 13.5 percent of the volume of the reservoir has been lost and the projected remaining useful life of the reservoir has been put at 43 years.

References

SAR, Report No. 1911-PH, April 1978.
SAR, Report No. 215aPH, November 1978.
SAR, Report No. 727aPH, June 1975.
PAR, Report No. 7923, June 1989.
"Dam Job Overcomes Faults." ENR, August 21, 1980, pp. 24-25.

MORAZAN HYDROPOWER PROJECT (HONDURAS)

The Project

The project's principal features are a 238 meter high concrete arch dam on the Humuya River, a powerhouse equipped with four 73 MW units, and ancillary works including 60 km of access roads. The project is located near the confluence of the Humuya and the Sulaco Rivers about 80 km southeast of San Pedro Sula, Honduras' major industrial city. The reservoir has a gross storage capacity of 5.6 billion m^3 and a surface area of 94 km^2. The project was appraised by the Bank in 1980 and completed in 1985, a year ahead of schedule. The cost of the project at completion was US$618 million, 6 percent over appraisal estimates. The Bank contribution was in the form of a loan of US$105 million and a credit of US$20 million.

Project Rationale

Sector Background—In the late 1960s when the Morazan (previously known as El Cajon) project was first being considered, surveys showed hydropower to be the most abundant energy resource of Honduras. Estimates indicated a theoretical potential of 4,000 MW with annual energy of about 35,000 GWh. About one-third of this potential had already been inventoried and sites representing about 2,000 GWh annual production had been studied at the feasibility level. Hydropower use grew rapidly after 1970, but by 1976 still represented only 13 percent of energy consumption compared to 44 percent provided by petroleum products. With its hydropower potential largely untapped, Honduras remained heavily dependent on costly fuel imports.

The Bank's involvement in the Honduras power sector began in 1959 with a series of loans to Honduras' national electricity authority to build small hydro and thermal plants, to extend distribution to rural areas, and to link the system to Nicaragua. Although electricity output grew at an average annual rate of 15 percent between 1967-1977, consumption on a per capita basis in 1976 was 178 kWh, putting Honduras in fifth place among the six Central American countries. Only 22 percent of the population, most of them urban, had access to electricity. Rising demand, particularly from the industrial sector, where sales had increased sevenfold between 1973 and 1978, highlighted the role electricity would play in the country's future economic growth. The Morazan development appeared attractive for two reasons. First, it represented use of indigenous resources for electric power production at a time of concern about dependence on high-priced foreign oil. Second, it was a project at an advanced stage of preparation that offered a large annual production capacity (1,350 GWh).

The project's primary purpose was to effect in a single stroke a large enough increase in the generating capacity of the Empresa Nacional de Energía Eléctrica (ENEE) to enable Honduras to meet internal growth in demand for electric energy during the 1980s, to sell surplus energy to neighboring countries, and to reduce the country's dependence on imported fuel. Morazan was designed to increase ENEE's installed capacity by 150 percent, from about 200 MW to 500 MW. The project was also expected to improve flood control in the Sula Valley and to regulate the flow of the Humuya river downstream of the dam, thus enabling future development of irrigated areas.

The Morazan project was a decade in the planning stage. It was originally identified in a survey of Honduran hydroelectric potential carried out in 1967. A project feasibility study was completed by Motor Columbus in 1973, and updated in December 1977. In addition, EBASCO carried out studies (financed by IDB) of the project's size and timing in connection with a system optimization review. These documents supplied the basis for the Bank's appraisal of the project in 1978. Reportedly, some Honduran engineers raised objections to proceeding with Morazan, but no other program for electricity production was advanced enough to offer a viable alternative.

Economic Justification—Morazan was subjected to the standard least-cost analysis to determine its economic viability. Two major alternative power system development modes were studied: one based on Morazan with its approximate 300 MW capacity, the other based upon smaller oil-fired plants supplemented by diesel and gas turbines. No other major hydroelectric schemes were considered. The equalizing discount rate derived from comparing Morazan with the all-thermal alternative was 11.5 percent without taking into account benefits from flood control and sale of initial surplus energy to neighboring countries and 14.3 percent if these benefits were included in the analysis. The PAR (1989) criticizes the appraisal for failing to test results for sensitivity to market development, though it concedes that only in recent years has this become a standard element of Bank analysis of hydro schemes. On balance, the PAR concludes that the Bank placed too much reliance on a somewhat limited analytic exercise and not enough on common sense which indicated that Morazan was large relative to the market it was to serve and costly relative to the country's resources.

Development Impacts

Power—Morazan was completed ahead of schedule at a cost only 6 percent over appraisal estimates. At the time the plant was commissioned in 1985, it was the largest hydroelectric installation in Central America. It more than doubled Honduras' total installed capacity and pushed the hydro portion from 50 percent to 75 percent. Judged solely from the standpoint of its hydropower production capability, the project represented success, and, in fact, it was given a satisfactory rating in the Bank's 1989 PAR. But from a financial standpoint it was a disaster, burdening the country with unmanageable debt service obligations. In the PAR's view, Morazan epitomizes the risks inherent in constructing a very large project in a very small economy. If demand is lower than expected, the project can become a serious drain on the economy. The PAR for Morazan faults project evaluation techniques, claiming that the project was too large even if demand projections had been correct; however, it concedes that some unforeseen factors intervened as well, chief among them civil unrest and insurgency in Honduras' neighbors. As of 1989, ENEE had more than twice the installed capacity than it needed.

From a 1995 perspective, Morazan gets better marks. The trend of the 1990s has been towards full utilization of all hydro plants, in particular, Morazan which from 1987-1992 accounted for over 60 percent of Honduras' total electricity generation. While exports of surplus electricity from Morazan were lower than anticipated in the period 1985-1990 due to political turmoil in the region, their overall impact on Honduras' economy was a positive one, providing valuable foreign exchange.

Flood Control and Irrigation—There are reports that river regulation at Morazan helped avoid at least two major floods in the Sula Valley in the period 1986-1988. There are reports that the control of the river has led to irrigation benefits but data are lacking.

Environmental and Social Impacts

As a condition of effectiveness of the loan, the Bank required the Government to prepare a detailed program for dealing with environmental concerns and resettlement of people living in the reservoir area. This was to include an inventory of land to be flooded, compensation for the approximately 400 families (about 3,618 people according to the project agency in May 1996) affected by the project, preventive health control measures, and reservoir clearing and protection of the watershed, fauna and archaeological (possibly Mayan) treasures. An expert with the Pan American Health Organization was engaged by the Bank to draw up the program; he continued as a consultant to the Bank on these issues through 1987. His final report concluded that the planned program was carried out satisfactorily but at a slower rate than provided for in the 1980 implementation schedule. A 1989 Bank review noted that failure to include financing of resettlement in the Bank loan may have contributed to delays in carrying out this component.

A 1995 ENEE report cites the need for a river basin management program to deal with problems including soil erosion, sedimentation, loss of biodiversity, and deforestation. A number of these problems are the result of a recent influx of people into the basin and not a direct consequence of the project: e.g., land clearing and tree cutting have led to a loss of forested area and unregulated hunting has endangered certain species. Few details on environmental problems and programs are available. Sediment inflow was estimated as 10 million m^3, compared to a dead storage of 1,400 million m^3. Thus, sediment depletion will not be a problem for 150-200 years.

Dam Repairs

After completion of the dam, massive seepage under the foundation threatened the integrity of the structure. The Bank helped finance the US$33 million Morazan Dam Emergency Project with an IDA credit of US$12.8 million. As of April, 1995, the problem had been dealt with successfully by injecting tons of sealants into the rock mass.

References

SAR, Report No. 2388a-HO, February 1980.
PCR, Report No. 5420, January 1989.
PAR, Report No. 7901, June 1989.
SAR, Report No. 10754-HO, July 1992.
CR 2306-2-HO, February 1993.
Morazan Dam Emergency Project supervision report, April 1995.
Energy Sector Adjustment Program, P-5592-HO, September 1991.
Empresa Nacional de Energía Eléctrica (ENEE), Report on Central Francisco Morazan, April 1995.
"Inauguration of El Cajon Hydroelectric." Central America Report, July 6, 1984.

NAM NGUM HYDROELECTRIC PROJECT (LAO)

The Project

The Nam Ngum project was constructed in three phases. Phase I, completed in 1972, consisted of a 75 meter high concrete gravity dam and spillway on the Nam Ngum River, a powerhouse with two 15 MW turbine generating units, and a transmission line from the dam site to Vientiane and from Vientiane across the Mekong River to join the power system of the Electricity Generating Authority of Thailand (EGAT). The Phase II Project added spillway gates and two additional generating units, each of 40 MW capacity, which were placed in commercial operation in 1978. A fifth unit, also rated at 40 MW, was installed by the Phase III Project completed in 1985. Phase I was financed by the Nam Ngum Development Fund, a multilateral fund administered by the Bank; Phase II by a Second Development Fund administered by the Asian Development Bank and with financing from Germany; and Phase III by an IDA Credit of US$15.0 million.

The project is located in a sparsely populated area about 80 km north of Vientiane, the largest city in the Lao PDR, and about 160 km upstream of the Nam Ngum's confluence with the Mekong River which forms the border between the Lao PDR and Thailand. The plant has a total capacity of 150 MW and average annual energy production of about 984 GWh. The Nam Ngum Reservoir has a gross storage capacity of 7 billion m^3 and covers an area of 370 km^2. Most of the estimated 3,200 people living in the reservoir area before construction of the Phase I project were engaged in subsistence agriculture on small clearings in the forest and along the banks of the river.

Project Rationale

Before Nam Ngum was built, power supply in Lao consisted of small diesel plants dependent on imported fuel. Energy demand was growing, particularly in Vientiane, and prospects existed for sales of electricity to Thailand. Nam Ngum was selected for development because it was the most attractive hydroelectric project in the Lao PDR in terms of costs per kilowatt hour, and it was close to the load center and to the system of the Electricity Generating Authority of Thailand (EGAT). Furthermore, the project had the required attributes of an export project, namely a river large enough to provide reliable year-round power and energy, and the potential for staged development.

