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Project RETA 5828

Study of Large Dams and Recommendations: Pilot Case Study- The Nam Ngum 1 Dam in Lao PDR

1. OVERVIEW OF RETA 5828

1.1 Background

Despite current popular opposition to the construction of further large dams, it is clear that the requirements of higher per capita water and energy supply, as of flood mitigation, must ensure that the issues of water resource management through dams and barrages are not going to disappear. It is essential that these issues be faced with more objective attention to the complex social, environmental and economic impacts than has been given to large dams in the past.

This ADB Regional TA is designed to complement and supplement the World Commission on Dams world-wide analysis of large dams. In this project four large dams are to be subjected to individual case study so as to identify and analyze lessons learned from the dam construction and operation, and to construct a framework for more objective and holistic decision making, acceptable to stakeholders, on best practices for the evaluation, design, construction, operation and decommissioning of large dams.

1.2 Selection of Pilot Case Study Dam

A list of more than a thousand dams was first reduced by analyzing quantitative parameters, available in literature and documentation, so as to maximize the possible impacts of the dam. This first short-list was then reduced further using qualitative or semi-quantitative socio-economic and environmental matrices, again to maximize effects. Finally, round-table discussion of the experts and the project advisers led to the selection of four dams, being:

1. Nam Ngum in Lao PDR
2. Victoria in Sri Lanka
3. Magat in Philippines
4. Lingjintan in China.

In case administrative, logistic or team-safety difficulties were to prevent the site visit to one or more of these dams, “reserve” dams were:

- | | | | |
|----|----------|----|-----------|
| R1 | Hoa Binh | in | Vietnam |
| R2 | Cirata | in | Indonesia |
| R3 | Kao Laem | in | Thailand. |

These seven have been selected so as to

- provide the maximum number of lessons to be learned for future decision making;

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- provide illustrations of the largest positive and negative impacts, as of other key issues;
- cover a variety of dam types, ages, geographical locations.

Nam Ngum 1 was chosen as the first, pilot, study because

- it satisfied “large” criteria in size and impacts;
- as the oldest dam selected it was planned and commissioned before environmental impact assessments and socio-economic planning became conventional and/or statutory;
- after 30 years the dam site environs should have reached environmental and human settlement equilibrium;
- the long term economic results could be compared with forecasts;
- potential problems such as siltation and deforestation could be observed;
- the site is easily available from the consultant team headquarters in Bangkok;
- domestic consultants could be contracted in the limited time available;
- much of the required documentation was either already in the possession of the consultant team or readily available.

2. CASE STUDY METHODOLOGY

2.1 Methodology

The methodology is a modified version of the one used by WCD in its own studies, but with 2 phases compressed into 1 because of the limited time available. The methodology is constructed around 6 key questions:

- What were the actual vs projected benefits, costs, impacts?
- What were the unexpected benefits, costs, impacts?
- What was the distribution of costs and benefits – who gained and who lost?
- How were the decisions made?
- Did the project comply with the criteria and guidelines of the day?
- How would this project be viewed in today’s context in terms of lessons learned?

In order to find answers to these questions information was first sought from literature and documentation. This was then supplemented by a series of structured interviews with stakeholders, including officials and affected villagers.

2.2 Field Mission

The domestic consultant team commenced work on 5 December 1999, and the first 3 international consultants arrived in Vientiane on 12 December 1999.

Village meetings were held at six locations in the affected area including

- communities resettled downstream in both irrigated and rain-fed areas;
- communities along the edge of the reservoir, one of which was partly composed of evacuees;
- communities downstream of the dam which might have benefited from irrigation and flood control.

A provincial consultation meeting was held to which representatives of Vientiane province, the three districts of Toulakhan, Keo Udom and Viengkham. Representatives of key private sector stakeholders (such as the fishery concessionaire) were invited.

Discussions were held, too, with individual concerned officials in Vientiane.

3. THE NAM NGUM 1 HYDROPOWER PROJECT

3.1 Brief Description of Nam Ngum 1

The project is situated 60 kilometers north of Vientiane on the Nam Ngum tributary of the Mekong River, Figure 1. It is a gravity concrete dam with a power station at the base of the dam and with the penstocks in the actual dam. The dam was originally constructed with two 15 MW generators, to which two 40 MW generators were added in 1978 and a final 40 MW generator in 1984.

3.2 History

After discussion and planning through the 1950's a feasibility study presented in December 1962 detailed the purposes of the project as being for:

- hydropower generation
- irrigation
- flood control
- downstream navigation
- industrial development.

The project was implemented by the Mekong Commission as part of the 1969-1974 Lao Development Plan. Construction of the dam was carried out from 1968 to 1971. The project was financed through the establishment of the Nam Ngum fund which comprised funds from multinational and national donors, administered by the International Bank for Reconstruction and Development, World Bank. The fund was later supplemented by additions from Japanese and Asian Development Bank sources in order to provide for the Stage 11 and Stage 14 extensions.

Although at the time of implementation no formal environmental and socio-economic assessments were reported, the site-visit interviews revealed that considerable attention had been paid to many of the issues relating to settlement of displaced persons.

3.3 Technical Details

Technical details of the dam are summarized in Table 1.

