2) Vegetation near the Project Site

The power generation project site belongs to the tropical rain green forest climate, but the phase of living creatures is poor since village communities, pastures, coffee plantations, etc., have been developed, creating environmental changes on a large scale. There are almost no forests in the vicinity of the project site, which will be directly affected by the project. There are overwhelmingly many orchards (coffee plantations) in the area upstream from the dam project site, and a lot of pastures near the power generation project site (Fig. 13-14). A lot of forests are seen on the left bank of the water-reducing section. The representative vegetation consists of grass and its ancillary plants and few trees and plants on farmland and river banks.

(1) Vicinity of the Dam Project Area

<1> Grass and Other Trees and Plant

The types of trees and plants observed here are as shown below. Growths of weeds are often seen along rivers and areas without cultivated coffee trees. The most common families are Compositae, Convolvulaceas, Euphorbiacea, Gramineas and Cyperaceae (Cyperus rotundus), and Zacate estrella (Cynodun nlemfuensis), Jungibrillo (Paspalum notatum) and Jaragua (Hyparhenia rufa) have been observed as grass.

<2> Farm Products Except Coffee

The types of farm products except coffee, which have been observed, are as follows:

Family	Species
Gramineae	*Saccharum* sp.
Leguminosae	*Phaseolus vulgaris*
Gramineae	*Zea mays*
Myrtaceae	*Eucaliptus* sp.
Musaceae	*Musa sapientum*
Cupresaceae	*Cupressus lucitanica*

<3> Other Observed Plants

Besides the above-mentioned ones, the following types of plants near farmland with cultivated farm products and on river banks have been observed as small groups.

Family	Species
Gramineae	*Bambusa* sp.
Gramineae	*Coix lacrima jobi*
Stercualiceae	*Guazuma ulmiforia*
Musaceae	*Musa sapa ntum*
Musaceae	*Musa paradisiaca*
Costaceae	*Costus* sp.
Leguminosae	*Inga* sp.
Leguminosae	*Mimosa pudica*
Leguminosae	*Cajanus* sp.
Leguminosae	*Erithrina* sp.
Pinaceae	*Pinus* sp.
Myrtaceae	*Psidium guajaba*
Euphobiaceae	*Recinus communis*
Anacardiaceae	*Manguifera indica*
Rutaceae	*Citrus aurantium*
Rutaceae	*Citrus limonium*
Umberlliferae (Apiaceae)	*Cariandrum sativum*
Meliaceae	*Cedrela* sp.
Malvaeae	*Sida rhombifolia*
Geraniaceae	*Geranium* sp.
Elaeocarpaceae	*Huntingia* sp.
Elaeocarpaceae	*Solanea* sp.
Cupresaceae	*Cupressus lusitanica*
Maraceae	*Cecropia* sp.
Bromeliaceae	*Tillandsia* sp.
Amaranthaceae	*Amarunthus spinosa*
Bromeliaceae	*Bromelia pinguin L.*
Begoniaceae	*Begonia* sp.
Convolvulaceae	*Ipomoea* sp.
Lamiaceae	*Hyptis* sp.
Cannaceae	*Canna* sp.

(2) Vegetation near the Power generation project Site

In the vicinity of the power generation project site, a forest has remained relatively well on its left bank. Since the construction of road(s) for construction work and conduit(s) has been planned, a survey was made by establishing a quadrat inside the forest in addition to investigation on the general conditions.

<1> General Conditions

The environment is full of variety from the dam to the power station, and secondary forests are mixed with natural

forests in cut over areas and forest-fire sites near the upper reaches of the river and its tributaries such as Quebradas las Delicias, Quebradas Quebradillas, etc. The phase of plants in this area is poor in both quantity and variety since forests are forced to change, cattle are grazed and land is cultivated continuously. The families of plants inside shrubbery forests or on mountainsides and on the slopes of valleys are as follows:
Composotae, Convolvulaceae, Euphorbiacea, Graminae

a. Types of Cultivated Plants: the types of perennial, sub-perennial and seasonal ones (mixed with others) are as follows:

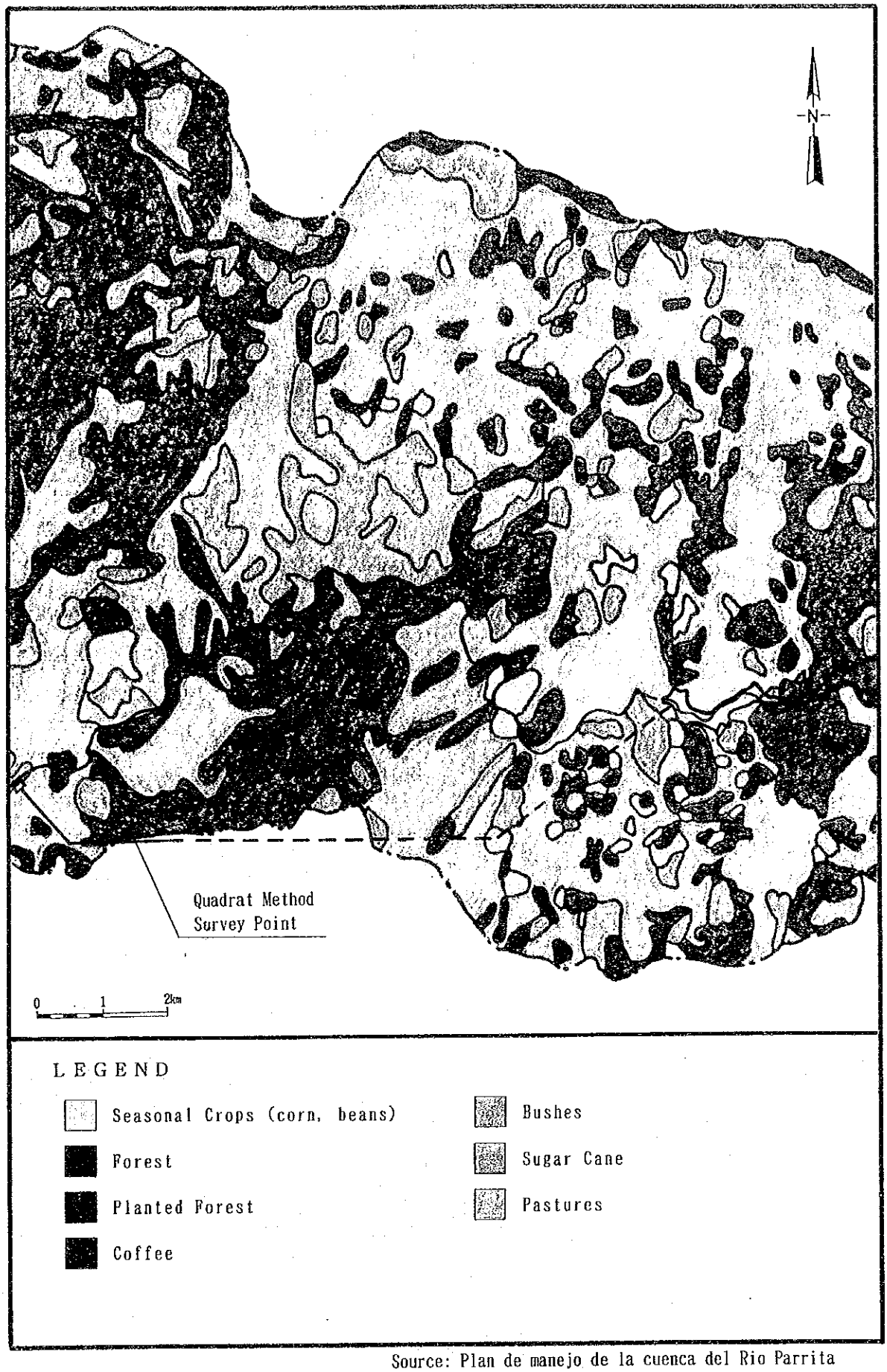
Family	Species
Rubiaceae	*Coffea arabica*
Gramineae	Saccharum sp.
Musaceae	Musa sp.

b. Others: the types of plants, which have been observed as small groups inside forests and grassland except the above-mentioned ones, are as follows:

Family	Species
Araceae	*Xanthosoma* sp.
Bombacaceae	*Ochroma* sp.
Leguminosae	*Inga* sp.
Stercualiaceae	*Guazuma* sp.
Leguminosae	*Mucuna* sp.
Anacardiaceae	*Anacardium exclsum*
Anacardiaceae	*Manguifera indica*
Elaeocarpaceae	*Muntingia* sp.
Euphorbiaceae	*Recinus communis*
Liliaceae	*Yucca elephantipes*
Costaceae	*Costus* sp.
Leguminosae	*Mimosa pudica*
Myrtaceae	*Psidium guajaba*
Malvaceae	*Sida rhombifolia*
Cupresaceae	*Cupressus* sp.
Moraceae	*Cecropia* sp.
Bromeliaceae	*Bromelia pinguin*
Piperaceae	Photomorphe sp.
Solanaceae	*Solanum* sp.
Burseraceae	*Bursera simaruba*
Bombacaceae	*Bombacopsis* sp.
Fagaceae	*Quercus* sp.
Amaranthaceae	*Amaranthus* sp.
Polygonaceae	*Triplaris americanus*

As for aquatic plants, a lot of green algae (Cianofitas) sticking to the bottom of the water, stones, rocks and bounding rocks on earth banks have been observed.