In 1971, the project's owner, Electricité du Laos (EDL) and EGAT entered into an agreement for the sale of Nam Ngum energy to Thailand. The agreement stipulated that Thailand would absorb electrical energy from Nam Ngum that was surplus to the needs of EDL. To take full advantage of this agreement, the Government of Lao decided to proceed immediately with a second stage project to install two or three additional generating units. In 1973, the Bank carried out an evaluation study for Phase II. The study compared several alternative installation schedules. These were ranked in order of the present value of net benefits over a range of discount rates. It was found that the best alternative was for two 40 MW units (Units 3 and 4) to be installed as soon as possible and that Unit 5 be deferred until needed to meet future capacity requirements. The financial return on the investment in the recommended installation schedule was 15 percent.

Since the justification for advancing the installation of additional units at Nam Ngum depended on the sale of energy to Thailand, the Phase II Project stipulated that the 1971 purchase agreement between EGAT and EDL be extended beyond 1981 with an appropriate price adjustment. Designed to optimize output from Nam Ngum, Phase III installed a fifth 40 MW unit to provide stand-by capacity to permit shutdown and maintenance of the older units without reducing exports to Thailand. The financial return on Phase III was estimated to 16 percent at appraisal and 18 percent at completion.

Development Impacts

Power System—The project has been a success in meeting energy needs in Lao and increasing foreign exchange earnings from sales to Thailand. The annual energy generated by Nam Ngum is virtually proportional to the annual inflow to the reservoir, which shows considerable year-to-year variations. For example, in the period 1990 through 1994, the high was 1,032 GWh and the low was 604 GWh. Domestic demand has grown rapidly in recent years, and now takes about 300 GWh. At the current export tariff, Nam Ngum's annual earnings are at present around US$18 million.

Flood Control and Irrigation Impacts—The Phase II Evaluation Study noted that the larger reservoir created by installation of spillway gates would help eliminate flooding in the lower Nam Ngum valley. Flow regulation provided by Nam Ngum also increases the dry–season flow entering the Mekong Delta by 150 cubic meters per second, thus offsetting the effects of increasing abstractions from the river by low-lift pump irrigation.

Social and Environmental Impacts

No resettlement plan was formulated prior to the Phase I Project. The Fund Agreement (1966) specified that the Government would be responsible for reservoir clearing and resettlement of the estimated 3,200 people living in the area to be inundated. Security problems restricted access to the reservoir and no clearing was undertaken. Also, the disturbed political situation impeded resettlement. About 800 people moved upstream of the reservoir. The remainder settled near the dam site to take advantage of employment opportunities during construction and to qualify for government support programs for displaced persons.

Failure to clear the reservoir created a water quality problem as the biomass in the reservoir decayed and an odor of decaying vegetation was, and continues to be, noticeable at the power plant. Water quality is now reported to have greatly improved. Fisheries development in the reservoir has emerged as one of the benefits of the project. However, failure to clear trees from the reservoir initially caused problems for fishing gear.

A survey of reservoir sedimentation study was carried out by Upsala University, Sweden in 1992. These observations were used to estimate future sediment deposition, and it was concluded that it will take more than 1,000 years for sediment to fill more than 50 percent of the reservoir's gross capacity.

References

Evaluation Study, Phase II 175-LA, May 1973.
Administrator's Final Report, 1974.
PCR, Report No. SecM90-213, February 1990.
Axelsson, Valter. "Sedimentation in the Nam Ngum Reservoir-Lao PDR, "Report submitted to the Mekong Secretariat, October 1992.

PANTABANGAN IRRIGATION PROJECT (PHILIPPINES)

The Project

The main project features are a 107 m high and rock-fill dam, a new and upgraded irrigation and drainage works serving 78,400 ha, a 100 MW power plant, and about 1,000 km of feeder roads. The reservoir has a capacity of 3.5 billion m^3 and the annual inflow averages 1.4 billion m^3. The project was appraised in 1969. Construction of the dam was completed ten months ahead of the target date, but completion of the irrigation system was delayed until 1977, thirty months behind schedule. The total project cost estimated at the time of appraisal was US$62.5 million, financed in part by a Bank loan of US$34 million. The cost at project completion was US$128 million, a cost overrun of 105 percent which was mostly due to inflation during the implementation period. The power plant was added in a later Bank-financed project.

Project Rationale

In the late 1960s, the Government launched a major program to achieve self-sufficiency in production of rice, the Philippines' main agricultural crop, accounting for about half of the total planted area. Recent introduction of high yielding varieties (HYVs) showed promise of progress toward this goal, but more vigorous expansion appeared essential to keep pace with the rice requirements of a rapidly growing population. The main constraint on increasing HYV cultivation was lack of reliable irrigation. Water resources, though abundant, were inefficiently used and existing irrigation systems depended on unregulated stream slows.

To improve irrigation, the Government initiated, as part of its Four Year Program (1967-1970), a comprehensive, long-range plan (a) to rehabilitate canals and drains to achieve higher water utilization efficiency and (b) to construct dams to store wet season flows for use in the dry season. The Upper Pampanga River Irrigation Project (UPRP) with its reservoir and irrigation system at Pantabangan, about 100 km north of Manila, was a key part of this program and the Bank's first true irrigation project in the Philippines. This was followed in the decade 1970-1980 by nine additional irrigation projects and two rural development projects with substantial irrigation components. Two of these projects are direct extensions of the UPRP, the Aurora-Penaranda Irrigation Project (1974) which taps into the Pantabangan reservoir and main canal system, and the Tarlac Irrigation Systems Improvement Project, a rehabilitation and expansion project along the western edge of the UPRP.

The aim of the project was to expand production of irrigated rice by providing a reliable water supply to a 77,000 ha service area in the heart of the Philippines' rice-producing region of Central Luzon. Project works were designed to make possible higher wet-season yields and a substantial increase in dry-season cultivation.

Cropping patterns and yield projections made at the time of appraisal assumed the successful introduction of HYVs over the entire project area by the tenth year of the project. At full development, annual rice output calculated on the basis of double cropping of HYVs was expected to be about four times the appraisal level. The major economic justification for the project was the fact that increased paddy production would help the Government meet projected rice demands without resorting to imports. In the economic analysis, the 440,000 metric tons of incremental rice production was assumed as import substitution. No benefits were credited to the project from power generation or from crops with a higher return than rice. Discounting costs and benefits over 50 years, the economic rate of return exceeded 13 percent.

Development Impact

The appraisal estimate of a 193 percent cropping intensity was achieved soon after project completion. Yields vary from 3.5 tons/ha to 5 tons/ha depending on weather and the impacts of pests and diseases, but on average they are significantly higher than the appraisal estimates of 3.8 tons/ha. Annual production of paddy is around 750,000 tons compared to the appraisal estimate of 500,000 tons. The project agency in June 1996 also noted that the project had brought about flood control benefits. Project performance was judged to be satisfactory by the 1980 PAR.

Social and Environmental Impacts

Environment—The project agency in June 1996 intimated that out of the established watershed area of 24,522 ha, only 10,711 ha exist to date. The decrease in the established watershed area has been the result of forest fires, insect infestation, encroachment into the plantation area by upland farmers, and inadequate maintenance. As of 1989, the project agency estimates the rate of sedimentation to be approximately 7.02 m^3 million per year. The reservoir volume lost so far is about 6.6 percent and the estimated remaining useful life of the reservoir is 107 years.

Resettlement—In the final tally, 2,308 families (about 13,000 people) were displaced by the Pantabangan Reservoir. Yet the issues involved in relocating, on an involuntary basis, a group of this size were not addressed either in the preparation studies or in the SAR. The audit noted that this lack of appreciation at appraisal of the magnitude and complexity of population resettlement led to protracted negotiations, a ten-fold increase in costs, lack of economic viability of the resettled farmers, additional inflow of compensation-seekers, and poor choice of resettlement site. During detailed design the dam crest was lowered by 3.5 m to avoid submerging the nearby town of Caranglan. Relocation became a very emotional issue and was magnified and exploited for political reasons. About 187 families relocated to irrigated lands and the remaining 2,116 families to four newly developed sites on hills along the southeastern rim of the reservoir. The hilly terrain proved incapable of providing a livelihood. The reservoir was filled 10 months early. Families turned down the offer of irrigated land to stay by Pantabangan town, which was inundated. As no more construction income was forthcoming they turned to logging and forest exploitation. Progressive degradation of the catchment area ensued. There was also a problem of squatters.

Thus, lack of preparation for resettlement came at high cost. Failure to identify before the project started who was to be resettled gave outsiders the chance to move into the project area in search of compensation payments. Failure to get agreement with settlers on the relocation site allowed this to become a divisive political issue, requiring protracted negotiations and resulting in selection of some sites where farming potential was poor. This in turn necessitated additional outlays of funds to train settlers in new skills. Ultimately, settlers were provided with housing, potable water, electricity, community buildings, and roads, but at a ten-fold increase in costs over appraisal estimates. Total expenditures for resettlement, excluding administrative overhead, were US$11.7 million or US$5,070 per relocated family.

References

SAR, Report No. PH2, July 1969.
PCR, Report No. 8494, 1980.
PAR, Report No. 3063, 1980.
Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation: Feedback into Resettlement Planning".

PEHUENCHE HYDROELECTRIC PROJECT (CHILE)

The Project

The Pehuenche Hydroelectric Project is located about 250 km south of Santiago at the confluence of the Maule River and its tributary, the Melado River. The main project works are a 90 meter high earthen dam on the Melado River, a small diversion dam on the Maule River, and an underground powerhouse with two 250 MW units. The reservoir, which covers only two km^2, has a live storage capacity of 33 million m^3. Construction of the power plant, which had already begun at the time of appraisal, was completed in September 1991, 17 months ahead of the original schedule. The shorter construction time was one of several factors contributing to a 51 percent cost savings (from US$799 million to US$395) and a consequent reduction in the Bank loan from US$95 million to US$40.6 million.

Project Rationale

Chile's hydroelectric potential is the country's most abundant and economic energy resource. In 1985, hydroelectric plants accounted for 57 percent or 2,300 MW of Chile's total installed capacity (public and private sector) of 4,000 MW. This represented 13 percent of the country's theoretical hydroelectric potential of 18,000 MW.