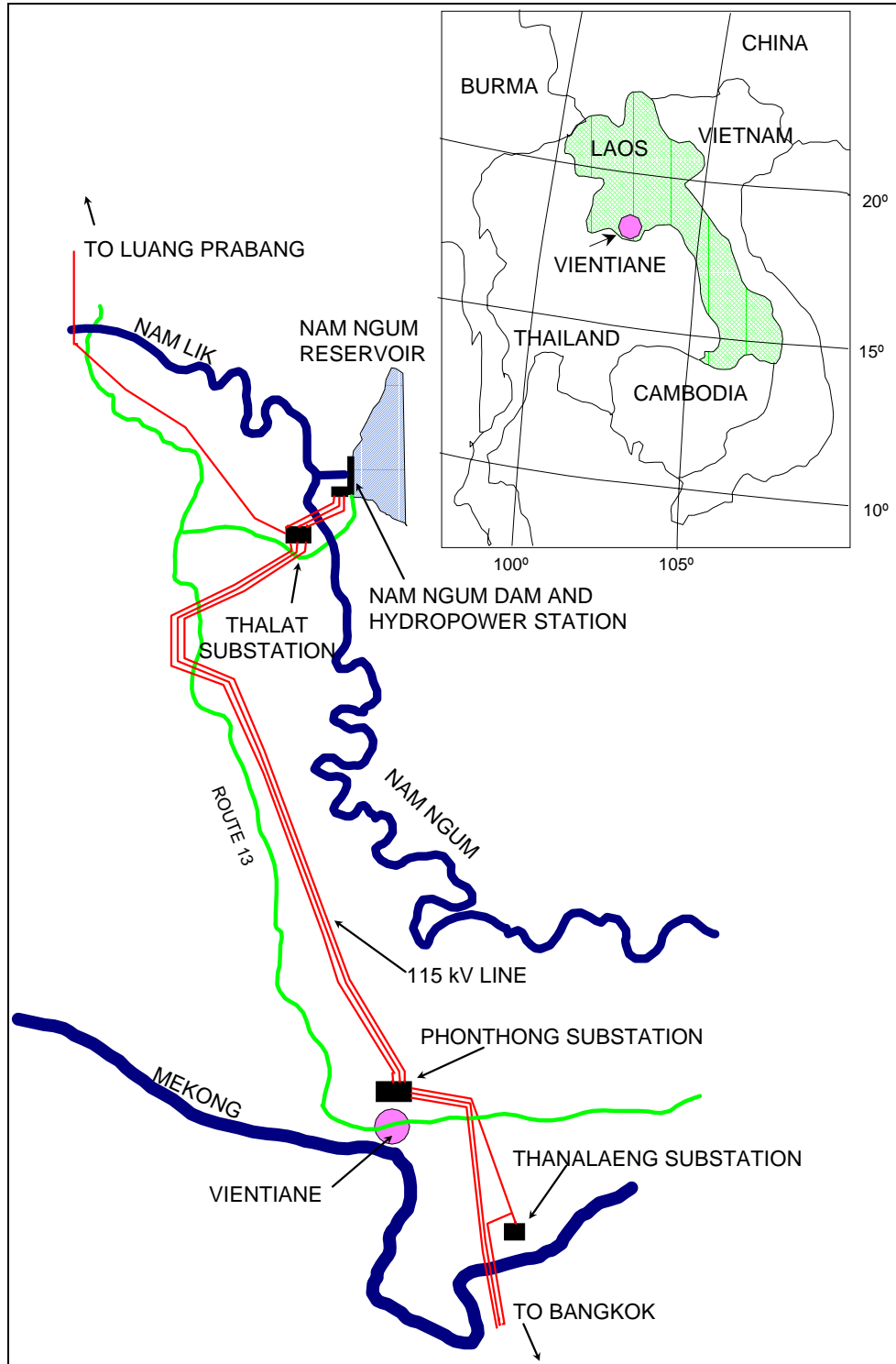


Figure 1 : Location of Nam Ngum Hydropower Station

Table 1 : Principal Technical Parameters of Nam Ngum 1 Hydropower Station

a) Reservoir				
Drainage area		8,460	km ²	
Surface (212 m asl)		369.5	km ²	
Storage capacity (212 m asl)		7,010	hm ³	
Full supply level		212.00	m asl	
Minimum operating level		196.00	m asl	
b) Dam		Mass-concrete gravity		
Type				
Crest length		468 m		
Maximum height		75 m		
c) Turbine intake		Roller type		
Type of gate				
d) Penstock	Units 1 & 2	Units 3 & 4	Unit 5	
Number	2	2	1	
Diameter	3.4 m	6.0 m	6.0 m	
Length	50 m	55 m	55 m	
e) Turbine	Units 1 & 2	Units 3 & 4	Unit 5	
Type	Francis	Francis	Francis	
Nominal Capacity	15 MW	40 MW	40 MW	
Speed	176.5 rpm	136.4 rpm	136.4 rpm	
f) Generator	Units 1 & 2	Units 3 & 4	Unit 5	
Maximum Capacity	17,500 kVA	53,000 kVA	53,000 kVA	
Voltage	11 kV	11 kv	11 kV	
g) Powerhouse		16 m		
Width				
Length		107 m		
Height		20 m		
h) Powerhouse Crane	No. 1	No. 2		
Main hoist	100 ton	80 ton		
Span	16.2 m	16.2 m		
Lifting height	20.0 m	27.5 m		
i) Transmission Lines				
- to Thalat (local supplies)	22 kV, 5 km			
- to Vientiane	115 kV, 2 double circuit + 1 single circuit, 73 km			
- from Vientiane to Thai border	115 kV, single circuit, 17 km			
- to Luang Prabang	115 kV, single circuit, 212 km			

Sources: JCI and LI/WI

3.4 Project Design

The project Design underwent successive revisions between the ‘Comprehensive Project Feasibility Report’ [Nippon Koei], issued in December 1962, through the ‘Feasibility Report’ [Nippon Koei], issued in August 1964, to the ‘Construction Design’ [Nippon Koei], issued in September 1969 at the start of construction work on the dam and appurtenant structures. In the course of this period additional geological and hydrological data became available and led to some adjustments in the details of the original 1962 design.

For the present case study only the ‘Comprehensive Project Feasibility Report’ of December 1962 could be made available. The following comments on key project structures are therefore based on that report:

Dam	The topographical and geological conditions prevailing at the selected dam site were suited to practically any type of dam. The original design examined three different types: earthfill, rockfill and concrete gravity. Cost and other considerations (e.g. climate, flood hydrology, ease of transport, availability of materials) were considered in making the final selection of a concrete gravity dam.
Spillway	The design flood was derived on the basis of extreme precipitation data observed at climatological stations in and around the Nam Ngum basin. The 1:1,000 year flood was estimated to have a peak discharge of 8,050 m ³ /s. A subsequent study of other projects in the Nam Ngum basin [Motor Columbus], carried out in 1986, based on the assumption of a 20-day rainfall caused by the passage of a typhoon followed by a severe tropical, yielded an estimated peak discharge of the Probable Maximum Flood (PMF) at Nam Ngum 1 of 8,800 m ³ /s. A subsequent re-assessment of spillway adequacy in 1995 [Lahmeyer/Worley], using information on observed flood volumes and peaks at hydrometric stations in the basin, arrived at an estimate of the 1:10,000 year flood of 7,450 m ³ /s. It was found that this flood could be passed with all four spillway gates, with a rise in water-level of 2.1 m over normal maximum operating level of 212 m asl; peak outflow would be 4,130 m ³ /s.
Intake	A single roller-gate intake to each penstock was selected. There is no mention of consideration of a multi-level intake in the ‘Comprehensive Project Feasibility Report’.
Fish ladder	There is no mention in the ‘Comprehensive Project Feasibility Report’ of consideration of the need for some form of fish pass in the dam.
Re-regulation pond	There is no mention in the ‘Comprehensive Project Feasibility Report’ of consideration of the need for a re-regulation pond.

3.5 Options Assessment and the Decision Making Process

Detailed review of the documents of the time reveal that the project was not conceived in the context of a detailed and comprehensive long-term river basin development planning process.

Contrary to some public misconception, the scale of development selected for the project (specifically reservoir capacity and turbine installed capacity) appear to have been reasonably appropriate. However, the 1962 project feasibility study was undertaken with information that would be considered relatively limited to today's standards. Detailed topographic and geological investigations were later undertaken in 1966 and 1967.

3.5.1 Selection of Alternatives

In the 1962 feasibility study selection of the most appropriate scale of development, represented by dam height (or, more precisely, normal maximum operating level), was made by estimating the specific energy production cost for a range of normal maximum operating levels between 208 m asl and 228 m asl. These computations showed that minimum energy production costs would be achieved at 212 m asl.

Consideration was given to the greater benefits from flood control, low flow augmentation for irrigation and downstream navigation which would be achieved with a normal maximum operating level higher than 212 m asl. However, it was considered that these benefits would be outweighed by the increase in construction time requirement (and hence interest during construction) and the overall 'undesirability' of a higher investment requirement. There is no mention in the report of the relative socio-environmental impacts of different normal maximum operating levels. A maximum operating level of 212 m asl was therefore selected.