Fig. 13-14 Vegetation Map (Vicinity of Planned Area)



Source: Plan de manejo de la cuenca del Rio Parrita
Ministrio de Agricultura y Ganaderia 1985.5

<2> Quadrat Method Survey

The names of existing tree types, diameter at the breast height, height, timber volume and stratus structure on the actual spot were surveyed by establishing a quadrat with an area of 400 m2 at the point (with an altitude of 500 m) shown in Fig. 13-14.

a. Existing Types

The types of existing trees in the quadrat and their height are shown in Table 13-4.

b. Timber Volume

The results of calculating the timber volume of some trees are shown in Table 13-4. The equation of Auvergne was used for its calculation.

V = 0.55 * D.B.H. * H

Where V = Timber Volume

D.B.H. = Diameter at the Breast Height (H = 1.37 m)

H = Height of Trees

c. Stratus Structure

The forest at the surveyed point belongs in bmh-T based on the classification on the ecological map of Costa Rica, which was mentioned above. The stratus structure of the forest at the surveyed point is shown in Fig. 13-5, and basically divided into four strata such as tall trees, short trees, trees and plants, and epiphytic creatures.

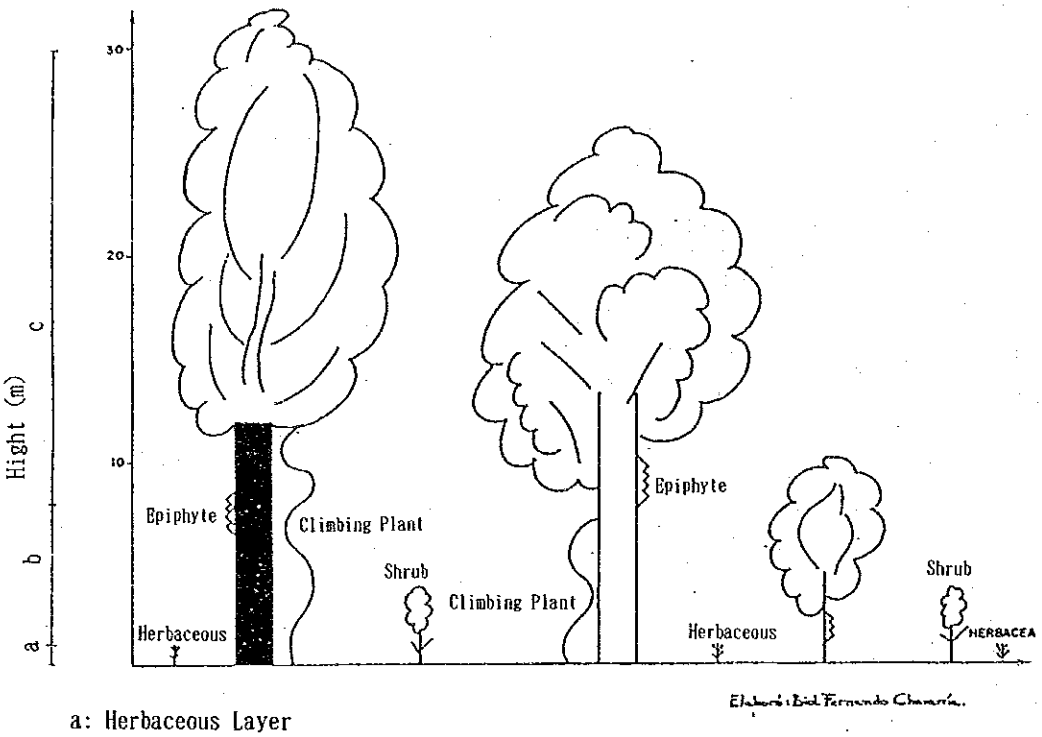
Table 13－3 Results of Quadrat Method Survey(1)

TYPE	FAMILY	HEIGHT(m)	SPECIES	COMMON NAME
Arbor	Guttiferaceae	5-12	*Vismia macrophylla*	Achiotillo
Bush	Solanaceae	1-3	*Solanum* sp.	Berenjena
Arbor	Lequminosae	4-6	*Cassia fructicosa*	Sen de Palillos
Arbor	Tiliaceae	7-10	*Luehea speciosa*	Guacimo macho
Bush	Palmae	1,5,4	*Chanaedorea costaricana oerst.*	Pacaya
Bush	Tiliaceae	1.5-3	*Triumietta Lappula*	Mozote de aba
Arbor	Meliaceae	10-25	*Cedrela mexicana*	Cedro Amargo
Climbing Plant	Araceae	---	*Philodemdron Hoffmannii*	Hoja Hombre
Climbing Plant	Passifloraceae	---	*Passiflora apetala Killip*	Calzoncillo
Herbaceous	Begoniaceae	0.5-1	*Begonia* sp.	Begonia
Bush	Piperaceae	1-2	*Pothomorphe* sp.	Anisillo
Epiphyte	Araceae		*Pothos* sp.	Epifita
Herbaceous	Heliconiaceae	0.5-1	*Heliconia* sp	Platanillo
Bush	Piperaceae	1-3	*Piper* sp.	Cordonicillo
Arbor	Anacardiaceae	10-25	*Spondias Monbin*	Jobo
Arbor	Burseraceae	5-25	*Bursera simaruba*	Indio Pelado
Bush	Urticaceae	1-3	*Urera elate*	Ortiga
Bush	Cecropiaceae	7	*Cecropia* sp.	Guarumo
Arbor	Phapilionaceae	10-25	*Piatymiscium pinnatum*	Cristobal
Arbor	Rutaceae	10-15	*Zanthoxylum insulare*	Lagartillo
Arbor	Bombacaceae	10-15	*Bombacapsis quinatum*	Pochote
Arbor	Anacardiaceae	15-25	*Astronium graveolens*	Ran-Ron
Arbor	Papilionaceae	8-15	*Gliuicidie sepium*	Madero Negro
Arbor	Boraginaceae	10-25	*Cordia alliodora*	Laurel
Arbor	Mimosaceae	5	*Stryphodendron excelsum*	Vainillo
Arbor	Meliaceae	10-25	*Swietenia macrophylla*	Caoba
Arbor	Myrtaceae	5-10	*Psidium guajava*	Guayaba
Arbor	Anacardiaceae	15-25	*Anacardium excelsum*	Espavé
Arbor	Monraceae	15-25	*Ficus* sp.	Higuerón
Arbor	Mimosaceae	5-10	*Acacia hindsii*	Cornezuelo
Arbor	Caesalpinaceae	15-25	*Hymenaea courbaril*	Guapinol
Arbor	Bignoniaceae	15-20	*Tabebuia chysantha*	Amarillón
Arbor	Mimosaceae	15-30	*Pithecolobium samam*	Cenízaro
Arbor	Bignoniaceae	15-40	*Tabebuia guayacan*	Guayacàn
Arbor	Moraceae	15-30	*Brosimun costaricanum*	Ojoche
Arbor	Bombacaceae	+10-25	*Ocrhoma lagopus*	Balsa

Table 13－4 Results of Quadrat Method Survey(2)

Diameter(cm) / Species	10-19	20-29	30-39	40-49	50-59	60-69	100-109	TOTAL (m^2)
Cordia alliodora			0.71	0.99				1.70
Bursera simanba					1.00			1.00
Anacardium excelsum				1.94				1.94
Tabebuia guayacan	0.11							0.11
Tabebuia chysantha		0.37						0.37
Pithecolobium saman		0.42				2.18		2.60
Brosimun costaricanum		0.23						0.23
Ficus sp.							6.41	6.41
TOTAL	0.11	1.02	0.71	2.93	1.00	2.18	6.41	14.35

Fig. 13-15 Stratification of the Forest



a: Herbaceous Layer
b: Shrub Layer
c: Arbor Layer

Type	
Arbor(~40m) : Pithecolobium saman, Tabebuia guayacan, Brosimum costaricanum.	Herbaceous Begonia sp, Heliconia sp
Arbor(~25m) : C. mexicana, C. alliodora, S. monbin, B. simarouba, P. pinnatum, A. graveolens, S. macrophylla, A. excelsum, Ficus: H. courbaril, T. chrysantha, O. lagopus, V. macrophylla, Z. insulare, B. quinatum, G. sepium	Climbing Plant P. hoffmannii, P. apetala
Arbor(~10m) : C. fistula, L. speciosa, Cecrop sp, S. excelsum, P. guajava, A. hindsii	Epiphyte: Photos sp.
Shrub(~4m) : Solanum sp, Ch. costaricana, T. lappula, Photomorphe, Piper sp, U. elata	

13.3.7 Animals

90% of the entire land of Costa Rica used to be covered with forests, and the phase of animals was also rich. The Pirris River basin is not an exceptional case, having peculiar birds such as green toucans, siskins, etc. Quezals also exist only at high altitudes, and the number of them is very small. Various kinds of tanagers and woodpeckers exist depending on the types of trees. Bevies of quail are seen in coffee plantations. As for mammals, there are squirrels, pouched mice, weasels, jaguarundis, wildcats, rodents, coatis, tapirs, etc. However, the above-mentioned animals are barely seen since food and dens provided by forests have become insufficient, in addition to the existence of human beings.

1) Dam project Site

Since the phase of plants in the vicinity of the dam project site is now poor, the phase of animals is also very poor. The following types of animals have been observed on the actual spot.

(1) Insects

The following types of insects have been observed. Besides them, chrysalies of Ephemeras, Odonata and Diptera have been observed.