Virtually all of Chile's existing hydroelectric capacity was part of the Sistema Interconectado Central (SIC), the system serving the central Chile-Santiago region, home to 93 percent of the population. Demand projections for this vital economic region, the origin of 95 percent of the country's GDP, showed an annual growth of 5 percent for the period 1985-1995. The biggest demands were expected to come from large industries and transport. To meet these demands, the Government planned to promote efficiency gains in existing SIC operations and add capacity to the SIC by exploiting hydro resources in the south of the country.

The main objective of the project was to meet the growing demand for electricity in Santiago and central Chile. The project was to provide 17 percent of SIC's capacity in 1993, the first year of full operation. No project-specific economic evaluation was made at the time of appraisal. Instead, an internal rate of return for the overall 1986-95 SIC investment program was calculated and found to be 11 percent, a figure judged adequate to justify the individual projects proposed as part of the program. Sensitivity analyses showed the rate of return to be sensitive to changes in electricity tariffs and sales and to increases in capital costs, and moderately sensitive to changes in operation and maintenance costs.

Development Impact

Growth of peak demand in the SIC for the five year period 1987-1992 averaged 6.7 percent, well above the SAR forecast of 4.3 percent, due to the faster than anticipated growth of the overall economy. Pehuenche, which came into service about a year and a half ahead of schedule, supplied 14 percent (2,087 GWh) of the SIC's total energy demand in 1991 and 19 percent (3,022 GWh) in 1992. Average annual generation is 2,871 GWh. Pehuenche's early commissioning well below budget meant that its impact on regional economic growth was even more positive than anticipated at the time of appraisal. This was all the more so since the country was then experiencing a period of extended drought and there were delays in bringing another SIC hydroelectric plant into operation. According to the PCR forecast, the Peheunche plant, as the second largest hydroelectric plant in the SIC, will continue to play a key role in Chile's energy sector though its contribution to power supply is expected to decline to 14 percent in 1995 and 11 percent in 2000 as demand increases.

Social and Environmental Impacts

There were no resettlement issues since the reservoir area was uninhabited. The main environmental issue addressed in the SAR concerned the Chilean Conure parrot, (cyanoliseus patagonus byroni) an endangered species resident in the reservoir areas and its environs. At the time of appraisal, the total population of Conure parrots, a species found only in Chile, was estimated to be 2,800. These birds were under pressure from farmers who hunted them because of the damage they did to crops. Inundation of part of their habitat would have placed them under further pressure. The project's environmental component, totaling US$1.1 million, financed a program to establish a population in a protected area near the project. This was reported to be successful with the parrots multiplying rapidly.

The project's environmental component also provided financing for what the SAR called a "national environmental program." Though much more modest than the name would imply, the program succeeded in training four Chilean environmental specialists, conducting public seminars on environmental issues, and supporting a pilot program to introduce an endangered species of pine, the Belloto del Sur (beilschmiedia berteroana), into the project area. The project has also contracted with the University of Talca to monitor the reservoir's water quality.

References

SAR, Report No. 6687CH, May 1987.
PCR, Report No. SecM94-1100, November 1994.

PLAYAS HYDROELECTRIC PROJECT (COLOMBIA)

The Project

The project is one of several major projects built to develop the Nare-Guatape-Samana River Basins. Its main features are a 65 m high rock-fill dam, a 3.6 m power tunnel, a 500 m long tailrace tunnel, and a powerhouse with three 67 MW units that will produce 1,450 GWh in an average year. The reservoir on the Guatape River has a capacity of 85 million m^3 and covers an area of 11 km^2. The project was appraised in 1980 and completed in 1986. The estimated cost of US$310 million was financed by the Bank, IDB and suppliers' credits. The owner is Empresas de Medellin (EPM).

Project Rationale

EPM operates power facilities and provides electricity service to the city of Medellin and surrounding areas. In 1980 the peak demand in EPM's service area was 800 MW and demand was growing at an annual rate of 9 percent. The project was part of a least-cost expansion plan for Colombia's power sector. At appraisal the EIRR was calculated as 15 percent, with benefits expressed as energy sales.

Development Impact

Despite construction problems which delayed project completion by two and a half years, the project successfully achieved the system expansion objectives defined at appraisal. The project's rate of return as recalculated in the 1993 PCR was slightly below the appraisal estimate but above the opportunity cost of capital in Colombia, estimated at 10–11 percent. The PCR rated the project's performance to date as satisfactory and the sustainability of its benefits to the power sector as likely. The project agency noted (May 1996) that Playas is a run-of-river plant and serves no irrigation or water supply functions.

Environmental and Social Impacts

Resettlement—The project agency (in May 1996) noted to OED that the number of displaced people amounted to 1,000. There is no mention of impacts on those relocated. The audit notes that the project agency's ability to handle resettlement was considered to be adequate.

Environment—Playas was a small element of a complex basin-wide system of reservoirs and diversions, so any downstream impacts directly related to the project would be negligible. A program to reduce erosion from roads was also undertaken. The natural vegetation of the inundated area was very poor consisting of scrubland vegetation. A buffer zone was established around the reservoir area. This is being reforested by promoting the natural regeneration of native species. It also serves as a protected area for birds and reptiles. The Project agency (May 1996) noted that 10 years after the creation of the buffer zone, the plants have a diameter of 15–20 cms.

The project agency (May 1996) notes that a watershed conservation study conducted in 1992 identified the main sources of sedimentation. On the basis of this study the project agency has undertaken works to restore slopes and borrow pits along the roads, and has implemented measures to improve the vegetative cover. This includes reforestation of approximately 30 ha of land. These watershed conservation works are being continued.

Downstream effects are also being monitored. Already some riverside farming families have been resettled. Community infrastructure that had been affected has also been replaced.

Fisheries on the Guatape River had been very poor before the project and the creation of the reservoir did not affect them either positively or adversely. In the reservoir, however, some sport fishing is practiced.

References

SAR, Report No. 3240b, February 1981.
PCR, Report No. 12641, December 1993.

HYDROELECTRIC PROJECTS ON THE RIO GRANDE (BRAZIL)

Development of the Rio Grande

Between 1949 and 1974, the Bank helped finance 18 hydroelectric projects in Brazil with a total installed capacity of 12,800 MW. Seven of these projects were on the Rio Grande. The first project was the 24 MW plant at Itutinga built in 1949 in the headwaters of the river. Then, in 1958, work began on Furnas (1,220 MW), the key project in the Rio Grande's development. With its large reservoir, Furnas controlled the flow of the Rio Grande and thereby created the potential for downstream projects. Following the construction of Furnas, eight projects with a capacity of 5,800 MW were built below Furnas on the Rio Grande, of which five were Bank financed (Table 1). The entire length of the Rio Grande is now developed. Flow regulation by Furnas also enhanced the potential at Ilha Solteira (3,200 MW) and Jupia (1,400 MW) on the Parana.

The Rio Grande, a tributary of the Parana, originates near the border between the states of Minas Gerais and Rio de Janeiro. About 20 km above the Furnas rapids the Rio Grande is joined by the Rio Sapucai, a river of similar size. The total catchment area above Furnas is about 52,000 km^2. The Rio Grande flows approximately east to west through the state of Minas Gerais, joining the Parana about 700 km downstream from Furnas. Seven of the ten projects financed by the Bank in the southeast region of Brazil in the period 1953-1973 were on the Rio Grande, four operated by Central Eletrica de Furnas, S.A. (FURNAS), a subsidiary of the government holding company, ELETROBRAS, and three by the state-owned company, Centrais Eletricas de Minas Gerais, S.A. (CEMIG). Other major tributaries of the Parana, the Paranapanema and the Paranaiba, were also the sites of Bank-financed hydroelectric developments: the 60 MW Salto Grande (60 MW) on the Paranapanema, and the Sao Simao (1,600 MW) and Itumbiara (2,080 MW) plants on the Paranaiba, managed by CEMIG and FURNAS, respectively.

In 1962 the Government employed CANAMBRA, a consortium of Canadian and U.S. consulting firms, to undertake a comprehensive study of six river basins in Brazil's southeast region. The objective of the study, financed by UNDP with the bank as Executing Agency, was to identify the most cost effective way to meet the regional power demands of the 1970s. The CANAMBRA report, issued in final form in 1965, outlined a fifteen year expansion program, predominately hydroelectric since hydro sites that could be developed at low unit cost were in abundance whereas known indigenous fossil fuels were scarce and of poor quality. The report recommended a sequence of new hydroelectric projects on the Rio Grande based on ranking each site according to its investment cost per kW. The highest priority was given to construction of Estreito which had the lowest per kW cost, followed by Jaguara, Volta Grande, and Porto Colombia. All were ultimately developed with Bank financing. ELETROBRAS updated the CANAMBRA study in 1970 with a market survey of its own. The survey showed regional demand expanding at about 11 percent through the 1970s with total regional consumption reaching 75,000 GWh by 1980. As a result of the survey, two further developments on the Rio Grande, Marimbondo and Itumbiara, were begun in early 1970.

Development Impact

The southeast region which encompasses the states of Minas Gerais, Sao Paulo, Rio de Janeiro, Guanabara, Espirito Santo and Goias, is Brazil's industrial heartland. The region around Belo

Horizonte in Minas Gerais is rich in minerals, including iron ore, manganese and bauxite; the mining and steel industries have long been the region's chief source of wealth. Agriculture has been a close second. In 1958, at the time of appraisal of the Furnas Project, the southeast accounted for nearly 80 percent of Brazil's industrial production, two-thirds of the country's crop output, and nearly a third of all livestock produced. There was at the time growing concern about possible future shortfalls in electricity supplies to this vital economic region. Demand projections based primarily on continued expansion of the metallurgical industries indicated that even with the Furnas plant in service, the region would have a 3,000 MW deficit in generating capacity in 1970. Reducing this deficit clearly required coordinated, long-term planning to follow Furnas with other hydro sites on the Rio Grande and other rivers in the Parana Basin.

There has been no retrospective analysis of the hydroelectric development of the Rio Grande. However, it would seem reasonable to speculate that the economic development of Brazil's heartland would have been retarded without the exploitation of the hydroelectric resources of the Rio Grande and other rivers of the southeast. Reliance on imported fuels for thermal power plants may not have been economically feasible. Also, the annual production of nearly 30 billion kilowatt hours of clean renewable energy instead of the combustion of the equivalent of 45 million barrels of oil every year, must have a significant environmental benefit in terms of air pollution and the release of greenhouse gases.