A maximum drawdown of 16 m to a minimum operating level of 196 m asl provides a total of 4,714 hm³ of active storage. This represents approximately 48% of the mean annual inflow, which generally corresponds to the amount of storage required to provide a significant degree of regulation under the hydrological regimes prevailing in Laos.

Spill occurred frequently in the initial years until 1984 when the final stage of installed generating capacity of 150 MW was completed. This capacity represents a discharge capability of 310 to 390 m³/s (depending upon the water level in the reservoir) or approximately 100 to 125 % of the long-term mean project inflow. Once again, this is a reasonably normal value in the hydrological regimes prevailing in Laos. After 1984 spill occurred only in the prolonged and pronounced high flow wet seasons of 1994 and 1995 before the Nam Song Diversion Project was commissioned in December 1995.

In summary, therefore, it would appear that at least from the hydrological and technical-economic points of view the selected final scale of development of the project, in terms of its maximum operating level and installed generating capacity, appears to be reasonable.

3.5.2 *Operation and Monitoring*

Responsibility for operation of the project rests entirely with the national power utility Electricité du Laos (EdL), a state enterprise under the Ministry of Industry and Handicraft.

Given the significant role which the project plays in the national economy, EdL places considerable emphasis on operation and maintenance of the plant. Electro-mechanical equipment is regularly refurbished (usually with financial assistance from the Japanese government) and plant outage rates are kept low [details are to be found in Lahmeyer/Worley post-evaluation report]. EdL maintains detailed records of plant operation.

4. PROJECTED AND ACTUAL EFFECTS OF NAM NGUM 1

4.1 *Irrigation and Agriculture*

Analysis of irrigation and rice cropping shows that yields in the irrigated area of the Vientiane plain are the highest in the country. This is attributed to the availability of water for irrigation and electric power for pumping.

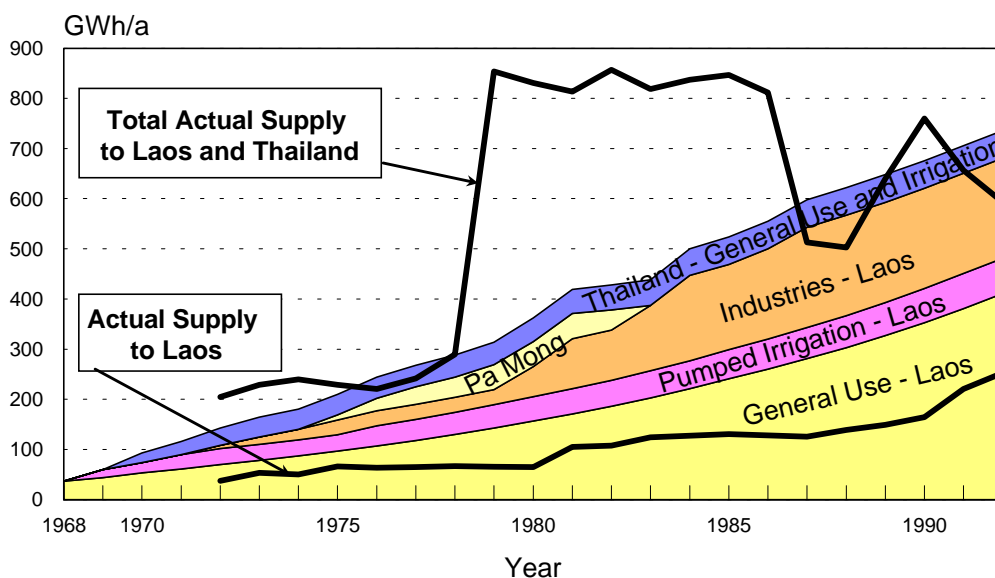
4.2 *Municipal and Industrial Water Supply*

Although industrial development was one of the objectives listed in the 1962 feasibility study, this has not yet taken place to any significant extent. However, at the present time water that is nominally for irrigation is being pumped to the developing industrial area on the outskirts of Vientiane, and further developments of this kind are expected in the future.

4.3 *Hydropower*

4.3.1 *Projected Demand and Actual Supply*

A comparison of electricity demand projected in the planning process and actual supply is presented in Figure 2.



Source: Nippon Koei, EdL

Figure 2 : Projected Energy Demand and Actual Supply from Nam Ngum 1

It is very clear that the actual domestic demand fell well below the early planning predictions.

4.3.2 *Economic Analysis*

A detailed discounted cash flow analysis using current prices indicates that by 1995 the Nam Ngum Hydropower component had paid its way. The current rate of return on an estimated present value of US\$20 million is calculated as 13%. Foreign exchange earnings from power export in 1997 fell to 15% (from over 50% until 1985), and for comparison is roughly 50% of received ODA.

4.4 *Flood Control*

No detailed studies of the reduction in flooded areas since initiation of project operation in 1972 have been carried out and it is therefore not possible to estimate flood damage prevented by project. However, a paper [Oud/Muir] presented at a recent international conference shows that the Nam Ngum project does have a significant effect on floods. The paper shows that during the severe storms which occurred over the Nam Ngum basin in late August / early September 1995 the reservoir absorbed two major floods and attenuated the peak flow of a third flood by around 20%.

4.5 *Recreation and Tourism*

It was not possible to analyze the impacts on recreation and tourism, which were judged to be small and insignificant by comparison with other impacts of the project. However, recent developments indicate that this is a potentially important factor.

4.6 Social Effects

4.6.1 Relocation of Communities

A census carried out in 1966 revealed a total of 579 households likely to be affected by the reservoir to be created by the Nam Ngum dam. The census survey included an assessment of the value of villagers' assets. The survey was as thorough as could be expected, given the difficult access to villages in the heavily forested area at the time.

In the even, despite the apparent good intentions of the government, the villagers had to help themselves in moving. That it was such was partly because the settlement process was caught up in the civil strife which affected Laos at the time.

4.6.2 Loss of Assets

All households evacuated lost their houses and land, including a standing rice crop (Village Consultation # 4) and most lost livestock. They left behind a typical subsistence economy. The resettlers from the Nam Ngum reservoir also lost social cohesion. This does not appear to have been a major constraint to cooperation during the rehabilitation period.

4.6.3 Restoration/Improvement of Livelihoods

4.6.3.1 The Downstream Irrigated Area: Pak Cheng

An emergency evacuation process meant that there was little or no provision for the resettlers. To facilitate the process, the Pak Cheng Agricultural Development Project was started in 1975 with a grant of US\$1.170 mln from the Netherlands Government. In the event the Pak Cheng Agricultural Development Project continued for a period of 6 years to March 1981.

Generally, the Pak Cheng Project was judged to be unsuccessful. A whole series of operational factors contributed to poor performance, including the fundamental lack of resources in terms of equipment and manpower.

In the context of the costs and benefits from dam construction, it may be noted that up to 1980 the resettlement area had not benefited from the electricity available from the Nam Ngum dam.

4.6.3.2 The Downstream Upland Area: Huay Khong – Dan Savann

During the village consultation, the villagers indicated that considerable benefit had been gained, particularly from the development of cash crops such as pineapple and bananas on contour bunds and the promotion of fish culture in ponds created by damming small streams. Much work still needs to be done to create a sustainable livelihood in the area. Particular constraints appear to lie in changing attitudes towards the management of forests, the systematic collection of animal manures and community management of grazing land. Secure markets for orchard produce appears also to be a problem.