Order	Suborder
Orthoptera	Saltatoria
Odonata	Anisoptera
	Apocrita
	Rhopalocera
Diptera	Nematocera
Diptera	Cyclorrhapha

(2) Batrachians

Toads (Bufus marinus) have been observed.

(3) Reptiles

As for iguanas, Basiliscus sp., and Anolis sp., have been observed.

(4) Birds

Four types of birds, such as one of each of the types belonging to hummingbirds, wild geese and ducks, siskins and doves have been observed.

(5) Mammals

As for mammals, only one type of mouse (Rattus sp.) has been observed.

2) Power generation project Site

(1) Results of the First Survey

The results of the first survey made in 1990 by I.C.E., are as follows:

<a> Insects

As for animals, a lot of insects have been observed as well as many types of them. The representative types are as follows:

Order	Suborder
Odonata	Zygoptera Anisoptera
Ortohptera	Saltatoria
Himenoptera	Apocrita(Apoidea) Apocrito(Formicidae) Apocrita(Vespidae)
Lepidoptera	Rhopalocera
Diptera	Cyclorrhapha (Muscudae)
Cursores	Blattaria

<b> Batrachians

Larvae of toads (Bufus marinus) have been observed.

<c> Reptiles

Lacerations (Lacertilia) have been observed.

<d> Birds

The following types of birds have been observed.

Family	Species
Cuculidae	*Crotophaga sulcirostris*
Tyrannidae	*Myidinastes luteiventris*
Thraupidae	*Thraupis episcopus*
Cathartidae	*Caragyps atratus*
Hirundinidae	*Notiochelidon cyanoleuca*

(2) Results of an additional survey

Results of an additional survey made in 1991 by I.C.E., is as follows:

<1> Insects

The types of them, which have been observed, are as follows:

FAMILY	SCIENTIFIC NAME
Sphingidae	*Agrius cingulatus*
Sphingidae	*Amplyterus gannascus*
Formicidae	*Eciton homatum*
Formicidae	*Alta atta*
Romaleidae	*Tropilocris cristata*
Acrididae	*Abracris flavolineata*
Papilionidae	*Papilio anchisiades idaeus*
Nymphalidae	*Memphis* sp.
Nymphalidae	*Marpesia* sp.
Donaidae	*Donaus* sp.
Apidae	*Bombus ephippiatus*
Apidae	*Apis mellifera*
Apidae	*Melipona* sp.
Apidae	*Trigona* sp.
Cicindelidae	*Pseudoxychila tarsalis*
Libellulidae	*Pantala flavescens*

<2> Amphibians

The types of them, which have been observed, are as follows:

FAMILY	SCIENTIFIC NAME
Bufonidae	*Bufo marinus*
Leptodactylidae	*Leptodactylus pentadactylus*
Dendrobatidae	*Drendrobates auratus*
Leptodactylidae	*Eleutherodactylus* sp.

<3> Reptiles

The types of them, which have been observed, are as follows:

FAMILY	SCIENTIFIC NAME
Iguanidae	*Iguana iguana*
Iguanidae	*Anolis* sp.
Iguanidae	*Basiliscus basiliscus*
Teiidae	*Ameiva undulada*
Colubridae	*Ninia maculata*
Viperidae	*Crotalus durissus*
Colubridae	*Spilotes pullatus*
Colubridae	*Imantodes cenchoa*
Colubridae	*Drymarchon coarais*
Viperidae	*Bothriechis schlegelii*
Viperidae	*Bothrops asper*
Elapidae	*Micrurus migrocinctus*
Boidae	*Boa constrictor*
Viperidae	*Bothriechis nasutus*

<4> Birds

The types of them, which have been observed, are as follows:

FAMILY	SCIENTIFIC NAME
Thraupidae	*Ramphocelus passerinii*
Icteridae	*Cacicus urppygialis*
Thraupidae	*Chlorophonia callophrys*
Pipridae	*Chiroxiphia linearis*
Accipitridae	*Elanus caeruleus*
Accipitridae	*Leucopternis albicollis*
Ramphastidae	*Ramphastos sulfuratus*
Ramphastidae	*Aulacorhychus prasinus*
Emberizidae	*Zonotrichia capensis*
Emberizidae	*Cyanocompsa cyanoides*
Emberizidae	*Tiaris olivace*
Emberizidae	*Sporophila torqueola*
Emberizidae	*Volatinia jacarina*
Turdidae	*Myadestes melanops*
Fyingillidae	*Carduelis psaltria*
Cracidae	*Crax rubra*
Cathartidae	*Cathartes aura*
Cathartidae	*Coragyps atratus*
Corvidae	*Cyanocorax morio*
Hirundinidae	*Hidrundo rustica*
Cuculidae	*Piaya cayana*
Caprimulgidae	*Nyctidromus albicollis*
Columbidae	*Columbina passerina*
Ardeidae	*Bubulcus ibis*
Tyrannidae	*Coryphotriccus albovittatus*
Tyrannidae	*Megarhynchus pitangua*
Cuculidae	*Crotophaga ani*
Cuculidae	*Crotophaga sulcirostris*
Turdidae	*Turdus grayi*
Columbidae	*Luptoitila rufaxilla*
Picidae	*Melanerpes hoffmannii*
Thraupidae	*Thraupis episcopus*
Icteridae	*Psarocolius wagleri*
Icteridae	*Quiscalus mexicanus*
Icteridae	*Molothrus aeneus*
Emberizidae	*Pheucticus ludovicianus*
Pipridae	*Schiffornis turdinus*
Tyrannidae	*Tyrannus melancholicus*
Tyrannidae	*Tyrannus savana*
Tityridae	*Pachyramphus polychopterus*
Tyrannidae	*Camptostoma imberbe*

<5> Mammals

The types of them, which have been observed, are as follows:

FAMILY	SCIENTIFIC NAME
Cebidae	*Cebus capucinus imitador*
Felidae	*Felis wiedi*
Dasyproctidae	*Agouti paca*
Dasypodidade	*Cabassous centraalis*
Dasypodidae	*Dasypus novemcinctus*
Procyonidae	*Potos Flavus*
Dasyproctidae	*Dasyprocta punctata*
Phyllostomidae	*Artibeus lituratus*
Tayassuidade	*Tayassu tajacu*
Sciurudae	*Sciurus variegatoides*
Sciurdae	*Sciurus granatensis*
Procyonidae	*Nasua narica*
Procyonidae	*Procyon lotor*
Mustelidae	*Conepatus semistriatus*
Didelphidae	*Didelphis marsupialis*
Heteromyidae	*Heteromys desmarestianus*
Heteromyidae	*Liomys saluini*
Echimydae	*Proeschymis semispinosus*
Cricetidae	*Sigmodon hispidus*
Cricetidae	*Zygodontomys brevicauda*
Cricetidae	*Oryzomys ophrastus*
Cricetidae	*Oryzomys concolor*
Cricetidae	*Tylomys watsoni*
Cricetidae	*Rheomys hartmanni*
Cricetidae	*Oryzomys palustris*
Cricetidae	*Oryzomys caliginosus*
Cricetidae	*Oryzomys alfaroi*

<6> Others

The types of crustaceans and centipedes, which have been observed, are as follows:

* Crustaceans

FAMILY	SCIENTIFIC NAME
Palaemonidae	*Macrobrachium americanum*
Atyidae	*Atya* sp.
Pseudothelphusidae	*Ptychophalla tristani*
Pseudothelphusidae	*Potamocarcinus magnus*

* Centipedes

FAMILY	SCIENTIFIC NAME
Scolopendridae	*Scolopendra giganta*

13.3.8 Aquatic Organisms

1) Vicinity of the Dam Project Site

(1) Fishes

Poecilia gillii belonging to Oluminas have been observed.

(2) Aquatic Insects

Chrysalies of Ephemeras, Odonata and Diptera have been observed.

2) Vicinity of the Power generation project Site

(1) Fishes

The phase of fishes is poor. The types of them, which have been observed, are as follows:

FAMILY	SCIENTIFIC NAME
Poeciliidae	*Poecilia gillii*
Mugilidade	*Agonostomus monticola*
Characidae	*Brycon behreae*
Characidae	*Astianax fasciatus*

(2) Aquatic Insects

The types of aquatic insects in the vicinity of the power generation project site are very few, but a lot of gastropods (Moluscos) have been observed.

13.3.9 Water Quality

(1) Water Contamination Problems in Costa Rica

Waste matter discharged from several hundred coffee-processing factories is causing river contamination all over the country. Waste matter discharged in the coffee-processing stage accounts for 70% of the causes of water contamination in Costa Rica, and the amount of waste matter discharged reaches 300 tons a day. River contamination gets even worse since the dry season with lower river flow rates falls at the time to reap coffee fruits.