Table 1: Hydropower Dams on the Rio Grande

Project	Installed Capacity MW	Annual Energy GWh	Reservoir Capacity mill. cu. m	Height of Dam m	Construction Period	Bank Financed
Camargos	40	140	U	50		N
Ituliliga	50	180	U	40	1949-53	Y
Sam Miguel	60	210	U	50	U	N
Funil	120	420	216	85	1961-69	N
Furnas	1220	5,700	22,900	127	1958-63	Y
Peixoto	480	2,200	4,000	72	1972-76	N
Estreito	1050	4,100	1,400	92	1964-69	Y
Jaguara	460	2,400	14,500	70	1970-74	Y
Igarapava	240	1,550	U	30	U	N
Volta Grande	440	1,800	2,300	56	1970-74	Y
Porto Colombia	320	1,300	1,500	25	1 971-75	Y
Marimbondo	1400	7,400	6,100	65	1971-75	N
Agua Vemelha	1,380	4,700	11,100	67	1974-79	N
Total	7,300	29,600				

U = Unkown

Environmental and Social Impacts

No data are available to judge other environmental impacts or the magnitude and social impacts of resettlement from the reservoir areas (there was no mention of the magnitude or impacts of resettlement in any of the Bank documents for the three projects). Of interest is the fact that in the 1981 audit for the Sao Simao project it was noted that no resettlement plan was required of the project agency (for the Sao Simao project) because of the "successful" history of the project agency in dealing with resettlement in the Jaguara project. However, as noted earlier, resettlement in Jaguara was not mentioned in either the appraisal or the audit. In fact, the audit for Jaguara mentioned that no resettlement plan was required for Jaguara because of the successful conclusion of the resettlement component of the Sao Simao project. It should be noted that this region was at that time the industrial heartland of Brazil, and one can imagine that the resettlement was considerable for this cascade of dams. "...This whole Rio Grande cascade in SC Brazil was a cozy deal as far as resettlement goes" (Ragsdale).

References

SAR, Report No. TO 184a, September 1958 (Furnas).
PAR, Report No. 2370, February 1979 (Estreito and Porto Colombia).
PAR, Report No. 1852, January 1978 (Jaguara and Volta Grande).
PAR, Report No. 2768, December 1979 (Marimbondo).
Eletrobras. Plano Diretor de Meio Ambiente do Setor Eletrico. Vols. I and II, Rio de Janeiro, 1991.
Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation:Feedback into Resettlement Planning".

ROSEIRES IRRIGATION PROJECT (SUDAN)

The Project

The Roseires Dam on the Blue Nile, 450 km upstream of Khartoum, was built to provide water for existing irrigation areas and for uncultivated land to be developed for irrigation. Construction began in 1961 and was completed in 1966. The dam is 60 m high and forms a reservoir with a capacity of 3 billion m^3, and its design allows for future raising by 10 m to add a further 4.6 billion m^3. The area that now benefits from the dam is over one million hectares. The dam was financed by a Bank Loan of US$19.5 million, an IDA Credit of US$13.5 million, and a KfW Credit of US$19 million. The cost of the dam including interest during construction was US$88 million, essentially the same as the cost at appraisal. The Bank Loan for the dam was preceded by a loan for the Managil Irrigation Project. Between 1973 and 1983, IDA financed a number of other irrigation projects in areas served by the Roseires Dam.

Project Rationale

The Blue Nile and the White Nile join at Khartoum to form the main stem of the River Nile. The land between the rivers—the gezira—has been farmed for centuries, and the land close to the rivers has been irrigated by small canals from the main river channel. Modern irrigation dates from the 1920s with construction of the Sennar Dam on the Blue Nile, about 300 km upstream from Khartoum, to supply water to what came to be known as the Gezira Project. The Gezira Scheme and an extension to the south, the Managil Scheme, now cover 800,000 ha. The Roseires Dam was conceived in the 1950s as a way to extend the irrigated area further along the left bank of the Blue Nile. A dam was needed to store the wet-season flow for use in the dry-season (January to May). In 1960 the Bank made a loan for the Managil Project, and at the same time reviewed plans for Roseires. In 1961 the Bank agreed to help finance the Roseires Irrigation Project. The project had two parts:

Part A:	The construction of the Roseires Dam;
Part B:	The development of new irrigation schemes and the extension and intensification of the Gezira/Managil Irrigation Scheme.

The financing of Part B was left to the Government of the Sudan, but shortage of funds and lack of detailed plans led to delays. It was not until 1973, seven years after the dam was completed, that the Bank financed the Rahad Irrigation Project. This 120,000 ha project along the Rahad River, a right bank tributary of the Blue Nile, is supplied by a canal from the Blue Nile. In 1981, a project to improve 22,000 ha served by the Blue Nile Pump Schemes was financed by IDA. Finally, the Gezira Rehabilitation Project to rehabilitate pumps, canals, drains, roads and supporting services in the 900,000 ha Gezira Project was financed by an IDA Credit in 1983.

In 1959 Egypt and Sudan signed the Nile Waters Agreement. This had a provision that would relax the limits on Sudan's withdrawals from the Blue Nile on the completion of the Aswan High Dam. This had the effect of giving Sudan more water than was assumed in the justification for the Roseires Dam. Thus, it might be argued that the dam could have been delayed for about five years until the demand for water reached the limit of unregulated supply. But, as the Bank's Impact Evaluation Report (IER) of June 30, 1980 points out, the course of events might not have been the same if the dam had been deferred. Delays in the irrigation schemes could not have been foreseen, and they might well have been delayed even more in the absence of the dam. It is also possible that the imminent construction of the dam gave Sudan, as the upstream riparian, a stronger hand in the negotiations on sharing the Nile waters.

Development Impact

Though the 1974 PAR judged the project's performance to be unsatisfactory, the Roseires Dam is now indispensable to the irrigation of more than one million hectares. Without the dam, a large area could not be cultivated, and cropping intensities and yields would be lower in the irrigated areas. The IER concluded, in 1980, that a rate of return of 10 percent was a realistic indication of the economic merit of the dam. It also found that, viewed from the standpoint of the Sudanese economy as a whole, the economic impact of the scheme was marginally favorable. However, the IER also refers to the extreme dependence of Sudan's economy on the agricultural exports from the areas watered by the dam. A PCR for the Rahad project in 1984 found an ERR of 20 percent, after considering the dam as a sunk cost. In contrast, the PAR for the Blue Nile Pump Schemes Rehabilitation shows the outcome as a 3.5 percent ERR. This PAR describes the many ups and downs of Sudan's economy in the 1980s, and the agricultural and taxation policies that in general appear to have been unsuccessful. Also, during the 1980s, low commodity prices, and inadequate funding of operation and maintenance, reduced farmers' incentives and held back the productivity of the irrigation schemes. Thus, it seems that the considerable promise of agricultural prosperity created by the Roseires Dam has yet to be realized. The potential for improvement is shown by the Gezira Rehabilitation Project (GRP), which with a relatively modest investment produced a gain in cropping intensity from 54 percent to 72 percent. The project also includes a 90 MW powerhouse at the dam. This has been a valuable addition to the Sudan power system.

Environmental and Social Impacts

The project has caused no significant changes in the sediment or morphological regime of the Blue Nile downstream of the dam. However, the sediment accumulation in the reservoir has been greater than estimated initially. This can be offset by raising the dam.

The spread of irrigation led to a higher incidence of malaria and bilharzia. A health component of the GRP, in association with the World Health Organization, was reported as successful. It brought the incidence of bilharzia down from 54 percent to 7 percent at a cost of US$3.5 million over eight years.

Resettlement of the 3,000 families (about 19,000 people) from the reservoir appears to have been successful, although they were not adequately compensated for rebuilding their dwellings. These families moved back from the river to the fringes of the reservoir where the water regime is more stable and predictable than along the river. They took up vegetable farming on the edges of the reservoir and in the draw down zone. This activity and income from fishing generally raised their standard of living.

Within the irrigated area the social impacts were more complex. These are described in farm surveys, carried out in 1980 to provide an input to the IER. Many of the settlers on the irrigation schemes had formerly combined subsistence farming of crops such as sorghum and sesame with animal husbandry. They also worked as seasonal laborers on existing projects. Not only did they keep their animals in their new setting, but so increased their herds that the livestock population went up by a factor of eight. The settlers exchanged the risks of subsistence farming in a harsh environment for the hazards of falling commodity prices, defective water management, labor shortages, and the vagaries of government policy. On balance they are probably better off now, but still as indebted as when they were subsistence farmers. However, they now have much better access to schools, social services, and transportation. Also, some nomadic groups appear to have been negatively affected.

References

SAR, Report No. Roseires, TO 277a, June 1961.
PAR, Report No. Roseires, 476, July 1974.
IER, Report No. Roseires, 3051, June 1980.
SAR, Report No. Rahad, PA 139b, February 1973.
PAR, Report No. Rahad, 476, June 1984.
SAR, Report No. Gezira, 428 SU, May 1983.
ICR, Report No. Gezira, 14024 SU, March 1995.
PAR, Report No. Blue Nile Pumps 12053, June 1993.

SAN CARLOS HYDROELECTRIC PROJECT (COLOMBIA)

The Project

The project is one of several major projects built to develop the Nare-Gutape-Samana River Basins. Its main features are a 77 m high earth dam, a 4.5 m power tunnel, a 1.6 m long tailrace tunnel, and an installed capacity of 1,145 MW that produce 5,400 GWh in an average year. The reservoir on the Guatape River has a capacity of 50 million m^3 and covers an area of 3 km^2. The project was developed in two stages. Stage 1 was appraised in 1978 and completed in 1984, and Stage 2 was appraised in 1979 and completed in 1987. Delays in Stage 2 arose because of geologic difficulties. The estimated cost of the two stages was US$503 million and the final cost was US$610 million. Bank financing amounted to US$198 million. The owner is Interconexión Eletrica S.A. (ISA).