Nor has the provision of basic social services been satisfactory.

4.6.3.3 Development of fisheries communities in the Nam Ngum

The opportunity created by the fishery was apparently seen by the local population. By 1981, the Nam Ngum reservoir had a population of 9,561 persons living in 1,652 households in 31 villages. Only around 10% of these fishermen are resettlers, as the original settlements were subject to extensive in-migration as the opportunities for productive fishery in the reservoir became apparent.

Unfortunately, the living standards of the fishermen around the reservoir remained poor.

Whatever the organizational problems of the fishery, it has continued to attract immigrants to the shores of the Nam Ngum reservoir. In 1991, the Burapha survey recorded that the number of villages on the lakeshore had increased to 40, with 2,498 households and a total population of some 15,700 inhabitants. Of these households, 92.5% were engaged in fishing activities, although only 20.2% claimed this as their main occupation. Others saw fishing as a secondary occupation to agriculture, mainly in the form of upland (hai) cultivation on the slopes surrounding the reservoir.

Unfortunately the growth of population has been a contributory factor in what appears to have been a decline in the value of the fishery.

The population of Ban Sanpatong has decreased over the last several years to only 60+ household. According to those remaining, this outmigration has two components, the movement of richer households who have become better off on the basis of the early fishing and involvement in logging and the movement of poorer people to seek wage employment or other land outside the area.

4.7 Regional and National Effects

These are not extensive and are subsumed into discussion under other subject headings, e.g. electricity sale to Thailand.

4.8 Ecological Effects

4.8.1 Description of the Natural River System

The Nam Ngum River originates in Phou Kout in the northeastern part of the Tran Ninh Plateau, through which the river flows southwestward. At the foot of the steep mountains, on the southwestern edge of the plateau, the river turns south, and flows down to the Viente plain where it is joined by the Nam Lik River, about 60 km., north of Vientiane. Further to the east at the Tha Ngon ferry site, about 20 km. north of Vientiane, the Nam Ngum River changes its course and discharges into Mekong River, at about 55 km. east of the city. The total length of the Nam Ngum River is about 420 km.

The rate of evaporation is at a maximum in April, because of the highest temperature and the lowest relative humidity. It is at its minimum in August, because of the highest humidity despite comparatively high temperature. The maximum relative humidity in Vientiane happens in August and is at its minimum in May. The mean value in the rainy season (May to October) is 87 percent and that in the dry season (November to April) is 74.2 percent.

4.8.2 *Water Quality Impacts*

4.8.2.1 Pre-impoundment Water Quality

According to the results of water quality analysis, the Nam Ngum water is suitable for all purposes, especially for irrigation. If the water is used for irrigation, it will be very effective for neutralizing the acid soil covering the Vientiane plain, because the water of the Nam Ngum shows an alkaline reaction in any season.

4.8.2.2 Post-impoundment Water Quality

1) Upstream

The upstream water quality data during the dry season, when water discharge is lowest, is very good, generally with low nutrient contents.

2) Nam Ngum Reservoir

The epilimnion is in constant contact with air and therefore generally contains a high dissolved oxygen contents. Lacking aeration, no photosynthetic activity and no mixing between the epilimnion and the hypolimnion, oxygen consumption by decomposing organic matter can create low DO concentrations or even anaerobic conditions in the hypolimnion.

Besides temperature and DO, other water quality indices also change accordingly to water depth, due to the effect of stratification in the reservoir. Values of hardness, conductivity, alkalinity, turbidity, ammonia and iron in the hypolimnion are higher than in the epilimnion, but values of pH decreased with water-depth. The top layer of water of more than 5 m. deep had a pH value higher than 7, but pH dropped to less than 7 in the water below. The highest pH value recorded was 9.0 - 9.1, in November.

3) Downstream

Intake of reservoir water at the dam to the powerhouse can be from the hypolimnion, particularly during the wet season, when the hypolimnion rises above the penstock elevation level. The water with low DO and high hydrogen sulfide contents released from the hypolimnion of the reservoir affects the water quality of the river below the dam. The monthly DO concentrations during each year in the Nam Ngum River just below the dam, are more often below the optimal DO concentration limit for aquatic life. DO concentrations below the dam during the mid-eighties even reached low levels, lethal for most aquatic life (2 mg/l). It can also be concluded that minimum DO levels are consistently observed at the end of each season, when reservoir water level is at its peak. High DO levels below the dam can be observed around January each year, when the reservoir is turning over.

The general high DO levels in Nam Lik improve the DO levels in the Nam Ngum river downstream of the confluence. High DO levels of the Nam Lik together with natural aeration of river water, especially in rapids and riffles, result in more or less normal DO levels in the Nam Ngum River at Thangone.

It can be concluded that the Nam Ngum dam determines water quality and significantly influences aquatic biodiversity and productivity downstream in the Nam Ngum River by the periodic release of reservoir water with low DO and high hydrogen sulfide contents. It can be also concluded that water quality in the Nam Ngum River downstream is poor, but only during the time when reservoir water is released from the hypolimnion. At times when the reservoir water is released from the epilimnion or when the reservoir is destratified, which is around January each year, the downstream water quality can be classified as optimum for aquatic life.

4.8.3 *Biodiversity and Habitat Affected*

4.8.3.1 *Nam Ngum Watershed*

Prior to the regulation of the Nam Ngum dam there was little baseline data on its biological communities and no ecological studies were undertaken prior to its construction.

4.8.3.2 *Forest Cover*

The total forest cover of the watershed in 1992 and 1997 accounted for 27.8% and 27.6% of the watershed total land area respectively. In-migration and settlement has led to deterioration of the forest cover.

4.8.3.3 *Terrestrial Biodiversity*

Altogether 766 plant and trees species have been recorded in the catchment area of Nam Ngum II Project (Electrowatt Engineering, 1998).

4.8.3.4 *Aquatic Biodiversity*

Pre-impoundment records of fish species in the area of Nam Ngum dam are given by Taki (1975)¹, who collected 33 species of fish at the dam site are in 1970-1971.

Post impoundment studies have been conducted of the reservoir fisheries since dam closure. Although some fish species have probably not been able to adapt to reservoir conditions and become locally extinct, a great many species obviously have adapted as 66 species are known from the reservoir commercial catches (Interim Committee, 1984).

¹ Cited by Interim Committee, 1984.

4.8.4 Fisheries Impacts

4.8.4.1 Pre-impoundment Fisheries

Despite the Pantulu (1969) note that no important commercial fisheries exploitation existed above and below the dam site on the Nam Ngum river, some aged fishers who had lived in the dam site and reservoir area during pre-impoundment period have indicated that they could catch large size fishes (pan fish) of many commercial species in the Nam Ngum river.

4.8.4.2 Reservoir Fisheries

1) Fisheries Development

Between 1988 and 1990 and between 1991 and 1993 Switzerland supported a project, Nam Ngum Fishermen communities Project. This project constructed primary schools, installed water supply and provided monofil gill nets and boat engines to selected villages.