(2) Outline of the Pirris River Basin

Pirris River has its water source which is Mt. Vueltas (with an altitude of 3,156 m) located on the borderline between San Jose Prefecture and Cartago Prefecture. The dam project site is located at an altitude of about 1,080 m and 30 km west of Mt. Vueltas, and the power station is planned to be located at an altitude of about 300 m and about 10 km west of the dam project site. Pirris River starts to go down south at a right angle at a point about 10 km west of the power station project site and flows into the Pacific Ocean at a point about 20 km away from the confluence of the river and Candelaria River running from the north. Forests exist only in the water source area, on mountain tops and in few parts of the banks of Pirris River and its tributaries, and they have already been cut down in most parts of the river basin. The existence of few remaining forests is in danger since they are also cut down continuously. Surface soil is relatively thin, laterite soil is exposed in various places and rainfall in the rainy season causes it to flow into rivers together with surface soil. The vicinity of the dam project site is used as pastures and coffee plantations. There are nine communities with a population of 19,000 in the catchment area of the reservoir and about 16,000 cattle and 3,000 pigs are raised. Five coffee-processing factories are operated and 62,000 tons of coffee fruits are processed annually. About 2,000 tons of nitrogenous and photospheres fertilizers are used annually in coffee plantations. The topography from the dam to the power station is very severe,

mountainsides on both banks of Pirris River rise steeply and its many tributaries flow as waterfalls into the river. There are pastures and devastated land on both banks and forests remain on mountain tops. According to the records of flow rates at the dam project site from 1964 to 1989, the monthly average maximum flow rate is 57.7 m^3/sec., the monthly average minimum flow rate is 0.5 m^3/sec., and the annual average flow rate is 11.1 m^3/sec.

(3) Present Situation of Water Quality

Water quality in rivers becomes worst when the dry season with lower river flow rates falls at the time to reap coffee fruits from January to April. Black sludge has accumulated thickly at the dam and power station project sites, emitting a foul odor which is offensive to the nose. Water is black in color, running together with bubbles in groups at the surface of water. Common aquatic organisms indigenous to torrents are scarcely seen, and organisms living in contaminated water, such as tubificids, snails, etc., are often seen. The breeding of harmful insects such as mosquitoes and flies which carry epidemics are often seen.

i) Water Quality Measurement

An investigation of water quality in Pirris River was conducted monthly by ICE at three points such as Dota, Tebacales and Bijagual for eight years from 1980 to 1988. A water quality investigation was conducted monthly by ICE at five points along Pirris River and its tributaries as a part of feasibility studies for one year from October, 1990 to September, 1991. Water quality at the water source was analyzed by the Water Supply and Sewerage Public Corporation from 1975 to 1984. The locations of water quality measurement and its results are shown in Fig. 13-6 and Table 13-5 to 7 respectively.

ii) Results of Water Quality Analysis

<1> The physical characteristics of water quality are as follows:

* The hydrogen ion concentration (pH) of water ranges from 7 to 8 and it is slightly alkaline. The observed value changes by 1 depending on the seasons. The standard deviation is an eight-year-long average of more than 1 at two points of three points. The influence of dissolved matter seems to appear in the dry season with lower river water flow rates.

* The electric conductivity is an eight-year-long average of 106 us/cm to 135 us/cm. The electric conductivity changes a lot depending on the season and sometimes exceeds a maximum of 200 us/cm in the dry season when it does not change.

* The content of inorganic dissolved matter is as much as the world average content in river water. The concentration of SiO_2 is 20 mg/liter and slightly higher than a world average of 13.1 mg/liter, and it seems to show the characteristics of this volcanic region.

* The concentration of dissolved oxygen (DO) indicates relatively-higher values ranging from 6 mg/l to 8 mg/l, and the reason for the higher values seems to be that oxygen is provided from the surface of water in the process of aeration since rivers are steep and have a rapid stream.

<2> The chemical characteristics of water quality are as follows:

* As for nitrogen and phosphor regarded as the index to the eutrophication of water quality, the concentration of nitrate nitrogen ranges from 0.13 mg/l to 5 mg/l and is an average of 2.4 mg/l. The concentration of phosphate phosphor ranges from 3.2 mg/l to 15.7 mg/l and is an average of 8.2 mg/l. The

concentration of nitrate nitrogen in ordinary rivers in Japan is the order of 0.1 mg/l and the concentration of phosphate phosphor is smaller than that by one figure, standing at the order of 0.01 mg/l. Compared with them, the concentration of nitrogen and phosphor in Pirris River is extremely high.

* The biochemical oxygen demand (BOD) regarded as the index to water contamination caused by organic matter ranges from 2 mg/l to 160 mg/l and is an average of 46.7 mg/l. The chemical oxygen demand (COD) ranges from about 30 mg/l to 65 mg/l. They are extremely-high values and mean that water is extremely contaminated in Pirris River. BOD is generally 2 mg/l or lower in the water sources of rivers. When BOD exceeds 5 mg/l, water is not fit for the existence of fishes. In the case of 10 mg/l or above, it emits a foul odor.

<3> Other characteristics of water quality are as follows:

* The number of colon bacilli can be regarded as the index to water contamination. 1,000 MPN/100 ml in "Water Service Class 2" corresponding to ordinary water purifying treatment in Japan and 2,500 MPN/100 ml to 5,000 MPN/100 ml in "Water Service Class 3" corresponding to high-degree water purifying treatment are considered to be the safety limitations of raw water for supply. In Copey, the values stand at a maximum of 24,000 MPN/100 ml, a minimum of 13 MPN/100 ml and an average of 2,700 MPN/100 ml, and if water is highly treated, it can be used as raw water for supply. In Santa Maria downstream from there, the values are high, standing at a maximum of 240,000 MPN/100 ml, a minimum of 95 MPN/100 ml and an average of 30,500 MPN/100 ml.

Fig. 13-16 Location of Water Quality Examination

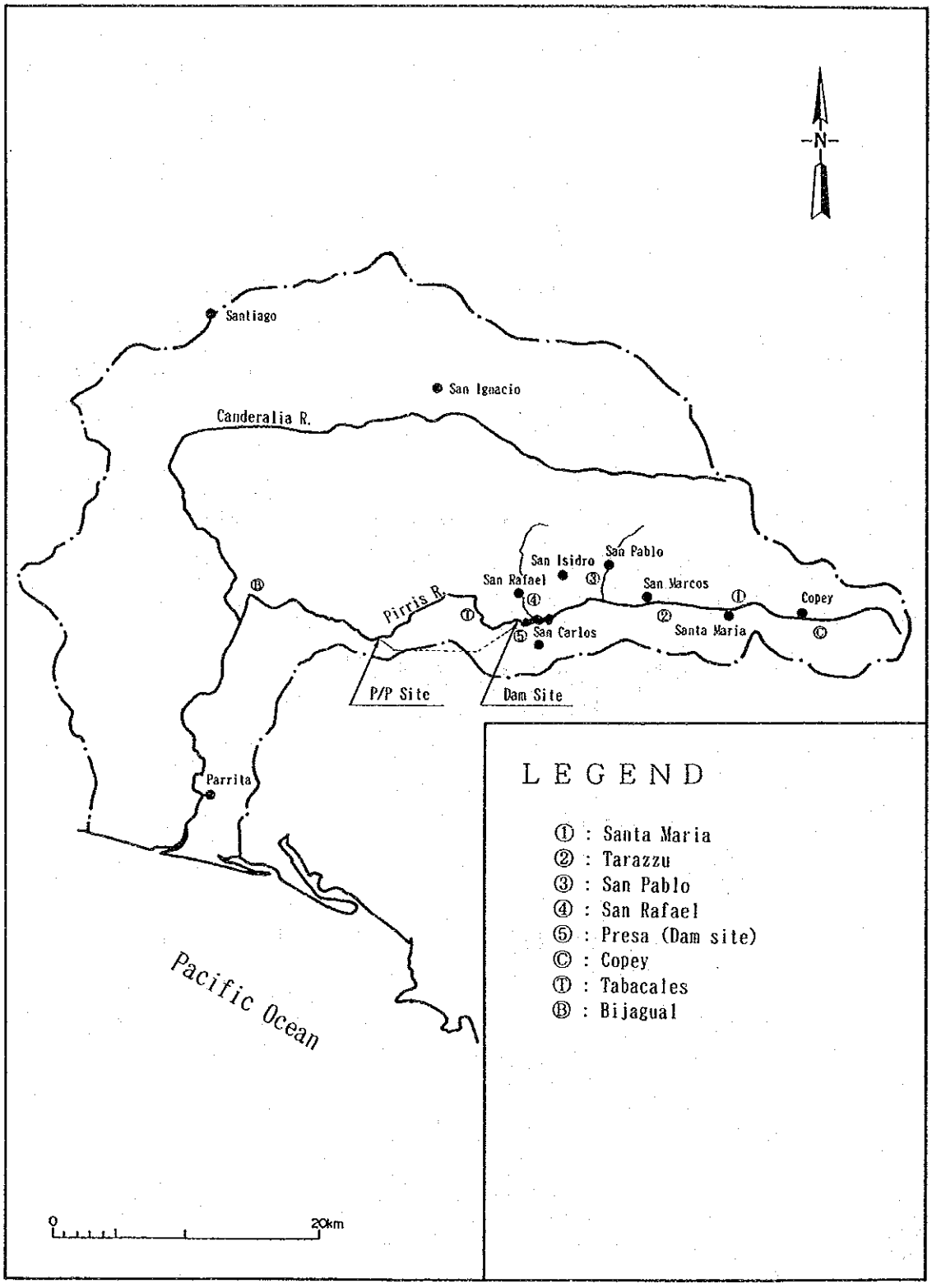


Table 13－5 Results of Water Quality Measurement(1)

COPEY			1981.3 ～1988.10	
	Unit	MAX	MIN	AVE
Temperature	℃	22.5	14.5	18.3 ± 1.79
pH	——	8.20	6.62	7.33± 1.250
Conductivity	μs/cm	150	62	106 ±18.7
Alkalinity	mg/l	85.7	25.1	53.7 ± 9.43
Cl	mg/l	3.8	1.0	1.8 ± 0.68
SO_4	mg/l	22.7	ND	11.9 ± 6.10
SiO_2	mg/l	48.0	11.8	21.7 ± 5.29
Na	mg/l	23.5	1.5	4.6 ± 3.28
K	mg/l	8.1	0.1	1.6 ± 1.44
Ca	mg/l	24.5	5.9	13.9 ± 3.25
Mg	mg/l	5.9	1.0	3.1 ± 0.75
$CaCO_3$	mg/l	75.6	25.1	49.4 ± 8.89