Project Rationale

ISA was established in 1967 to interconnect a number of utilities and to own and operate new generating plants. In 1978, Colombia's peak demand was 3,200 MW and expected to double by 1985. San Carlos was built to help meet this growth in demand. The project was part of a least-cost expansion plan for Colombia's power sector. According to the project agency (May 1996) the installed capacity of San Carlos is 1144.8 MW. Plant extension of 143.1 MW each year is planned from 2002–2003. Power generation in 1995 was 5409 GWh.

Development Impact

A Bank PAR in 1991 found that the project met its objective; and therefore, it was given a performance rating of satisfactory. It met Colombia's power demand through an efficient expansion of generating capacity, and it enhanced ISA's technical and institutional capabilities. The PAR calculated the EIRR as 20 percent compared to 14 percent at appraisal.

Environmental and Social Impacts

Resettlement—The reservoir flooded a small area and the project agency (May 1996) puts the number of displaced people at 520. There were initial problems with resettlement (the project agency does not specify what they were) which have been resolved for the most part according to the project agency. Employment of the resettled population has been achieved through the provision of incentives for developing community enterprises.

Environment—The project had no significant effect on the hydrology which was already modified by upstream projects, and so any downstream impacts directly related to the project would be negligible. Water quality is good with a minimal amount of organic matter and aquatic weeds (project agency, May 1996).

There was some degradation of the environment and loss of biomass associated with the creation of the reservoir. Some faunal species were displaced and there were problems with erosion along the access roads. A conservation program is in place that involves a nature reserve in the area around the reservoir as well as a reforestation and revegetation program. This reforestation program specially emphasizes re-introducing native species that are in danger of extinction. The reforestation program is being undertaken in eroded areas of the upper and middle basin and there is also deforestation control in the areas owned by the utility.

The sedimentation rate is estimated at 0.4 million cubic meters per year. The loss of reservoir capacity up to the end of 1995 was estimated at 8.5 million cubic meters out of a total volume of 74.7 million cubic meters. The project agency estimates the remaining useful life of the reservoir to be 50 years.

The project has had no impact on fisheries. A hydrobiological inventory shows no significant changes in fish dynamics. Fish farming is being developed in the reservoir. Indigenous people in the area continue to engage in subsistence fishing.

The project agency (May 1996) notes that there is no evidence of any direct or indirect health impacts on the population after the construction of the reservoir.

References

SAR, Report No. 1850a CO, May 1978.
SAR, Report No. 2464a CO, May 1979.
PCR, Report No. 10237, December 1991.
President's Report P-2239-CO, May 1978.

SAO SIMAO PROJECT (BRAZIL)

The Project

The project was part of a comprehensive program to exploit the rivers of Brazil's southeast region—namely, the Parana and its tributaries, the Paranaiba, the Parananema, and the Rio Grande—for hydropower generation. The Sao Simao hydropower plant was the first development on the Paranaiba River which drains a 220,000 km^2 basin extending south from the capital city, Brasilia. Main project features are a 128 m high and 3 km long earth fill dam, and an installed capacity of 1635 MW. The dam created a reservoir with a gross capacity of 12.5 billion m^3 about 150 km long with an area of about 674 km^2 located in a remote, sparsely populated part of Minas Gerais. The project was appraised in 1972. The total project cost at appraisal was estimated at US$396 million to be financed in part by a Bank loan of US$60 *million*. The project was completed on schedule at a cost overrun of 60 percent (in constant 1972 prices) as a result of underestimates in civil works and resettlement costs, and changes in project design to accommodate larger power units.

Project Rationale

Sao Simao was one of the low-cost hydropower sites identified in a UNDP-financed power master plan prepared for Brazil's southeast region. This region, Brazil's industrial heartland, then accounted for about 80 percent of the country's total installed generating capacity, most of it derived from hydropower. Twelve power utilities operated the region's transmission system, including the Centrais Eletricas de Minas Gerais (CEMIG) which served the state of Minas Gerais, site of Brazil's mineral-based industries. In 1970, CEMIG, the owner of Sao Simao, provided 77 percent of the state's total production. CEMIG, as a major power supplier, was pivotal to growth of Brazil's industrial base in the southeast and, therefore, to the health of the national economy generally. At the same time, the Government's new regional plan for power expansion called for coordinated operation of regional generating facilities as a more cost-effective way of meeting power needs than the current trend toward state self-sufficiency. In addition to the development at Sao Simao managed by CEMIG, the new plan authorized construction of another major hydro plant further upstream on the Paranaiba at Itumbiara to be run by the large regional utility, FURNAS. The additional upstream storage provided by the Itumbiara allowed CEMIG to increase the number and capacity of generating units originally planned for Sao Simao.

The project's main objective was to provide additional generating capacity in time to meet an expected 11 percent p.a. growth in demand for energy in Minas Gerais during the 1970s. The project was included as a priority development in an all-hydro program which, taken as a whole, was determined to be the least-cost strategy at discount rates below 10 percent, at that time considered to be the opportunity cost of capital. No least-cost analysis of Sao Simao was carried out at appraisal. The project's economic rate of return was calculated as 17 percent.

Development Impact

The project came into service in time to meet the expected growth in demand for CEMIG's energy. In 1980 the Sao Simao plant generated about 7,100 GWh or almost half of CEMIG's total energy sales. This allowed CEMIG to become a net seller of energy on the interconnected system, thus stimulating growth of both state and regional industry.

Social and Environmental Impacts

Resettlement—At the time of appraisal, it was thought that the 674 km^2 Sao Simao reservoir would inundate three small villages with a total population of 7,400 and "nothing of architectural or historical significance." The project was to provide US$25 million to cover the costs of "land and reallocation." In actuality, creation of the reservoir required resettling 14,000 inhabitants from four urban areas and a small, unspecified number from rural areas. The final cost of this component was US$21 million over the appraisal estimate. CEMIG compensated property owners for lost land and dwellings without incident in 95 percent of the cases; the remaining cases were resolved by court action. CEMIG purchased sites for two new towns and one new village, built infrastructure and public buildings, provided transportation for settlers and their goods, and gave each displaced homeowner existing housing or plots on which to construct houses at the new sites. A 1981 Bank review concluded that settlers were better off than before the move, noting, in addition, that there was no evidence of health hazards as a result of construction of the dam. While rating the resettlement component an overall success, the Bank review pointed out that compensation payments should have been issued only upon completion of infrastructure at the new sites. The fact that payments were made in advance led a few settlers to make immediate cash purchases only to find themselves short of funds when the new sites were ready for them to start house construction.

Environment—An ecological reconnaissance mission which visited the Sao Simao site in 1971 reported that the project would have no significant adverse consequences. The main impact would be loss of the Sao Simao gorge and waterfalls situated about 16 km upstream of the dam site. The mission concluded that the gorge was not likely to become a tourist attraction because of its inaccessibility and distance from population centers. Since the mid-1970s, the Brazilian power authorities have made significant progress in instituting social and environmental safeguards in the power sector. Beginning in 1982, Environmental Impact Assessments have been a legal requirement for all power projects.

References

SAR, Report No. PU-86a, April 1972.
PAR, Report No. 3500, June 1981.
MOP P5057, April 1989 (Environmental Reform and Energy Conservation Loan).

SIDI SALEM MULTIPURPOSE PROJECT (TUNISIA)

The Project

The main features of the project are a 70 m high rock-fill dam, a 36 MW hydropower plant, a 126 km long canal, a 10,600 ha irrigation system, and improvement of an existing 6,000 ha irrigation system. The dam forms a reservoir with a storage of 550 million m^3 on the Medjerda River. Annual reservoir inflow averages 950 million m^3. At appraisal the cost was estimated to be US$386 million. Construction began in 1977 and the project was completed in 1984 at a cost of US$373. The project was financed by the Bank, China, KfW, the European Investment Bank, the Kuwait Fund and the OPIC Fund.

Project Rationale

The project was designed to be a key element in the Northern Tunisia Water Master Plan. The Plan is the centerpiece of the Government's efforts to develop water resources for the urban, rural and agricultural sectors in Northern Tunisia. Its main objectives were: (a) to secure a reliable supply of water for Tunis/Cap-Bon, Tunisia's main urban and industrial area; (b) to improve the water supply for existing irrigation systems; and (c) to develop new irrigated areas.

Development Impact

The project has met its objectives and has made a considerable contribution to the economic development of Northern Tunisia. A Bank PAR in 1987 found that the project had greatly enhanced the supply of potable water to Tunis and surrounding areas. The Sidi Salem dam provides Cap-Bon with additional water resources for irrigation and for ground water replenishment to combat the intrusion of sea water. The project has also resulted in a major reduction in flood damage as none has been recorded after the completion of the dam. It should be noted that losses from the major flood of 1973 amounted to US$3 billion apart from 100 deaths. Fisheries have increased and the project agency in May 1996 noted that 100 tons of fish are produced bringing in revenues of about US$500,000. As regards agriculture, the impact is positive, and the farmers have responded by growing more high-value fruits and vegetables than anticipated at appraisal. The area has also become an important tourist attraction according to the project agency.

Social and Environmental Impact

Environment—The PAR notes that the project's impact on the environment has been better than expected at appraisal. The waters of Sidi Salem are less saline than had been expected. An environmental study on the water quality of the reservoir was conducted and a strict system of pollution monitoring is now in place. Further work is continuing under German bilateral assistance on the disposal of effluent directly into the Medjerda River. The effects of a sugar factory upstream are also being monitored by the project agency. An unexpected and adverse effect has been the discharge of oil into the Medjerda River by the powerplant due to technical problems encountered with the equipment provided under supplier credit. The discharge is of sufficient quantity that remedial steps should be taken.

In a communication with OED in June 1996, the project agency noted that the wildlife around the reservoir has improved, especially migratory birds. Soil conservation works on the Medjerda watershed are one of the Ministry of Agriculture's priority programs. Many works have already been undertaken and the annual sedimentation rate is decreasing every year. The estimated annual incoming sediment volume is 4 million cubic meters with an annual sedimentation rate of 0.7 percent. The useful remaining life of the reservoir is approximately 120 years. Aquatic weeds are under control ever since fish were seeded in the reservoir. Wastewater treatment plants which have been in operation for the four cities of Jendouba, Bou Salem, Beja and Medjez El Bab, recently have helped considerably in controlling the water quality of the Sidi Salem reservoir. Though the Medjerda River is less saline than before, the salt content of the reservoir's waters sometimes reaches 1.4g/l. This has to be mixed with water from Echkeul's reservoirs in order to meet water supply standards.