2) Species Composition

Changing the ecosystem from lotic (riverine) environment to lentic (reservoir) environment during the operation of hydropower project has affected the composition, diversity, distribution and abundance of the fish communities. Sixty six species of fish have been recorded from Nam Ngum reservoir (Electrowatt Engineering, 1998). Many species are important in terms of quantity and commercial values.

3) Fish Disposal Pattern

In Lao PDR as anywhere else in the world confusion exists about fisheries statistics.

A recent study conducted by Phommachan, Nilsson and Phounsavath (1999) indicates that the main portion of fish catch (about 70% of the total fish catch) is sold and collected by the local fish traders. The rest is sold to other fish outlets. Based on the meetings at town and provincial level of this study on 22 December 1999, approx. 60-65% of the total catch is sold to the Fish Dealer at Tha Lat (dam site) fish landing places. The rest of 35-40% is illegally sold to other fish outlet.

4) Fisheries Yield and Catch Composition

According to the Mekong River Commission (1997) there exist no annual catch data for the years 1972 to 1981.

The annual fishing yield or annual fish catch of the reservoir is the sum of (i) the recorded fresh fish trade, (ii) the recorded processed fish trade, and (iii) the annual fish consumption by the reservoir population.

Balavong, et al. (1999) have estimated the annual fish catch for the year 1998 from the catch per unit effort survey data and effort survey data. By the year 1998 the estimated annual fish catch has increased to 2,293 mt.

Despite of the increase of the annual fish catch, the overall value of the catch has decreased, because the value of Pa Keo is relatively low, about $\frac{1}{4}$ of Pa Sagang. They believe that the decrease of fish catch is caused by increase of effort, decrease of fish stocks, use of illegal fishing methods such as dynamites, chemicals and speagums, and increase of turbidity due to underwater cutting of logs in the reservoir. They agree that fish restocking program and protection of fish sanctuaries and fishing during the fish spawning period will help to increase the reservoir fish stocks.

4.8.4.3 Downstream Fisheries

Downstream fisheries complain that they catch considerably less fish, as compared with the pre-impoundment period. Change in catch composition is obvious and size of fish caught is relatively small.

4.8.5 *Sediment and Erosion Issues*

The amount of the suspended matter in the dry season was estimated to be 1.2 – 6.6 ppm of the river water and in the rainy season below 66.6 ppm of the water. As the dead storage, i.e. volume of the reservoir below the minimum operating level of 196 m asl, is 2.3 hm³, it is not conceivable that the function of the reservoir would be lost by silting, even if silting might be 2 or 3 times greater than calculated from these figures. Further, to confirm this conclusion, recent measurements of suspended solids in the Nam Ngum river upstream of the dam ranged from non-detectable to 9 ppm, so that the amount of material transported by the river and deposited in the reservoir is small.

Finally, an investigation of sedimentation in the reservoir was carried out after 20 years of operation, and showed an actual sediment accumulation of about 2.1 hm³ per year.

It was estimated that “it would probably take more than 1,000 years to fill with sediment 50% of the reservoir storage below the present mean low-water level”.

4.9 Energy Development

One interesting fact is that, so far, there has not been any ministry nor any central institution or organization specifically responsible for overall energy issues in the country. Energy issues are spread among diverse ministries or organizations.

Moreover until the 1990's no overall energy planning study had been undertaken in Laos.

4.9.1 *Evolution of Energy Needs and Demand*

Traditionally, three types of energy have been consumed in Laos: fuel wood and electricity, which are produced locally, and petrol-products which are imported.

a) Fuelwood

Historically, fuel wood has been the major source of energy in Lao PDR. It is principally used for cooking and lighting, especially in the rural areas, but also in a lower extent, in the urban areas.

In terms of evolution, there have been few changes in the importance of consumption of fuel wood for energy needs, since this fuel still represented around 90% of the total energy consumption in the country in 1992.

b) Petroleum products

From 1965 to 1970, the consumption of petrol products in Laos increased regularly, and they have been a relatively important part of the total imports bill (over 10%).

The imports of petroleum products increased from 76 kilotons in 1987 to 118 kilotons in 1990 at an annual average growth of about 10 percent².

c) Electricity

The electricity consumption within Lao has remained at low levels in spite of the clear statement to develop this sector. One important reason for this has been the absence of an integrated electricity distribution network at the country scale. Within Laos, the main consumption center for electricity is located in the Vientiane province.

d) Consumption of other energy sources

It can be mentioned that in the late 1980s, coal was found in Vientiane province. A 600 MW coal-fired power station is scheduled to come on stream in 2001³, indicating the will of the Government to exploit this resource in a more extended manner.

4.9.2 *Energy Supply Development*

a) A marginal national energy supply policy

The Government declared its intention to ensure a rational exploitation of a forest inventory, the development of reforestation activities, and the implementation of soil protection laboratories. Control of logging activities was also attempted.

b) The power section in Lao PDR

At present, the following objectives influence power development policy in the country:

- Provide a source of foreign exchange to fund economic and social development and alleviate poverty;

² "Sectoral Energy Demand in Lao People's Democratic Republic". United Nations. 1992.

³ "Country Profile – Cambodia, Lao". The Economist Intelligence Unit. 1998/1998.

- Meet the commitments specified in the MOUs with Thailand and Vietnam;
- Expand the customer base through grid extensions and satisfy growth in domestic demand;
- Explore and exploit mutually beneficial cross border exchanges and sales of electricity with People's Republic of China, Cambodia, and other countries in the sub-region;
- Extend off-grid rural electrification to promote better socio-economic conditions within isolated communities; and
- Replace dependence on imported fuels for energy generation.

Given the abundance of water resources in Lao, hydropower generation has been the focus of energy sector policy in general and power sector development in particular.

c) Institutional framework

Overall responsibility for power sector development rests with the Department of Electricity (DOE) of the Ministry of Industry and Handicrafts (MIH). DOE is responsible for power sector planning and management. It formulates policies and strategies for the development of national and export-oriented power projects in conjunction with other ministries and agencies.

The Electricité du Laos (EdL), on the other hand, undertakes the major electricity sector functions of generation, transmission, and distribution. EdL owns and operates the main public sector generation, transmission, and distribution assets, and manages cross-border electricity trade.

The Committee for Energy and Electric Power (CEEP) was established to coordinate the program to meet the targets of the MOU between Lao and Thailand.

4.9.3 Hydropower Development in Lao

a) A strategy of large-scale hydropower development oriented towards export

Hydropower is the most abundant and cost-effective energy source with a theoretical hydroelectric potential of about 26,000 MW excluding mainstream Mekong.

During the 1960s, power production of Laos was not sufficient to comply with the national needs of the country and had to be increased through local production and power loans from Thailand. Recent development of large hydropower schemes in Laos are mainly oriented towards foreign exchange purposes, and several large projects have been proposed since 1960.

b) A strategy of smaller hydropower for national needs

At the same time that large hydro projects were developed, the necessity to implement smaller schemes for local consumption of electricity within the country has increased. Through ADB's assistance the government has implemented a rural

electrification program. Once again, this program mainly concerns the surroundings of Vientiane, as the most important implementation criterion for the different villages is the proximity of existing electricity lines.

The 1997 crisis of Asia has showed the danger for Laos to rely heavily on foreign countries. Any reduction of the demand from Thailand is a serious menace for the future of the Lao overall hydropower system viability, in particular, but also for the Lao economy as a whole.