TABACALES			1981.1～1988.10	
	Unit	MAX	MIN	AVE
Temperature	℃	22.0	16.5	19.0 ± 1.26
pH	——	9.15	6.31	7.31± 1.164
Conductivity	μs/cm	220	68	114 ±28.3
Alkalinity	mg/l	87.6	17.3	57.9 ±12.62
Cl	mg/l	4.4	0.2	2.1 ± 0.80
SO_4	mg/l	31.1	ND	9.8 ± 5.89
SiO_2	mg/l	28.4	11.0	20.3 ± 3.37
Na	mg/l	10.2	1.5	4.6 ± 1.56
K	mg/l	14.1	0.5	2.1 ± 2.73
Ca	mg/l	20.8	2.8	15.6 ± 3.29
Mg	mg/l	5.1	1.1	2.7 ± 0.58
$CaCO_3$	mg/l	69.1	18.5	50.8 ± 9.58

BIJAGUAL			1983.9～1988.10	
	Unit	MAX	MIN	AVE
Temperature	℃	26	22	24.4 ± 1.42
pH	——	9.30	6.99	7.99± 0.52
Conductivity	μs/cm	180	90	135 ±22.1
Alkalinity	mg/l	128.8	47.6	82.5 ±14.8
Cl	mg/l	6.9	0.6	3.0 ± 1.28
SO_4	mg/l	19.8	ND	5.8 ± 4.60
SiO_2	mg/l	50.0	7.0	23.7 ± 6.60
Na	mg/l	11.0	2.0	5.1 ± 1.82
K	mg/l	4.8	0.2	1.2 ± 0.81
Ca	mg/l	31.8	7.4	19.6 ± 4.49
Mg	mg/l	6.7	1.5	4.1 ± 0.86
$CaCO_3$	mg/l	89.6	21.2	65.5 ±12.58

Table 13－6 Results of Water Quality Measurement(2)

Station 1 (Santa Maria) 1990.10~1991.9													
Item	Unit	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Temperature	℃	17.9	18.5	19.3	17.8	14.4	21.7	19.6	16.7				
pH	－	7.37	7.22	8.02	7.1	7.7	8.0	7.77	7.72				
Conductivity	μs/cm	78.0	104.1	103.8	117.3	125.0	134.9	145.5	127.7				
Dissolved Oxygen	mg/l	6.8	7.0	7.4	5.7	8.6	8.1	8.3	7.3				
Alkalinity	mg$CaCO_3$/l	－	76.73	80.36	85.0	91.3	83.9	98.0	94.12				
Sedimentation Volume	ml/l	35	0.0	ND	ND	ND	0.0	ND	ND				
Dissolved Solid	mg/l	111.0	88.0	88.0	94.0	112.0	125.0	99.0	68.0				
Hardness	mg$CaCO_3$/l	32.6	37.6	40.85	47.8	50.8	52.7	59.5	54.5				
Ca	mg/l	14.68	8.6	8.4	9.8	15.9	15.4	16.1	15.43				
Mg	mg/l	7.4	2.8	2.7	3.15	4.1	4.1	4.5	3.46				
SiO_2	mg/l	78.86	20.0	25.0	19.4	18.4	21.3	18.4	17.74				
Cl	mg/l	5.04	4.3	3.7	4.35	2.5	7.6	19.6	14.7				
NO_3	mg/l	3.0	2.3	<2	2.0	0.6	－	－	－				
Fe	mg/l	26.5	0.5	ND	0.10	0.8	0.7	0.2	1.01				
PO_4	mg/l	－	8.28	6.4	5.04	3.2	2.5	1.9	2.78				
SO_4	mg/l	－	－	－	14.0	－	－	－	－				
BOD_5	mg O_2/l	44.0	20.0	－	12.0	44.0	12.0	60.0	25.0				
COD	mg O_2/l	－	－	－	64.7	－	－	249.9	61.20				

Station 2 (Tarazzu) 1990.10~1991.9													
Item	Unit	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Temperature	℃	19.4	19.4	20.4	19.6	15.0	22.7	21.8	18.4				
pH	－	6.74	7.14	7.87	6.2	7.4	7.4	7.39	7.6				
Conductivity	μs/cm	85.8	101.5	101.1	132.4	130.0	132.7	139.3	125.3				
Dissolved Oxygen	mg/l	6.2	7.1	6.2	4.8	8.2	6.8	7.4	8.6				
Alkalinity	mg$CaCO_3$/l	－	72.58	85.55	93.0	97.0	83.9	86.0	101.3				
Sedimentation Volume	ml/l	0.9	0.0	ND	5.0	2.5	0.05	ND	ND				
Dissolved Solid	mg/l	297.0	89.0	87.0	157.0	105.0	84.0	99.0	85.0				
Hardness	mg$CaCO_3$/l	30.1	37.6	38.0	47.3	49.8	49.8	57.0	59.5				
Ca	mg/l	8.27	8.3	8.40	10.7	15.8	14.7	15.0	15.33				
Mg	mg/l	3.5	2.6	2.6	3.14	4.0	49.8	4.2	3.29				
SiO_2	mg/l	80.14	21.9	26.0	21.7	21.1	22.4	18.4	19.16				
Cl	mg/l	7.6	5.5	3.7	6.96	5.0	8.8	14.7	14.7				
NO_3	mg/l	4.8	2.5	<2	2.0	0.1	－	－	－				
Fe	mg/l	7.94	0.5	ND	0.10	0.5	0.8	0.6	1.22				
PO_4	mg/l	－	11.44	8.2	9.0	5.3	2.5	3.9	2.71				
SO_4	mg/l	－	－	－	14.6	－	－	－	－				
BOD_5	mg O_2/l	84.0	2.0	－	76.0	55.0	14.0	42.0	19.0				
COD	mg O_2/l	－	－	－	56.7	－	－	459.1	84.26				

Station 3 (San Pablo) 1990.10~1991.9												
Item	Unit	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Temperature	℃	19.3	19.3	20.3	19.3	14.8	19.8	20.1	19.2				
pH	–	6.21	6.16	7.28	6.4	5.8	7.1	7.2	6.73				
Conductivity	μs/cm	49.7	57.3	7.87	81.4	97.0	85.6	86.0	75.5				
Dissolved Oxygen	mg/l	6.0	8.4	5.8	5.0	9.7	6.4	7.6	8.7				
Alkalinity	mg$CaCO_3$/l	19.7	22.81	31.6	31.0	47.1	34.8	39.0	24.8				
Sedimentation Volume	ml/l	0.05	0.0	ND	3.5	0.3	0.1	ND	0.3				
Dissolved Solid	mg/l	56.0	50.0	58.0	130.0	183.0	86.0	56.0	63.0				
Hardness	mg$CaCO_3$/l	12.5	17.5	19.9	26.6	25.9	25.9	29.7	29.7				
Ca	mg/l	2.86	3.4	3.6	5.7	9.4	7.9	8.2	8.0				
Mg	mg/l	0.9	0.9	0.97	1.27	1.6	1.5	1.5	1.10				
SiO_2	mg/l	17.66	13.5	17.1	15.0	14.7	13.4	12.5	11.7				
Cl	mg/l	10.1	5.3	7.4	7.83	10.1	11.4	17.2	14.7				
NO_3	mg/l	5.0	2.8	<2	2.0	0.7	–	–	–				
Fe	mg/l	0.5	0.3	ND	0.8	4.3	1.5	0.7	1.42				
PO_4	mg/l	–	7.28	4.8	13.95	15.7	4.7	1.5	1.54				
SO_4	mg/l	–	–	–	11.8	–	–	–	–				
BOD_5	mg O_2/l	60.0	12.0	–	78.0	160.0	37.0	78.0	17.0				
COD	mg O_2/l	–	–	–	27.9	–	–	287.6	110.41				

Station 4 (San Rafael) 1990.10 ~1991.9												
Item	Unit	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Temperature	℃	19.3	17.3	21.7	19.3	21.2	23.4	22.2	19.3				
pH	–	8.06	7.90	7.89	7.8	8.2	8.2	8.38	8.22				
Conductivity	μs/cm	167.2	182.3	110.8	178.0	227.0	254.0	235.0	197.5				
Dissolved Oxygen	mg/l	5.5	7.1	6.3	5.3	7.6	7.3	8.2	9.9				
Alkalinity	mg$CaCO_3$/l	159.7	167.28	184.0	206.0	223.1	235.3	247.0	194.4				
Sedimentation Volume	ml/l	0.05	0.0	ND	3.0	0.5	0.1	ND	0.1				
Dissolved Solid	mg/l	139.0	131.0	106.0	167.0	166.0	215.0	145.0	126.0				
Hardness	mg$CaCO_3$/l	82.7	85.2	87.4	99.6	103.5	115.0	113.9	109.0				
Ca	mg/l	17.4	19.8	23.3	26.2	39.3	42.5	33.3	32.05				
Mg	mg/l	2.6	2.4	2.8	3.04	3.9	3.8	3.8	3.08				
SiO_2	mg/l	26.64	20.3	28.0	25.2	22.2	23.6	20.7	20.38				
Cl	mg/l	7.6	5.0	5.6	5.22	5.0	11.4	14.7	14.7				
NO_3	mg/l	3.0	2.7	<2	2.0	–	–	–	–				
Fe	mg/l	1.62	0.2	ND	0.14	0.5	2.2	0.2	1.16				
PO_4	mg/l	–	9.78	8.2	8.9	6.2	9.4	1.7	2.78				
SO_4	mg/l	–	–	–	4.9	–	–	–	–				
BOD_5	mg O_2/l	68.0	8.0	–	30.0	59.0	69.0	40.0	15.0				
COD	mg O_2/l	–	–	–	43.5	–	–	284.7	98.80				