Resettlement—Though the SAR mentioned the need to relocate 3,500 people, there was no information on relocation in either the PCR or the PAR. The PCR does note, however, that a major factor responsible for the long delays in the irrigation component was due to the delay in resolving land ownership issues for the location of the pumping station complex of Medjez El Bab. It states that "...Projects often take for granted the release of ownership rights of land needed for the execution of works. However, in densely populated areas where land is extremely valuable, this issue cannot be minimized and should be more closely examined, the predictable bottlenecks identified in time, and legal procedures, if needed, started at an early stage". This would seem to suggest that there were problems with implementing resettlement but no details are provided in the Bank documents as mentioned earlier. The project agency put the numbers of displaced people at 1,365 (in June 1996) but does not provide further details apart from mentioning that after the project the standard of living has risen in the area.

The PCR mentions that the project beneficially affected 4,400 farm families in the area. Almost half the beneficiaries with farms of 3–5 ha increased their incomes from well below the relative poverty level before irrigation to a level which approaches the overall average per capita GNP. The same happened to farmers in citrus plantations who, though not quite as poor as the previous group, saw an increase in income post-project that was close to or above the national per capita GNP.

Health—The project agency noted that the project had a positive impact on the health of the population. Food habits have changed and the standard of living has increased since the project was implemented.

References

PAR, Report No. 7037, December 1987.
PCR, June 1986.

SIR HYDROELECTRIC PROJECT (TURKEY)

The Project

The main features of the project are a 120 m high concrete arch dam on the Ceyhan River and a powerhouse equipped with three 94.5 MW units. The reservoir has a gross storage capacity of 1,120 million m^3. The project was appraised in 1986 and was completed essentially on schedule and within budget in 1991. Total Bank financing amounted to US$132 million out of total project costs of US$259 million. The Sir Hydroelectric Project was the twentieth Bank operation in the power subsector in Turkey, the second to develop the Ceyhan River. Sir was the first power plant in Turkey to be constructed and financed without public funds, an action taken in accord with a new Government policy to expand private sector involvement in the development and production of energy. The owner is Cukurova Electrik A.S. (CEAS).

Project Rationale

Sector Background—In 1985, Turkey's total installed capacity was about 8,500 MW, a 70 percent increase over the figure for 1978. The percentage of the population with access to public electricity also showed impressive growth over the period, rising from about 50 percent in 1978 to nearly 80 percent in 1985. However, demand for electricity continued to outstrip supply, resulting in power interruptions and excessive reliance on oil imports. Total demand was forecast to grow at about 10 percent annually for the balance of the 1980s, tapering off to around 8 percent during the 1990s. To meet this growth in demand for electricity Turkey needed to bring on stream about 5,500 MW by 1990 and to sustain this level of development during most of the 1990s. The Government's Five Year Plan of 1985-89 placed priority on continued exploitation of Turkey's hydroelectric potential.

Project Objective—The project's main objective was to exploit the power potential of the Ceyhan River to help overcome Turkey's chronic electricity shortages and in so doing to reduce the country's dependence on imported oil. The project was part of a master plan initiated in the mid-1960s to develop the entire Ceyhan River basin for purposes of power and irrigation. A series of feasibility studies to determine optimum dam sites resulted in projects for the construction of twelve dams, all but one now complete. Included in the list are three Bank-financed dams in the lower basin: the multipurpose Ceyhan-Aslantas dam, in operation since 1984, and, further upstream, the Sir power dam completed in 1991 and the Duzkesme/Berke power dam now under construction. The decision to build Sir and Duzkesme/Berke emerged from a 1979 feasibility study which showed the two dams in combination to be the most cost effective development of the upper part of the lower basin. At the time of appraisal of Sir, which was earmarked for first phase development, the Bank also concluded that, while no countrywide ranking of hydro projects was available, the proposed project compared well with other economically viable hydroelectric projects then being advanced for Turkey as a whole. Furthermore, an extensive review of the cost of thermal alternatives showed that Sir would generate electricity at a lower cost than any other base load thermal plant and most of the hydroelectric plants included in the 1985-1995 power expansion program. The rate of return for the entire expansion program was calculated at 11.5 percent compared to an opportunity cost of capital of 12 percent; this result reflects low tariffs rather than the viability of the program.

Development Impacts

The Sir Hydroelectric Project, which was designed to increase peaking capacity in Turkey's southern regional system, nearly doubled the installed capacity of CEAS, the region's major supplier and operator of the Sir plant. In the initial years of its commissioning, 1991-1992, the project added about 600 GWh to CEAS' average annual generation of 1,400 GWh. Bank projections in 1993 of Sir's energy output for the period 1993-2021 shows a drop to 735 GWh by 2000 and 560 GWh by 2021, as increasing amounts of water are released into new irrigation facilities being constructed in conjunction with the upstream Menzelet dam. This accords with the SAR estimate that at full irrigation development at Menzelet, Sir's generation would be reduced on average to 550 GWh. In a 1993 Bank review of the Sir project, the rate of return was calculated at 13 percent, higher than the appraisal estimate.

Social and Environmental Impacts

Resettlement—The Sir reservoir displaced or indirectly affected about 4,950 inhabitants of nine villages, most of them subsistence farmers working small plots planted with maize, cotton, and vegetables or grazing animals in the arid hills. Resettlement planning began early on in the project. At the time of appraisal, valuation of the 5,000 ha to be submerged by the project was well under way and relocation agreements had been reached with the 300-400 families affected by the first stage of reservoir filling. Landowners were given the option of government-assisted resettlement on government-owned land or a one-time cash payment which would allow them to purchase their own replacement plots. The project provided US$20 million to cover new land purchases, cash payments, and construction of infrastructure in newly established villages. The vast majority of landowners chose to be compensated in cash. The resettlement program was implemented in three stages over a five year period; the final two stages, covering the period of project execution, were carried out in accordance with a detailed plan of action agreed to with the Bank. According to a 1993 Bank review, the program was completed satisfactorily, supervised by the CEAS and local authorities, closely monitored by the Bank, and with few recorded incidents of popular dissatisfaction.

Environmental assessment—As in the case of resettlement, environmental concerns were addressed at the project preparation stage. In September of 1984, Cukurova University carried out an environmental impact study of the Sir and Duzkesme/Berke dams. The study concluded that on balance the projects would have beneficial effects. The reservoirs would increase humidity in the area, resulting in regrowth of forests currently depleted by fires and indiscriminate felling. Encouraged by milder climatic conditions, new plant life and other species would appear along the shoreline of the reservoirs. Water quality was expected to remain unchanged. The reservoirs could be stocked for fishing, an industry not yet developed on the Ceyhan River or its tributaries. There were also important archaeological sites in the area that could be developed for tourism.

Sedimentation—Analysis of the river's sediment content at the Sir site carried out at the time of appraisal indicated that the reservoir would have an operating lifetime well in excess of 50 years. Completion of the upstream Menzelet dam in 1986 was expected to reduce the rate of sediment accumulation in the Sir reservoir.

Dam safety—As part of the project design process, and with Bank oversight, engineering consultants appointed by CEAS carried out detailed geological investigations at the proposed site to determine the safety of the dam and reservoir. On the basis of field data, it was concluded that landslides would not occur in the vicinity of the dam site and that any that might occur further away would not affect dam safety. Water leakage from the reservoir was not expected, primarily because the chosen site was in a deep mountain divide which protected lower drainage areas. Seismicity test results were taken into account in the ultimate dam design. The soundness of the appraisal investigations was borne out during project construction, which was free of delays related to geological problems.

References

SAR, Report No. 5919 TU, August 1986.
PAR, Report No. 12650, December 1993.

SOBRADINHO HYDROELECTRIC POWER PROJECT (BRAZIL)

The Project

The first project to develop the hydroelectric resources of the Sao Francisco River, the main river in northeastern Brazil, was the 180 MW Paulo Afonso I, financed by the Bank in 1950. This was followed by Paulo Afonso II (435 MW) and Paulo Afonso III (412 MW). Further development at the Paulo Afonso site required upstream storage to regulate the river's flow. In 1974 the Bank and the Inter-American Development Bank agreed to help finance Paulo Afonso IV. The project, as defined for purposes of appraisal, included the following major works:

a) the Sobradinho dam, a 3.4 km long, 33 meter high dam situated about 470 km upstream from the Paulo Afonso Falls in the middle reaches of the Sao Francisco;

b) the Paulo Afonso IV hydroelectric station consisting of a 5 km bypass channel, a spillway, and an underground powerhouse with space for six 410 MW units; and

c) transmission facilities consisting of 390 circuit-km of 500 kV lines, 1,290 circuit-km of 230 kV lines and 22 substations.

The Bank loan was applied to the purchase of transmission line and substation equipment, and IDB financed miscellaneous power station equipment, and equipment for the substations.

While the Bank did not finance the Sobradinho Dam, the Loan Agreement required the owner, Companhia Hidro Electrica do Sao Francisco (CHESF) and the Brazilian Government to prepare, for Bank review and comment, plans to:

a) resettle the population living in the Sobradinho reservoir;

b) minimize the spread of plague, schistosomiasis, and malaria, and minimize the effect of decaying biomass in the Sobradinho reservoir; and

c) assess the impact of the project on downstream agriculture and prepare a plan for compensation.

The Sobradinho Reservoir covers an area of 4,214 km^2 and has a storage capacity of about 36 billion m^3. Creation of the reservoir and downstream flooding as a result of dam construction required resettling some 70,000 people and undertaking costly (US$66 million) flood plains protection measures under separate projects. The dam was completed on schedule in 1977; the Paulo Afonso IV hydro plant and transmission network were fully operational in 1982 and 1985, respectively. Total project costs estimated at the time of appraisal were US$693 million, financed in part by a Bank loan of US$81 million. Final costs (in 1973 constant prices) were US$963 million with most of the overrun attributed to the dam and resettlement components.