4.10 Financial Cost and Benefit Analysis

First, the analysis of the 1962 Study proposal is conducted in two forms. The 40 MW and the Full Scheme version.

According to both cases, the internal rate of return of the project is put at 3.5%, though the payback period differs between the two versions. This is the justification for requiring that the project be supported by a low interest loan of 3%.

The analysis shows that the project had recovered its cost by 1997, and is now giving a rate of return of 13%.

If the benefits from activities associated with the power project, for example irrigation and fishery, are added to the project, the rate of return of the project would be even higher.

Macroeconomic Impacts

Financing: The use of external financing throughout the project meant that the impact on the macro-economy was mostly positive. The project brought in additional resources which would not have been available in the economy without it.

Export and Foreign exchange: The export of power, produced by the project, also had a positive impact on the economy.

Public Finance: The project contributed to government finance by (1) payment of tax and (2) retention of profit as a State-Owned-Enterprise.

Regional Economic Impacts

The project has a visible positive impact on the local economy. By providing power for irrigation, it helps to stimulate agricultural production in the Vientiane region.

The extension of the distribution of power to Luang Phrabang also has a positive impact on other regions of the country.

Project Net Benefits

The net benefit of the project, taking into account power production, irrigation benefit, flood prevention and fishery, is positive.

5. DISTRIBUTIONAL EFFECTS OF THE NAM NGUM PROJECT

5.1 Anticipated Distribution Effects of the Nam Ngum Project

The anticipated distribution impact of the Nam Ngum project was seen mostly in terms of irrigation and power benefits for the Vientiane Plains. Subsequent benefits from fishery were also seen for the people living around the reservoir area.

5.2 Actual Distribution Effects of the Nam Ngum Project

The actual distribution benefits of the project are more wide-ranging.

First, power production from the project benefits a neighboring country, namely Thailand, although Laos gets the revenues.

Secondly, irrigation benefit was slow in coming. This was due to the particular circumstances prevailing in the country. Wartime disruption and lack of government funding to start on irrigation projects meant the irrigation benefits were delayed.

Thirdly, fishery benefits were obtained by a wide range of people.

6. SUMMARY OF DEVELOPMENT EFFECTIVENESS

This section addresses the six key questions of the WCD and this project Methodology.

Amongst key government informants, the Nam Ngum dam is seen as a highly effective development project, offering a wide range of benefits to the country. This was the first large-scale development project in the country and its completion in a period of civil strife was seen as a significant achievement and source of pride for the country.⁴ Visitors to the country have often been taken to the damsite, where they have commented on the exemplary management of the facility. It is true that some of the intended benefits have come on stream significantly behind schedule. This is particularly the case with the expected irrigation benefits. However, this failure must be set in the context of the political isolation of the Lao PDR from 1975 to 1987, which limited the amount of foreign aid received and also the government's own revenues streams. It can be argued that this period was a gap in the development of the Nam Ngum multi-purpose project and that only now is the further investment being made in the infrastructure which will facilitate the achievement of the intended benefits. Fortunately for the country, significant 'unexpected' benefits have in the meantime derived from the development of the reservoir fishery.

⁴ It is worth noting that, although there was fighting around the damsite, the future Pathet Lao authorities were equally committed to the Project which was seen as a valuable resource for the whole country. According to one key informant, instructions were given to the Pathet Lao troops "not to touch Nam Ngum". The same informant described the Project as a 'pearl in the ocean' for Laos.

Q1: What were the predicted Vs actual benefits, costs and impacts

Benefits:

The ‘Comprehensive Project Feasibility Report on the Nam Ngum Project’, issued in 1962, envisaged that benefits from the project would accrue in four principal areas: *power production, flood control, irrigation and navigation*. A later report of the Mekong Secretariat ascribes two further potential benefits to the Nam Ngum 1 project: *fisheries and downstream low-flow augmentation* (for any future downstream hydropower and/or irrigation schemes on the mainstream Mekong river). In the late-1990s the Nam Ngum 1 reservoir was predicted to become the site of a major development for *tourism/recreation*.

• **Power production:**

- *Predicted:* A gradual build-up over 25 years to a supply of 738 GWh per annum, around 90% of which would serve general, industrial and pumped irrigation loads in Laos, the remainder to be exported to Thailand; including a total of 260 GWh to be provided over the period 1975-1982 for construction of the Pa Mong project on the main Mekong river.
- *Actual:* A three-stage build-up over the first 12 years to an average annual supply of 811 GWh over the 16-year period 1979-95. In 1996 implementation of the Nam Ngum Diversion Projected bringing an expected increase in power production of around 20% or 160 GWh per annum. Actual power supplies to Laos turned out to be around only one half of those forecasted; the proportion of supplies exported to Thailand therefore accounted for around 80% in the initial years, decreasing to around 65% in the mid-1990s.
- *Provision of electricity to the urban consumers of Vientiane:* The predicted demand for electricity for the development of heavy industry in the Mekong Basin did not materialize.

• **Flood control:**

- *Predicted:* Approximately 10,000 ha of the downstream Nam Ngum basin protected from floods of magnitudes up to 1 in 100 year recurrence interval.
- *Actual:* No assessment of actual benefits from flood protection has been carried out. The Nam Ngum 1 project is operated by the national power utility, EdL, expressly for the sole purpose of power production, with reservoir operating policies designed to secure electricity supplies to demands on the northern Lao power grid and to maximize expected revenues from export of surplus power to Thailand. It is known that, during the high floods experienced in the lower Nam Ngum basin in August/September 1995, the Nam Ngum 1 reservoir effected a 20% attenuation of

the flood peak at the project site; the impact on damages incurred downstream is not known.

Nevertheless there is some evidence of benefits from the regulation of flow (both low flow augmentation and flood control) of the Nam Ngum river, particularly in the lowest areas of the Vientiane Plain. Here typical rice yields have increased from an extremely uncertain 0.7 tons per ha prior to dam closure to around 3.2 tons/ha at present. Some ten villages in the south of Vientiane province are set to have benefited in this way, although the total area has not been quantified.

- **Irrigation:**

- *Predicted:* Provision of pump irrigation to the Vientiane Plain was predicted to be implemented immediately after dam construction.
- *Actual:* Provision of electricity for pump irrigation in the Vientiane Plain. This only occurred after the ADB-funded projects “Vientiane Plain Rural Electrification I and II” from 1981 onwards and the actual development of the irrigation systems in the Vientiane Plain is ongoing. 21 separate systems have now been developed based on pumping from the Nam Ngum in Vientiane province and others in Vientiane Municipality. Some of these have been built by government, others through foreign-aid projects, starting with the Mekong River Commission in Pak Cheng and including the EU and JICA. Rice yields have increased to an average of 3.5 tons/ha. However, the development of dry season cropping has been constrained by a combination of factors, including poor system design, unsuitable soil conditions and the lack of secure markets. Most recently, high production costs as a result of rising prices of imported fuel and fertilizer have even constrained the expansion of dry season rice cultivation.

- **Navigation:**

No information is available.