Station 5 (Presa) 1990.10~1991.9													
Item	Unit	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Temperature	℃	20.0	17.7	19.1	18.8	20.0	21.6	22.9	19.7				
pH	-	7.38	7.43	7.57	7.60	7.80	8.0	8.68	7.73				
Conductivity	μs/cm	106.8	106.4	106.8	134.1	150.0	161.0	169.8	134.0				
Dissolved Oxygen	mg/l	7.7	8.1	5.8	5.9	8.0	7.8	7.7	8.9				
Alkalinity	mgCaCO₃/l	75.7	93.32	90.73	147.0	126.9	128.9	123.0	111.4				
Sedimentation Volume	ml/l	0.1	0.0	ND	1.0	, 1.2	0.2	ND	0.2				
Dissolved Solid	mg/l	140.0	102.0	105.0	12.8	113.0	113.0	108.0	113.0				
Hardness	mgCaCO₃/l	40.1	47.6	45.6	55.7	60.3	63.2	69.3	59.5				
Ca	mg/l	8.62	10.5	10.4	12.8	20.0	20.4	20.4	17.0				
Mg	mg/l	2.5	2.5	2.5	2.97	3.8	3.7	4.0	2.76				
SiO_2	mg/l	26.9	21.4	26.3	26.1	20.7	23.1	17.7	18.17				
Cl	mg/l	10.1	6.1	3.7	6.1	7.6	8.8	14.7	14.7				
NO_2	mg/l	4.6	3.4	<2	2.0	2.3	-	-	-				
Fe	mg/l	1.62	0.4	ND	0.14	1.7	1.0	0.7	2.63				
PO_4	mg/l	-	10.69	7.8	9.10	5.3	2.9	1.7	2.71				
SO_4	mg/l	-	-	-	6.10	-	-	-	-				
BOD_5	mg O_2/l	84.0	2.0	-	34.0	62.0	26.0	32.0	29.0				
COD	mg O_2/l	-	-	-	29.2	-	-	328.3	104.60				

Table 13－7 Results of Water Quality Measurement(3)

(1975～1984, MPL/100ml)

		Total Coliform	Fecal Coliform
COPEY DE DOTA	MAX.	24,000	24,000
	MIN.	13	13
	AVE.	2,703± 3,690.1	1,214± 2,574.4
SANTA MARIA	MAX.	240,000	110,000
	MIN.	95	33
	AVE.	30,554±62,090.4	15,402±27,364.5

13.3.10 Noise

There is no artificial noise source near the planned area.

13.3.11 Vibration

There is no artificial vibration source near the planned area.

13.3.12 Local Communities

(1) Situation of Costa Rica and its Neighbor Countries

Costa Rica is a politically-stable country compared with its neighbor countries which have had civil wars and vehement power changes, and it is well-known for the spread of education. And, the planting of coffee trees regarded as a representative exporting cash crop has recently increased, reflecting an economic policy to obtain foreign money while beef cattle have rapidly increased to export meat mainly to the United States. As a result of that, forests which used to cover 90% of the entire national land only account for about 30% of the entire land, remaining on the eastern and western coasts at present. It is characteristic of the land possession structure that only just over 200 owners manage those pastures in Costa Rica.

(2) Measures for Natural Conservation and Environmental Protection

Costa Rica is a world-wide prominent country which has a lot of types of animals and plants and has recorded 785 types of birds exceeding the number of them in North America as well as more than 8,000 types of plants including at least 1,000 types of orchids. The existence of these animals and plants has been put in danger as the few remaining forests have been further decreased by deforestation through burned-over fields in historical agriculture, firewood collection and pastures' expansion. In Guanacaste Prefecture, etc., known as leading livestock-farming land, typical disasters such as drought caused by insufficient rainfall and

floods caused by excessive rainfall have increased due to the destruction of forests. Therefore, the Government of this country has started conducting a campaign to promote the conservation of tropical forests and the planting of trees.

(3) Locations of the Project Sites

The dam project site belongs in San Carlos Section, Terrazu District, San Jose Prefecture and is located at an altitude of 1,090 m about 30 km south of San Jose City, the capital of this country. The power station project site is located at an altitude of 325 m about 10 km west of the dam project site. The river basin upstream from the dam project site is a gently-sloping area, which chiefly has coffee plantations and pastures and is also developed as communities, but the section from the dam project site to the power station project site is a steep-sloping area where houses are scarcely seen. In the vicinity of Parrita River existing in the lower reaches of Pirris River, irrigation agriculture is carried out and palm trees are cultivated on a large scale for collecting fats and oils for industrial use.

(4) Population

Most people in Costa Rica live in the central highlands (equivalent to 6% of the national land) where San Jose, the capital of this country is located. Native people (Indigenous) had lived in this county before Spanish people settled there, and their population is said to have been 27,000. They remarkably decreased to a present population of only 1,000 since diseases were brought from Europe and they became mixed with Spanish blood. Therefore, twelve reservations for native people have been established. The population of white people has continuously increased up to two times since their first settlement two centuries ago. Although the population growth rate has recently started decreasing, it has exceeded 3% in the latter half of the 20th century. As of 1990, the population of Costa Rica stands at about 3 million. According to the results of the national census taken in 1984, the population in the vicinity of the power station project site is as shown in Table 13-8. The following towns are shown in order of population

size. San Marcos - 5,381 people, Santa Maria - 3,324 people, Sabanillas - 3,006 people. The following ones are also shown in order of population density. San Marcos - 127.6 people/km^2, San Pablo - 81.9 people/km^2, San Isidro - 60.9 people/km^2. The population structure of San Marcos is as follows: less than 20 years of age - 50%, 20 to 50 years of age - 39%, more than 50 years of age - 11%. According to the population growth rate from 1974 to 1984, the rate has a tendency to increase, standing at 16.6% in San Marcos and 12.9% in Santa Maria. They have an average of about 5 members per family. Table 13-8 Population (District in the Pirris River Basin).

Table 13-8 Population (District in the Pirris River Basin)

Province	Canton	District	Total			Urban			Rural		
			Total	Male	Female	Total	Male	Female	Total	Male	Female
San José	Tarrazú										
		San Marcos	5.381	2.728	2.653	980	488	492	4.401	2.240	2.161
		San Lorenzo	2.391	1.300	1.091	-	-	-	2.391	1.300	1.091
		San Carlos	1.073	554	519	-	-	-	1.073	554	519
	Aserrí										
		La Legua	1.446	748	698	-	-	-	1.446	748	698
	Acosta										
		Cangurejal	1.924	1.020	904	-	-	-	1.924	1.020	904
		Sabanillas	3.006	1.639	1.367	-	-	-	3.006	1.639	1.367
	Dota										
		Santa María	3.324	1.684	1.640	862	445	417	2.462	1.239	1.223
		Jardín	368	195	173	-	-	-	368	195	173
		Copey	1.242	663	579	-	-	-	1.242	663	579
	León Cortés										
		San Pablo	2.532	1.311	1.221	845	423	422	1.687	888	799
		Llano Bonito	1.497	770	727	-	-	-	1.497	770	727
		San Isidro	1.138	597	541	-	-	-	1.138	597	541
Puntarenas	Parrita										
		Parrita	9.774	5.157	4.617	1.965	971	994	7.809	4.186	3.623

(P.H.Pirris. Banco de datos ambientales Cuadro 2 ICE 1990)

(5) Industries

Main industries in the vicinity of the power station project site consist of livestock-farming and coffee cultivation. In livestock-farming, cattle and pigs are mainly raised. About 16,000 cattle are raised by 1,400 farming families, and the number of both groups accounts for about 6% and about 14% of the total number of those in San Jose Prefecture respectively. The number of cattle raised by a farming family is about 10 to 20, and there are few families who raise 50 cattle except Dota. In the case of cattle-breeding areas, about 50% of the cattle in number are raised in Dota (Table 13-9).

Table 13-9 Livestock Number

Name of Area		Cattle	Pig
Tarrazu: 523 operations 4,594 head	San Marcos San Lorenzo San Carlos	1,401 2,155 1,038	370 467 304
Leon Cortes: 429 operations 3,397 head	San Pablo San Andres Llano Bonito San Isidro Santa Cruz	790 327 1,140 708 432	179 216 418 215 203
Dota: 414 operations 7,493 head	Santa Maria Jardin Copey	3,612 1,246 2,635	629 19 13
Total		15,484	3,033

Agricultural and livestock census, 1984 Costa Rica

The main farm product is coffee, and in addition to this, sugar cane, frijol beans, onions, bananas, etc., are seen. The families of Arabic, Catoura and Catoay coffee are cultivated by using Musesas (one family of plantains), and Bucare trees as sunshades. Coffee beans are directly purchased by cooperative association(s) and shipped after being processed by their own refinery processing factories. Five refinery processing factories upstream from the dam project site are operated. The locations and outline of those factories are shown in Fig.13-18 and Table 13-10 respectively. As for people engaged in each industry, the number of people engaged in the primary industries such as agriculture, etc., accounts for more than 90% of the entire labor population (Table 13- 11).