Project Rationale

Sector Background—Beginning in 1969 the Government undertook several power studies of Brazil's Northeast region, which at that time accounted for only 10 percent of the country's total energy consumption. Demand was projected to grow at about 14 percent per year over the period 1971-1982, much of it coming from the region's three most populous states where large industrial expansion programs were under way. To meet this high projected load growth, the regional electricity authority, Companhia Hidro Electrica do Sao Francisco (CHESF), proposed a long range program to exploit the hydroelectric resources of the 2,660 km long Sao Francisco River, starting with a 400 MW generating plant at Moxoto, followed by 1,500 MW (original estimate) at Paulo Afonso and 4,000 MW at Xingo. This represented a considerable increase in installed capacity over the 1,300 MW (over 90 percent hydro) in operation in the Northeast in the early 1970s.

In response to (a) the oil crisis of 1973, which heightened concern about dependence on imported fuels and (b) a new estimate of Northeast power demands, which showed annual growth at 18 percent rather than 14 percent, CHESF substantially altered the design of the Sobradinho/Paulo Afonso complex immediately following loan approval in 1974. At Sobradinho, the decision was made to advance the date of construction of a 1050 MW power station at the foot of the dam from 1991 to 1979. At Paulo Afonso, the planned installed capacity was increased from 1,500 MW (four 375 MW units) to 2,460 MW (six 410 MW units).

Objectives and Justification—The project's main objective was to develop the hydroelectric potential of the Sao Francisco River to meet the growing electricity demands of the Northeast region's 30 million people. Bank and CHESF analysts found that the most attractive hydroelectric option was to build the Sobradinho regulating dam in combination with a fourth powerhouse at Paulo Afonso. The PAR describes Paulo Afonso IV as "a nearly ideal hydroelectric solution as it uses one of the few sites along the river where a substantial head is naturally available." To confirm that Paulo Afonso was also the least-cost solution when compared with thermal and nuclear alternatives, analysts first prorated Sobradinho's investment costs among Paulo Afonso IV and other downstream hydro plants, existing and planned, whose benefits likewise derived from the dam's regulating effects. In the case of Paulo Afonso IV, this meant adding 40 percent of Sobradinho's costs to the costs of constructing and equipping the hydroelectric station itself. Even at this level of investment cost, compared with thermal/nuclear options Paulo Afonso IV was found to be the least-cost alternative at discount rates up to 18 percent. The economic rate of return for Paulo Afonso IV was calculated at 23 percent.

Development Impact

Power System and Regional Economic Growth—The PAR concluded that, based on actual market developments as of 1986, Paulo Afonso IV was still the least-cost solution, being superior to the all-thermal alternative assumed at appraisal. The PAR's rate of return calculations were 13 percent compared to 23 percent forecast at appraisal, a reflection of lower tariff levels. Power consumption figures for the Northeast region for the years 1973-1982 show an overall rate of growth of 14 percent over the period. This demonstrates that Paulo Afonso IV, which represented one-third of CHESF's total capacity when it was commissioned in 1985, was a success from the standpoint of expanding electric energy generation in support of rapid urban-industrial growth in the northeast. The report goes further, crediting Paulo Afonso IV along with Itaparica and the two flood plain projects with broad development of the entire Sao Francisco valley, particularly expansion of capital intensive irrigated agriculture and associated agroprocessing enterprises. Such developments have meant an increase in jobs and local commercial activity. However, this growth picture, which the report describes as "impressive," has been uneven. Some towns have fared better than others and many of the largest urban centers have seen a rise in poverty and unemployment. In the countryside, the gradual shift from smallholder to large-scale, commercialized farming has increased the ranks of the landless poor.

Social and Environmental Impacts

The Bank and the Government were aware from the start that construction of the Sobradinho dam would have an enormous impact on the local population, both upstream and downstream of the dam. Creation of the reservoir, stretching 325 km from Sobradinho to Barra, required the removal of some 9,700 families from farms and villages along the river. Downstream, changes in river flows as a result of the dam threatened permanent flooding of 32,000 ha of rice land, which would deprive 11,000 farm families of their livelihood. In both cases, the affected populations were in the lowest income categories, ill-equipped to cope with changes brought on by the project.

At the time of appraisal, the Government and CHESF agreed to submit plans for resettlement and flood plain protection within nine to twelve months of loan signing. The resettlement plan made CHESF responsible for relocating the "urban" population, some 25,000 people (4,000 families) living in four small towns in the area to be evacuated. These people were to be moved to new towns constructed about 1,000 km upstream of Sobradinho near the city of Bom Jesus da Lapa. The Instituto Nacional de Colonizacao e Reforma Agraria (INCRA) was to manage resettlement of the rural population, mostly on sites closer to the reservoir. In the process, the lines between urban and rural became blurred: some 6,200 families chose to remain close to the reservoir, not 3,700 families as originally expected, and only 1,000 families rather than 4,000 decided to settle permanently in the new towns. Ultimately, this too proved to be an impermanent arrangement. Neither the upstream settlement schemes nor the lakeside agrovilas prospered and many people left the area entirely.

The resettlement component suffered from lack of advance planning and poor coordination among implementing agencies. Costs escalated from the US$12 million appraisal estimate to US$62 million upon completion. A glaring weakness was the inadequacy of compensation policies which stipulated that only those farmers with legal titles would be paid for loss of land. Many farmers who had worked the land and fished the river for decades under informal arrangements were left destitute. Timing was another problem. For example, a fisheries scheme, which was to have generated additional income for the displaced, failed to achieve its intended results because only 1,000 ha could be cleared before the reservoir filled rather than the 8,000 ha planned.

The PAR, on the other hand, while referring to the hardships suffered by displaced persons, finds enough positive evidence to conclude that "the new towns are at least a modest success and form the nucleus for a relatively strong development." One certain impact of the Paulo Afonso IV resettlement experience is that it encouraged the Bank to adopt more stringent guidelines for managing involuntary resettlement in Bank-financed projects.

Government efforts to protect downstream areas affected by altered river flows from Sobradinho were assisted by two Bank-financed projects, the US$23 million Lower Sao Francisco Polders Project (1975) and the US$43 million Second Irrigation Project (1979). Some areas in the Lower Sao Francisco had been farmed each year as the seasonal flood receded. The overall aim of these projects was to develop polder irrigation schemes in place of traditional flood plain agriculture, thus making possible a second annual rice harvest. Newly irrigated plots were to be given to formerly landless farmers along with access to credit and farm technology. Reportedly, some 3,200 families, as compared with an appraisal target of 4,600, were permanently settled in this fashion and saw their farm incomes more than triple. However, another 10,000 families migrated out of the area between 1975 and 1980 in response to initial flooding or convinced that better income-earning prospects existed elsewhere.

In compliance with loan covenants for Paulo Afonso IV, the Government submitted plans to (1) monitor and control the possible spread of endemic diseases (plague, schistosomiasis, and malaria) in the reservoir area and (2) minimize the undesirable effects of the decaying vegetation on the biochemical properties of the reservoir. In the first instance, Government health programs have apparently kept endemic diseases under control. On the second matter, the Bank concluded that the effects of decaying vegetation on the reservoir would be short-lived.

References

SAR, Report No. 80b, May 1950.
SAR, Report No. 396a-BR, May 1974.
PAR, Report No. 6578, December 1986.
Redwood, John III. World Bank Approaches to the Environment in Brazil: A Review of Selected Projects. Washington, D.C.: The World Bank, 1993.

TECHI HYDROELECTRIC PROJECT (TAIWAN)

Project Description

The project consists of a 180 m high arch dam on the Tachia River, and a 234 MW power plant. The dam forms a reservoir with a capacity of 232 million m^3, and the annual inflow averages 1.1 billion m^3. In addition to exploiting the hydroelectric potential of the Tachien Gorge, the project provides some regulation of the river to benefit downstream plants. The cost of the project, appraised in 1969, was US$89 million of which the Bank financed US$50 million.

Development Impact

The project was compared with a thermal alternative and was found to be the least-cost at discount rates below 20 percent. With revenues as benefits the economic rate of return was 9 percent. Although the cost of the project increased by 25 percent in real terms, the equalizing discount rate on completion was 15 percent. The project provided river regulation for four downstream projects on the Tachia River and, as a result, over 200 MW of new capacity was added and the annual energy production was increased from 1,400 GWh to 2,100 GWh. The project was given a rating of satisfactory in the Bank's 1976 PAR.

Other Benefits—The project agency (June 1996) notes that the project may supply industrial and drinking water to two million people living downstream (no profits gained yet as this water was not supplied directly). The project would also regulate the water volume of the Shihkang Dam downstream which may increase irrigated areas by approximately 8,000 ha. The project would also control 40 percent of the flow of the Tachia River and decrease the flood peak by two meters and thus reduce flood damage downstream. In addition, the tourism potential of the region has been realized after the creation of the Techi Reservoir which has become a popular sight-seeing spot in central Taiwan.

Social and Environmental Impacts

Resettlement—No information is available from Bank documents on the impacts of resettlement, nor is there any mention of land acquisition which was, however, a budget item (US$250,000). The reservoir was in a remote area and likely to be only sparsely populated. According to the project agency (June 1996) 45 households totaling 200 people were displaced by project activities. The project agency notes that there was no problem with the resettlement and does not provide further details.

Environment—According to the project agency, the project had no effects on fisheries and human health. Ever since the completion of the Techi Dam, conservation programs for the catchment area have been undertaken. These include prevention from sand damage, management of the forested land, land use, reservoir protection, and conservation of natural habitats.

The water quality of the reservoir is eutrophic, but the project agency (June 1996) notes that it is not serious enough to affect human health.

The reservoir capacity is small compared to the annual runoff and has no material effect on the downstream hydrologic or morphologic regime. The average annual sediment volume is 1.1 million cubic meters and at the end of 1995 the reservoir volume loss amounted to 23.7 million cubic meters. The estimated remaining useful life of the reservoir is approximately 216 years.

Health—The project agency notes that there were no adverse impacts on health. The audit does mention that there had been 307 injuries, 31 deaths, and a problem with falling rocks and landslides. There was inadequate information on precautions taken by the contractor and unsound practices. The Bank was concerned that safe practices be used and due care given.

References:

SAR, Report No. TO 677, November 1968.
PAR, Report No. 1402, December 1976.
Tod Ragsdale. September 1991. Draft Working Paper. "Lessons from Resettlement Evaluation: Feedback into Resettlement Planning".