- **Downstream Low-Flow Augmentation:**

- *Predicted:* No specific benefits were attributed to low-flow augmentation on the mainstream Mekong river.
- *Actual:* No major developments have been constructed on the downstream Mekong river. The Nam Ngum 1 reservoir provides an increase in the order 200 m³/s to low flows at the project site; at Thakhek the Mekong has a normal low flow of about 1,450 m³/s and at Pakse about 1750 m³/s. A benefit (or negative impact) on the mainstream Mekong river which could be ascribed to the Nam Ngum 1 project is thus likely to be small.

Costs:

- *Predicted:* No specific cost package was created for displacement of persons from the reservoir area.

- *Actual:* Although relatively few families were affected, the costs in support of activities to improve their livelihood has been substantial in the long-term. In the Pak Cheng resettlement area alone, the Mekong Secretariat provided funds of over US\$2.0 mln in successive development projects in from 1975-1988. The second resettlement area at Dan Savann was the subject of a pilot project under another MRC initiative in 1991-95.
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- **Impacts:**
- *Predicted:* Displacement of some 550 farm families from the reservoir area was predicted.
- *Actual:* The process of settlement was badly distributed by warfare, so that the process of reconstruction was significantly attenuated.

The need for monitoring of (downstream) fisheries was mentioned in the feasibility studies, but the degree of impact was not anticipated. It appears that the downstream fishery, which offered substantial livelihood opportunity for many villages, was badly affected, with the disappearance of several migratory species. It is difficult to associate the total overall quantitative decline in the fishery to the dam, since there has been growing population pressure in the lower Nam Ngum valley, an effect which was not predicted.

Q.2: What were the unexpected benefits, costs and impacts

Benefits:

1. Although it was understood that there might be benefits from the development of fisheries in the Nam Ngum reservoir, the importance of the fishery as a source of income for government and livelihood for a large number of people was not anticipated. The reservoir fishery attracted a large number of in-migrants from the period of the change of government in 1975 and the lakeshore population has grown steadily until the last couple of years. An annual fish catch of around 1,400 tons with a value of around US\$1.0 mln has been achieved. The fishery has also provided employment in trading, processing and transportation.
2. The Nam Ngum reservoir has also proved a tourist attraction, mainly for domestic tourists. This has benefited the communities close to the damsite. Recently an international resort featuring an hotel and a casino has opened on the lake, although it is difficult to quantify the benefit of this development.

Costs:

The unexpected costs were those associated with resettlement summarized in the answer to Q.1.

Impacts:

These papers were prepared as submissions to the Fourth Regional Consultation of the World Commission on Dams in Hanoi. The views, conclusions and recommendations are those of the writers and are not intended to represent the views of the Commission or the Government of Vietnam.

1. The attraction of the Nam Ngum lakeside for settlement has had the result of opening up the watershed area in general, particularly to the east of the dam. Since the fishery has not proved to be a major and sustainable occupation for many families in the medium-long term, this process is having a severe effect on the degradation of the Nam Ngum watershed.
2. Increased erosive power in the Nam Ngum river downstream may have led to increased riverbank erosion.

Q.3: What was the distribution of benefits, costs and impacts?

The export earnings gained from the supply of electricity from the Nam Ngum dam mean that the benefits of this Project have been nationwide. Among key government officials involved, these benefits are regarded not only as economic, but also political. The Nam Ngum dam is seen as a flagship project, demonstrating the capacity of the Lao PDR to handle such projects in an effective way. National revenues from the Project have also been gained through the exploitation of the timber and fishery resources, on which central government and Vientiane and Xaisomboun provinces have levied concession fees and taxes.

The more direct benefits from the dam have accrued to:

- a) urban consumers in Vientiane and other towns in the region who have benefited from domestic electricity supplies and cheap fish;
- b) the farmers of the Vientiane Plain who have benefited, albeit belatedly, from the electric pump irrigation schemes in this lowland area, as well as from improved flood control;
- c) the migrants from many parts of the country who settled around the reservoir to exploit the fishery. However, in recent years, the benefit from the fishery appears to be more and more concentrated in the hands of the more professional fishing communities in certain parts of the reservoir;
- d) those involved in the delayed logging of the reservoir, both as concessionaires and labourers.

The main group suffering loss from the dam has been the 570 or so households evacuated from the reservoir. Almost thirty years later, some of these families have still to develop a secure livelihood and their communities lack basic services, including electricity.

Q.4: How were decisions made?

Planning Phase:

Energy Context: There are three main energy sources to supply final energy consumption in Laos-fuelwood, electricity, and oil or petroleum products. As for all traditional fuels, it is difficult to have a real energy supply policy for fuelwood. Oil was imported, so the government could not absolutely influence its supply. So the energy supply policy was

concentrated around electricity. Specifically, given the country's hydro resources, the policy focused on hydropower development.

Moreover, given the importance of the Vientiane province, a solution had to be sought to supply electricity to this area. Later, when Laos re-oriented its energy policy to supply electricity to Thailand, Nam Ngum was thought to be the best solution.

River Basin Planning Context: The project was not conceived within the context of a comprehensive river basin development plan for the Nam Ngum basin. However, shortly after initiation of construction of the project, the Mekong Secretariat produced an overall plan of development for the basin. There is no evidence to conclude that the Nam Ngum project, as constructed, precluded any more advantageous development of the whole river basin than that proposed by the Mekong Secretariat.

Project design: The initial project feasibility design [Nippon Koei] of 1962 was undertaken with extremely limited field information, particularly with regard to hydrology (only 14 months of flow observations at the dam site – but estimated long-term mean flow turned out to be within 2 - 3 % of the actual flow observed in the first 23 years of operation). However, further information was obtained before construction of the dam and appurtenant structures was initiated in 1969.

Settlement: Planning involved a detailed survey of the livelihood of the communities to be flooded by the reservoir. They were given ample notice to move and some were able to visit prospective settlement sites. However, they were informed of the decision, rather than being consulted.

Construction Phase:

Settlement was disrupted by civil strife, which prevented the provision of compensation and adequate preparation of resettlement sites. As such, decision-making for the settlement process at this stage was largely ad hoc and dependent upon the resources available to the then government.

Operation Phase:

Operational Responsibility: Although the Nam Ngum 1 was conceived as a multi-purpose development project, operational responsibility was placed in the hands of the national power utility, EdL. The utility was not constrained to consider flood control in its operational decision-making. The project has therefore been operated exclusively for power production purposes (although operating policies designed specifically to secure power supplies to Laos and to maximize revenues from power exports to Thailand were not introduced until nearly 20 years after initiation of operation of the project). There appears to be some potential to introduce consideration of flood damage mitigation measures into present operational practices, albeit with a trade-off against a likely reduction in power export revenues.

Power Demand Supplied: The growth in power demands in Laos to be supplied by the Nam Ngum 1 project as forecast in the project feasibility study of 1992 [Nippon Koei] did not in fact materialize. However, demand surplus to actual requirements in Laos could be exported to Thailand.

Settlement: In so far as the meaning of ‘operation phase’ is extended to livelihood reconstruction, this depended on the availability of grants through the Mekong Secretariat (and latterly ADB) for the first 15 years of development. Only in the 1990s did the local population begin to have a role in the management of the development process.

Q.5: How did the project comply with criteria and guidelines of the day?