Table 13-10 Coffee Factories

Name of Factory	Average Process Volume (ton/yr)	Working Period
Leon Cortes ① Coope Llano Bonito ② Coope Leco	3,380 22,100	Oct-Mar Nov-Feb
San Marcos: ③ La Meseta ④ Coope Tarrazu	13,000 16,900	Nov-Feb Dec-Mar
Santa Maria: ⑤ Coope Dota	6,500	Nov-Mar
Total	61,880	

Table 13-11 Employed persons by Industry Group

Province	Canton	District	Total	Agriculture, hunting, forestry	Mining	Manufacturing	Electricity, gas, water	Construction	Sale, hotel	Transport, warehousing, communication	Finance, insurance, real estate	Service	Establishment not adequately described
San José	Tarrazú												
		San Marcos	1,841	1,048	1	116	15	88	168	13	28	293	71
		San Lorenzo	884	758	-	16	2	22	25	1	-	49	11
		San Carlos	324	306	-	-	-	4	3	1	-	9	1
	Aserrí												
		La Legua	367	325	-	2	-	3	6	2	-	21	8
	Acosta												
		Cangurejal	613	554	-	7	-	5	6	-	-	15	26
		Sabanillas	997	948	-	-	-	8	7	1	1	22	10
	Dota												
		Santa María	1,113	703	-	30	3	43	53	2	16	243	20
		Jardín	131	117	-	-	1	3	4	-	-	3	3
		Copey	454	399	-	3	6	3	11	7	1	22	2
	León Cortés												
		San Pablo	865	571	-	21	-	58	48	9	4	135	19
		Llano Bonito	475	442	-	2	-	-	5	1	-	22	3
		San Isidro	418	382	-	6	-	2	4	-	-	16	8
Puntarenas	Parrita												
		Parrita	2,971	1,986	-	165	15	132	220	13	12	269	159

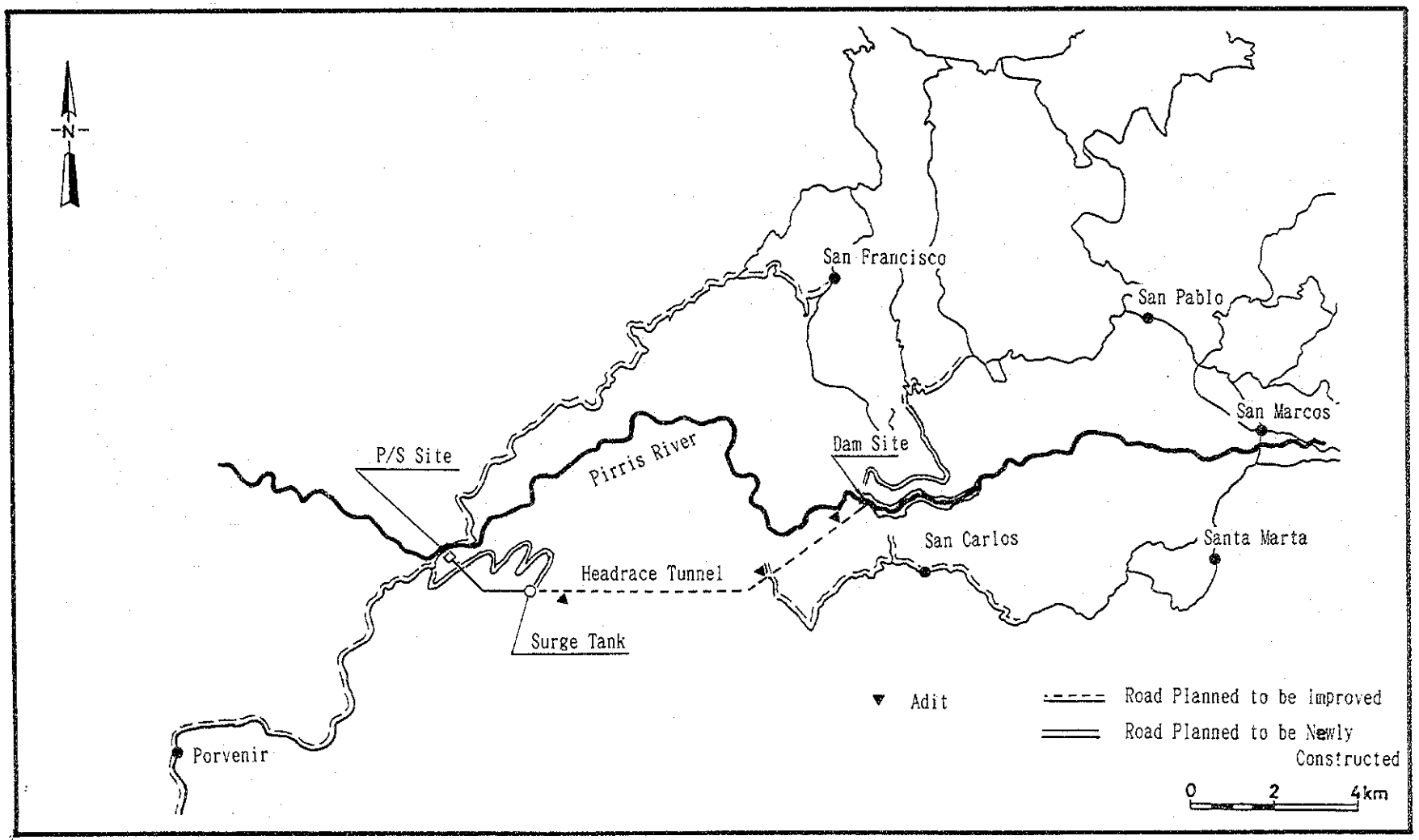
(P.H.Pirris. Banco de datos ambientales Cuadro 7 ICE 1990)

13.3.13 Transportation and Public Facilities

(1) Transportation

There are only buses and taxis as public transportation systems in the vicinity of the project sites. There is bus service from San Jose, the capital of the country to San Pablo, San Marcos, Santa Maria, Copey and San Carlos which are upstream from the dam by using National Road No. 222. There is also bus service from San Jose to Parrita, a town located at the mouth of Pirris River by way of Caldera, a port town. The road(s) from San Jose to the vicinity of San Marcos are paved, but not paved in the area upstream from Santa Maria and in the area downstream from San Marcos. The road leading to the power station site from San Marcos by way of the dam site is so narrow and steep all the way that only small-sized four-wheel motor vehicles can go through. It becomes impossible to go through this road at many points after the rainy season starts. The condition of the road is considerably bad, and it happens to become impossible to go through this road even in the dry season when a landslide takes place. Retaining walls, gutters and gradient surface protection are not seen at all along the road. The condition of the road from Parrita, a town located at the mouth of the river to the power station site is the same as the above-mentioned conditions. There is a suspension bridge over Pirris River in the section planned to be submerged between San Carlos and San Isidro. There is also a concrete siphon culvert at the power station site, but it is possible to go through the culvert only in the dry season. It is necessary to construct new roads and improve existing ones for the construction and operation of the power station. The road from Parrita to the power station site will be widened, its roadbed will be strengthened and the protection of gradient surfaces along the road will be improved to transport equipment and materials such as generators, etc. A part of the road from San Pablo to the dam site will be improved or newly constructed to build the dam. Similarly, the road from Santa Marta to the conduit tunnel site will be improved while the road from the power station site to the other side of the tunnel site will be newly constructed to excavate the tunnel (Fig.13-17).