YANTAN HYDROELECTRIC PROJECT (CHINA)

The Project

The Yantan Hydroelectric Project is located along the Hongshui river in the Guangxi Autonomous Region in South China. The project proposed to support economic growth in South China through the cascade development of the Hongshui river. Main features include a 110 m high concrete gravity dam with an associated spillway, shiplift and powerhouse with an installed capacity of 1,210 MW[8]. In addition, two single circuits of 500 kV transmission lines and three associated substations were developed to provide a link between the Yantan power station and the South China Power Grid. The project was appraised in November 1989 and completed in June 1994, one year beyond the date originally envisaged. Total project cost amounted to US$593.9 million, financed in part by a Bank loan of US$52 million.

Project Rationale

At the time of project appraisal, China was the world's fourth largest producer and third largest consumer of commercial energy. From 1949 to 1984 annual per capita generation of electricity increased from 8 kWh to 363 kWh. However, it was postulated that slow growth of energy supplies could be a constraint on the Government's ambitious economic growth efforts for the period 1986–2000. Accordingly, in the Sixth and Seventh Five Year Plans the development of the energy sector was given high priority. The fuel mix was (and still is) dominated by coal. Hydropower, at that time accounted for 32 percent of the total installed capacity. Though the country's hydropower potential, estimated at 1900 TWh pear year, was among the largest in the world, at the time of the project only 87 TWh had been developed. This was due primarily to the fact that much of China's hydropower resources (in southwestern and northwestern China) are at great distances from the major industrial load centers.

South China, one of the most important economic regions in the country, was short of energy resources with the exception of hydro potential mainly in the Guangxi Autonomous Region. Future economic growth was contingent on the accelerated economic development of this hydro resource along with other energy sources. The Hongshui river basin with a total potential of 11,000 MW was the key hydro option for the region. According to the basin wide development plan, Yantan was one of 10 projects planned for the cascade development of the river basin. Two (Etan and Dahua) of the 10 projects were completed in 1981 and Phase I of another project (Tianshengqiao low dam) was under construction. The Yantan project with four units of 302.5 MW each was part of the system's least-cost expansion program for 1992/1994 operation[9]. The project also proposed to promote interconnection within the South China Grid, help build relations with the Guangxi Electric Power Bureau (GEPB) and the regional authority, South China Electric Power Administration (SCEPA),[10] provide transfer of technology in dam design and construction, and upgrade financial planning and management practices in the electricity

8. In August 1986, a decision was made to increase the capacity of each of the four generating units to 302.5 MW (from 275 MW) bringing total installed capacity to 1,210 MW (up from 1,100 MW).

9. This was independently verified by comparing Yantan with a coal-fired thermal alternative.

10. The Bank expected to collaborate with this agency on future projects.

subsector. Additional implied objectives were those of financial, environmental and social sustainability.

Development Impacts

Power—In relation to power grid systems, three units of Yantan (total 907.5 MW) were in operation by 1994, which represented 33 percent of the capacity of the entire Guangxi power grid and 50 percent of hydropower capacity. The power generation capacity of the project was 3.099 TWh in 1994, which amounted to a share of 25 percent of the total power of the Guangxi power grid and 42.8 percent of hydropower capacity. Yantan will also permit the transmission of more power to Guangzhou which is in line with project objectives of transmitting power to the rapidly growing eastern region.

Regional Economy—The project achieved its primary objective of supporting economic growth through development of the indigenous hydropower resource. The Bank is engaged in discussions with the Government on the establishment of a South China power market involving Guangxi, Guizhou and Yunnan which have relatively large energy resources and the fast-growing coastal areas of Guangdong, Shenzhen, Fujian, Hainan, and (after 1997), Hongkong. The Bank has also been involved in the preparation of Longtan, a major development immediately upstream of Yantan.

Agriculture and Fisheries—Secondary benefits from the project included the development of new orchards and forestry on hill slopes. The replacement of much rice and corn agriculture with orchards has the potential to significantly improve the standard of living of the resettled population in the medium term. Fish cages were also introduced and it is anticipated that as further experience with them is gained sustainable production will be achieved.

Social and Environmental Impacts

Resettlement—The resettlement of project affected people proved to be more extensive than originally foreseen. Eventually, according to the PCR (June 30, 1995) 43,176 persons[11] were physically relocated and new production arrangements had to be made for 62,430 people. The task has taken 10 years and is still incomplete as two out of three relocatees were not considered fully rehabilitated economically by the end of 1994. The main factor that affected resettlement implementation was the early emphasis on physical relocation at the expense of household and village production systems. Since production systems such as orchards, forestry and fish cages required a lead time of several years before producing revenue, a time lag developed between the loss of income and produce from reservoir lands and the production and associated income from new systems. Additionally, during project implementation a shift in selected orchards from citrus to "longan" was made causing further delay. The underestimation of the time required to bring new systems into production stems largely from inexperience and the lack of early detailed planning. On the Bank's part, the supervision of resettlement did not receive the right sort of attention. Though each Bank mission covered resettlement, the emphasis was on relocation of population rather than re-establishment of income. There were two specific resettlement missions in 1991 and 1992, but while both missions provided many useful suggestions neither emphasized that production measures were running behind relocation measures.

---

11. The 1993 Bank report on China Involuntary Resettlement cited the number of involuntary resettlers to be 40,000.

The resettlers are pleased with their generally higher housing standards after relocation, but they are experiencing very high unemployment rates and most remain dependent on Government grain rations. Little land remains that can be cultivated, tree crops have not done particularly well and few opportunities for commercial enterprise development have been identified. As land for the displaced persons was not enough to permit all of them to be resettled as farmers, project officials have tried to create off-farm employment opportunities. There is a plan to shift 36 percent of the farmers who practiced diversified agricultural production to other local industries or into specialized forestry production. Counties and townships which were unable to generate ideas for enough enterprises to absorb available resettlement funding have developed a system to make private enterprise loans based on simple business plans.

The Bank's 1993 review of involuntary resettlement in China notes that those activities under project control, such as housing and local infrastructure control, are well done when funds are sufficient. However, the major determinant of long-term resettlement success—the creation of employment for displaced labor—depends as much on the external environment as on project investments. The Chinese emphasis on local resettlement means that most reservoir resettlers will struggle in marginal economic environments. Lacking mineral or other resources not found in areas closer to major markets, the Yantan area can expect to have difficulty developing industry or services. Yantan resettlement managers now respond to this challenge by supporting out-migration from the reservoir zone. For all its risks and difficulties, that would appear to be an important and under-used component of almost all sizable reservoir resettlement efforts.

The PCR is optimistic that the situation will improve significantly in the next few years when the orchards reach production capability and experience with fish cages results in sustainable production. Moreover, provision has been made for two special funds after the resettlement construction budget has been expended: one extends 10 years for completion work, and another provides for 0.001 yuan per kWh from power plant revenue towards development in the reservoir area for the life of the project. On the physical side, more than one million square meters of new housing has been constructed and inundated infrastructure has been replaced. Housing and infrastructure quantity and quality are considerably better than the original. A total of 426 million yuan (6,800 yuan per capita) was spent on the resettlement component.

A key lesson learned from Yantan is that as with most resettlement projects, the resettlement component was much more extensive, costly, complex and time-consuming than originally contemplated. For a resettlement project of this magnitude it was important that project preparation in relation to resettlement be at least as advanced as that of the construction component and preferably further advanced. This would have helped solve the underestimation of numbers and costs and allowed for an early focus on the re-establishment of income—the most critical aspect. Also, increased resettlement supervision on the Bank's part including an extensive mid-term review of resettlement implementation would probably have resulted in a more favorable outcome.

Environment—The SAR noted that the reservoir would cover parts of five counties in the Guangxi Autonomous Region. Losses incurred include the inundation of 3,142 ha. of farmland, 547 ha. of forests, and public facilities such as roads, transmission and distribution lines, etc. The average sedimentation was estimated at approximately 43.4 million tons per year and it was assumed that after the completion of two upstream reservoirs (Tianshengqiao Phase 2 and Longtan) in the early 1990s the sediment load downstream of these reservoirs would be significantly reduced. No downstream degradation was expected as the discharge of the Yantan dam was supposed to be fed directly into the backwater zone of the Dahua reservoir.

An Environmental Impact Assessment Report was prepared in accordance with Government regulations[12] before the commencement of construction. This was followed by an Environmental Monitoring and Management Program (EMMP) for the implementation phase. The EMMP included monitoring of potential leakage in areas with karst topography, sediment accumulation in the reservoir, water quality in the reservoir and downstream, climate, terrestrial and aquatic and organisms, impacts of the resettlement program (socioeconomic, and soil and water conservation), and bank stability in the reservoir drawdown area. The PCR points out that monitoring results indicate that adverse impacts are limited and consistent with expectations. The most significant negative impact was unanticipated reservoir induced waterlogging in some areas, as a result of which affected households were relocated. Currently, the reservoir is subject to significant algal blooms due to nutrient enrichment from decaying submerged vegetation. The PCR maintains that this is likely to be a short-term phenomenon and is apparently not adversely affecting fishing or water quality. Water quality monitoring has not indicated any negative impacts such as depleted dissolved oxygen levels.

Health—The incidence of some water-borne diseases such as malaria were anticipated in shallow water areas after impounding. A public health program was carried out which addressed a wide range of issues including the occurrence of schistosomiasis vectors in several villages near the reservoir thought to be at risk.

References

The World Bank. Yantan Hydroelectric Project (Loan 2707-CHA). Staff Appraisal Report No. 6050-CHA. May 5, 1986.

The World Bank. Yantan Hydroelectric Project (Loan 2707-CHA). Memorandum and Recommendation of the President Report No. P-4135-CHA May 6, 1986.

The World Bank. Yantan Hydroelectric Project (Loan 2707-CHA). Implementation Completion Report No. 14773. June 30, 1995.

The World Bank. China Power Sector Reform: Toward Competition and Improved Performance. Report No. 12929-CHA. September 15, 1994.

The World Bank. China Involuntary Resettlement. Report No. 11641-CHA. June 8, 1993.

12. The Government was ahead of the Bank in this aspect as the Bank requirement for conducting environmental assessments for investment projects was only put in place in 1989 after Operational Directive 4.00 was issued.