Economic Impact:

From the commercial and social point of view, the dam has given Laos foreign currencies necessary to import the petroleum energy sources that the country cannot produce, and has generated development of the Vientiane area. Moreover, as mentioned before, the general feeling when observing the past and present policy of the Lao government is that the project is still considered a good one.

However, the team did encounter criticisms of the project, especially with regard to the price of the electricity being sold to Thailand. Considering this and the level of domestic prices, the financial viability of the project has been questioned by certain correspondents.

Nevertheless, considering the particular economic, geographic, and demographic situation, the country has few options for development. The development of its hydropower resources, of which Laos has probably the greatest potential, could not be ignored even if it costs the country in the short term.

Social Impact:

There is evidence that the Project implementing organization, the Mekong Secretariat, did attempt to provide adequate compensation, assistance in relocation and planned resettlement for the evacuees. Settlement was planned so that evacuees would be beneficiaries of the development of irrigated agriculture downstream. Unfortunately warfare and the relative political isolation of the Lao PDR after 1975 meant that the effort of reconstruction of livelihood was slow and limited.

[It is not clear that physical preparation of the settlement sites was in the plans and, arguably, the rural population were used to land reclamation in the normal process of settlement development].

Q.6: How would the project be viewed in today’s context?

Social Impact:

Inevitably the Project lacked the comprehensive consultation process which is characteristic of the current practices which have been introduced into the Lao PDR in the 1990s. The Project was planned in the context of national development, and especially with a view to supporting regional co-operation. Evacuees were informed about the need to move, not consulted. There was inadequate consideration of the difficulties of livelihood development.

7. DEVELOPMENT PROCESS

7.1 Existing Practices

7.1.1 Technical Aspects

- In the planning phase, the practice of 30 years ago when the dam was planned would appear to be no longer relevant. In Lao PDR, planning of dams has become more elaborate, in line with requirements of donor agencies and international practices. But in fairness to the past practitioner, it should be said that the planning undertaken at the time was highly professional.
- The existing management of the dam is a highly efficient organization.
- Forecast power demands in Laos, in particular industrial loads, proved to be considerably over-estimated (but the situation was 'saved' by the essentially unlimited possibility of supplying surplus power to Thailand).
- No (or, at least, limited) efforts were made to implement the envisaged flood control component of the project.
- Efforts to implement the irrigation component of the project were fragmented and required over 20 years to come to even partial fruition.

7.1.2 Socio-Economic Aspects

Policy in the Lao PDR towards social impact of large infrastructure projects, including dams, in the period from the planning of the Nam Ngum dam to the end of the 1980s was ad hoc and largely dependent upon the availability of limited donor funding channeled through the Mekong Committee. A combination of inadequate planning and the prevailing macro-economic environment conspired to prevent the settlers from attaining anything like adequate living standards in either area by the end of the 1980s.

At present there are no firm guidelines for implementation and support of resettlement programs of large hydropower projects and it is the relevant provincial office which is the actual implementing agency and this issue is only dealt in a scattered way in various decrees and laws.

Recently, however, a draft on Resettlement Policy for Major Projects in the Lao PDR has been prepared in April 1997, apparently in connection with the Nam Theun 2 project. It is proposed to establish a National Resettlement Committee (NRC) and a supporting technical office at national level, although it is not clear on the location of this.

Clearly, and at least partly in response to the protest over the Nam Theun project led by international NGOs, the Government of the Lao PDR and the World Bank are now taking considerable care to ensure that all possible steps are taken to offset the impact of this project on the local population.

Conversely there is evidence from Nam Ngum itself that these principles and procedures are not being implemented as firmly as the Government would wish to suggest.

7.2 Lessons Learned

7.2.1 *Technical Aspects*

- The main lesson learned from the economic study is that a dam can have wide-ranging benefits and costs. In particular reference to a multipurpose dam, it is the total sum of benefits that leads to the economic feasibility of the project. Costs have to be internalized to make sure that the project accounts for all the negative impacts on the environment and socially disadvantaged groups.

Financial lessons are that not all project benefit can be monetized. However, the project financial set up may be arranged so as to cover the financial cost.

- Industrial development planning should be integrated into power load forecasting, power system expansion planning and individual project planning.
- Implementation of the irrigation components of multipurpose projects should be integrated more closely into original project, including funding, institutional cooperation, etc.
- If potential flood control benefits of a large dam project are to be realized, construction of the project should be accompanied by all other necessary measures, e.g. land-use planning in downstream flood-prone areas, drainage improvement in these areas, introduction of flood-warning systems, deployment of appropriate operating policies and designation of responsibilities (see next bullet)
- In general, and in the particular case of multipurpose projects such as Nam Ngum 1, greater attention should be paid in the planning and implementation stages to how the project should actually be *operated* to achieve the forecast benefits. This should include specific consideration of reservoir and power plant operating policies and benefit trade-offs as well as institutional responsibilities.

7.2.2 *Socio Economic Aspects*

It seems clear from the discussion in the previous section that the Government of the Lao PDR has begun to adopt new policies to deal with social and environmental aspects of large infrastructure projects, particularly the large dams, the development of which remains central to national development policy. These encapsulate:

- a) The need to look at any new hydropower scheme in the context of the wider catchment;
- b) The need to consider carefully the social and environmental aspects and ensure that adequate funds are available to address these issues *within* the Project;
- c) The need to consider carefully the implementation of any irrigation component, which is often seen as a major benefit of the development, but in practice has proved extremely difficult to implement successfully and, as such, quite disappointing to the Government.
- d) Current rhetoric concerning the social impact of large dams calls for the benefits of dams to be extended to the so-called ‘affected persons’, especially those displaced

by the creation of the reservoir and other aspects of the dam's construction. Conventionally, attempts to provide alternative livelihood for the displaced have been based on a land-for-land strategy, ideally with the development of land in the downstream irrigated areas often created by multipurpose projects. Despite its relatively early development, planning for the Nam Ngum included this positive option, based upon the pumping of water from the more regulated Nam Ngum river through the provision of cheap electricity from the dam.

Such projects as were implemented and those which have followed economic liberalization of the country demonstrate, however, that the securing of benefits from irrigated agriculture does not come easily.

- e) Probably the anticipated benefit of a hydropower project which is most eagerly anticipated by the rural population is domestic electricity. What appears to have rankled most with the Nam Ngum population is the failure of the Government to provide this facility, especially to resettlers.
- f) In contrast to the provision of irrigation, the opportunity for livelihood creation through the development of reservoir fisheries should not be neglected. This has been a major feature of the Nam Ngum reservoir, but needs more planning than was undertaken.

7.3 **Implications for Future Practices**

- (i) *Future practice of dam planning should pay attention to the full range of positive impacts of the dam, and take into account the negative impacts. To the extent possible, the negative impacts should be minimized by appropriate mitigation measures in the design of the dam.*
- (ii) *Dam Management should aim for increasing value-added from the dam-related services such as power generation and water regulation through the exploration of possibilities for improving resource use.*
- (iii) *For all aspects of dam investment, participation of local and national stakeholders is a necessary part of the process. Due to specific circumstances of the country, there may have been too little participation of the local stakeholders in this case. However, in Lao PDR, with dam projects, this aspect of dam planning has been recognized.*

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