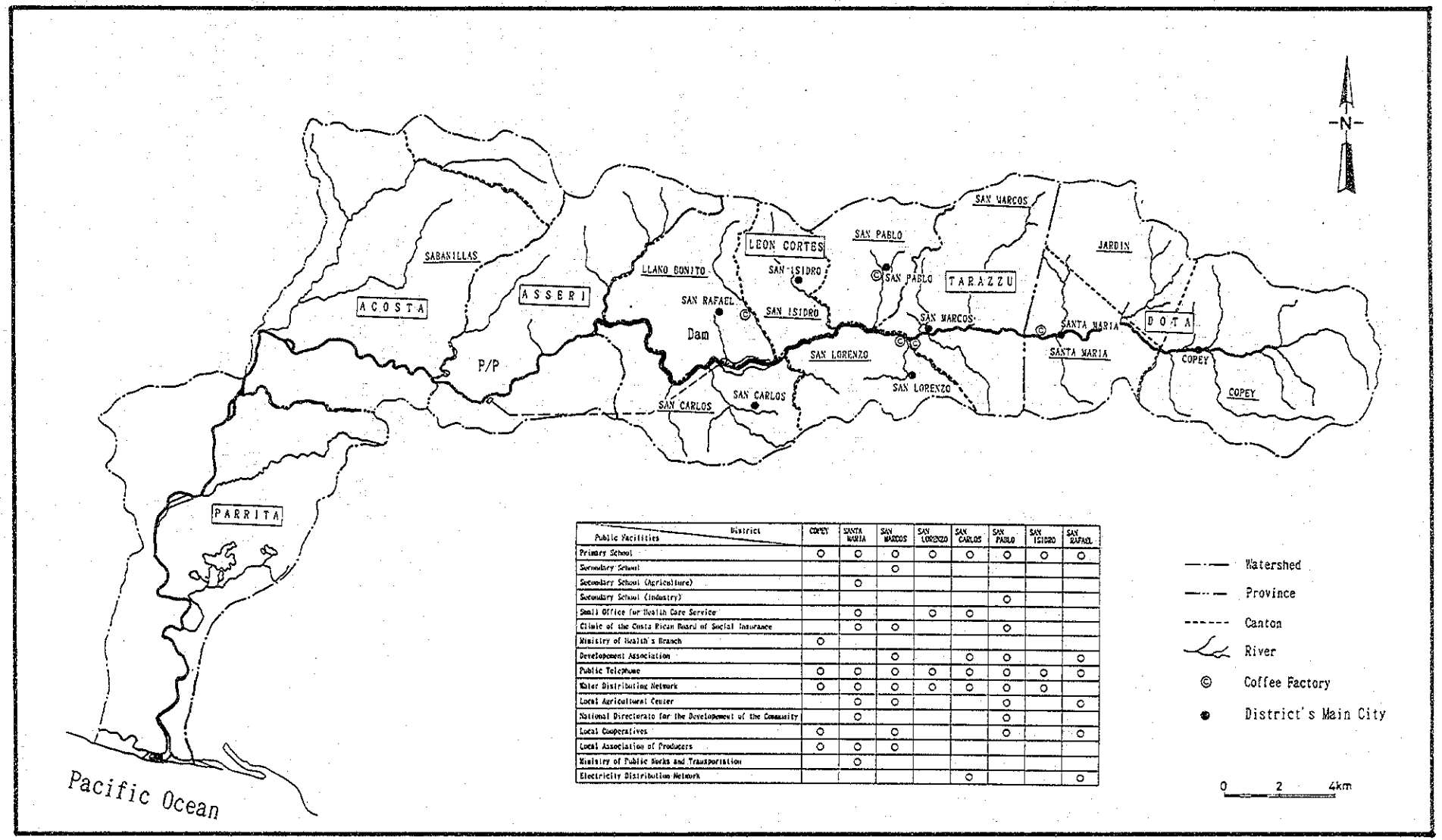
Fig. 13-17 Traffic Route Map



(2) Public Facilities

The locations of public facilities in the vicinity of the project sites are as shown in Fig.13-18.

Fig. 13-18 Location of Public Facilities and Administration District Map



Public Facilities \ District	COPEY	SANTA MARIA	SAN MARCOS	SAN LORENZO	SAN CARLOS	SAN PABLO	SAN ISIDRO	SAN RAFAEL
Primary School	○	○	○	○	○	○	○	○
Secondary School			○					
Secondary School (Agriculture)		○						
Secondary School (Industry)						○		
Small Office for Health Care Service		○		○	○			
Clinic of the Costa Rican Board of Social Insurance		○	○			○		
Ministry of Health's Branch	○							
Development Association			○		○	○		○
Public Telephone	○	○	○	○	○	○	○	○
Water Distributing Network	○	○	○	○	○	○	○	
Local Agricultural Center		○	○			○		○
National Directorate for the Development of the Community		○				○		
Local Cooperatives	○		○			○		○
Local Association of Producers	○	○	○					
Ministry of Public Works and Transportation		○						
Electricity Distribution Network					○			○

13.3.14 Land Utilization

Since agriculture and livestock-farming are main industries in the Pirris River basin, the situation of land utilization differs a lot depending on the gradients of land, the conditions of soil (thickness, sensitivity to erosion, fertility, pudding stones mixing in soil, draining, erosional conditions) and meteorological phenomena (rainfall, the number of dry seasons, temperature, etc.). As for forests, only Los Santos Forest Reserve remains naturally while forests in other areas are continuously cut down. Only few natural forests remain along the river and its tributaries and near mountain tops. Fig. 13-19 is a LANDSAT (land satellite) photograph taken in February, 1986. When the color of red becomes deeper, the activity index of vegetation is higher. The color of blue shows the state of areas with almost no trees, such as urban communities. A part of San Jose, the capital of Costa Rica is seen on the screen. On the lower part of the screen is the mouth of Pirris (Parrita) River. The activity index of vegetation in the entire Pirris River basin is low, and it can be said to be a developed area. In the middle part of the screen on the right side is the water source of Pirris River. The area is a forest reserve, and the color of red is deep, indicating the activity index of vegetation is high. The three towns of Copey, Santa Maria and San Marcos shown in blue are in a row toward the lower reaches of Pirris River. Many pastures on the northern side of Copey are shown in light red. Coffee plantations distributed from Copey to the dam site are shown as areas which are in red slightly lighter than forests and a little deeper than pastures. The area from San Marcos to the power station site is shown in light red and consists of pastures and devastated land. The right bank is more devastated than the left bank in this area. The area expanding from the power station site to the confluence of Pirris River and Candelaria River has a relatively-high activity index of vegetation. It can be seen that African palm trees are cultivated by irrigation on a large scale in the alluvial plain around the mouth of Pirris River. Fig.13-20 and Table 13-12 show the situation of land utilization in the Pirris River basin, which is described in the Parrita (Pirris) River Basin Development Project carried out by the Ministry of Agriculture, Forestry and Pasturage. In Copey, the development of orchards such as apples, oranges, etc., as well as the cultivation of rainbow trouts have recently been under way.

13.3.15 River System Utilization

The situation of water utilization in Pirris River and its tributaries is shown in Fig. 13-21. There are no irrigation facilities in the section from the reservoir site over Pirris River to the power station site. Coffee processing factories use water mostly from Pirris River in the area upstream from the reservoir site. There are irrigation facilities near the mouth of Pirris River downstream from the power station site. There is no fishery, and no fishery right has been determined either.

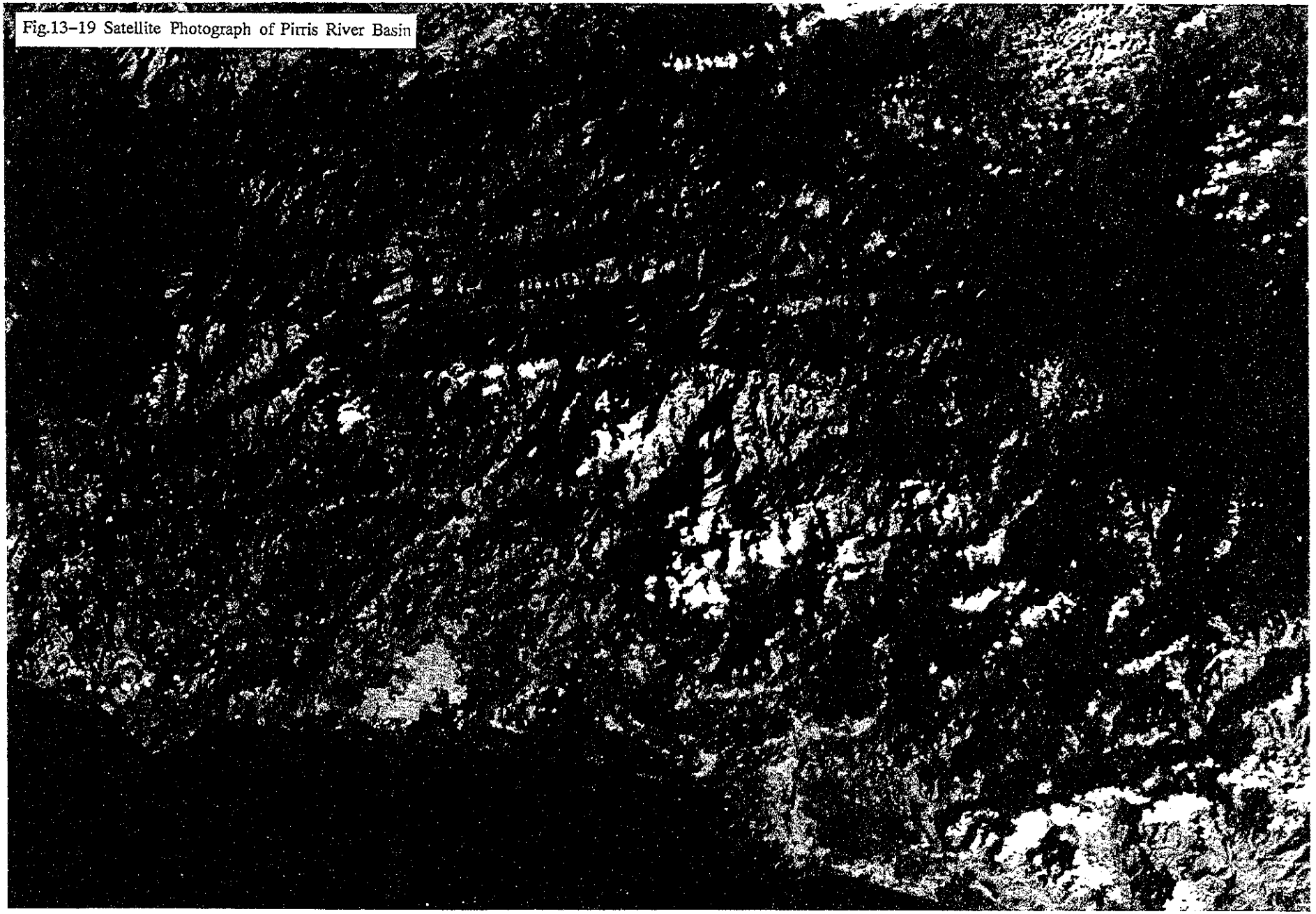
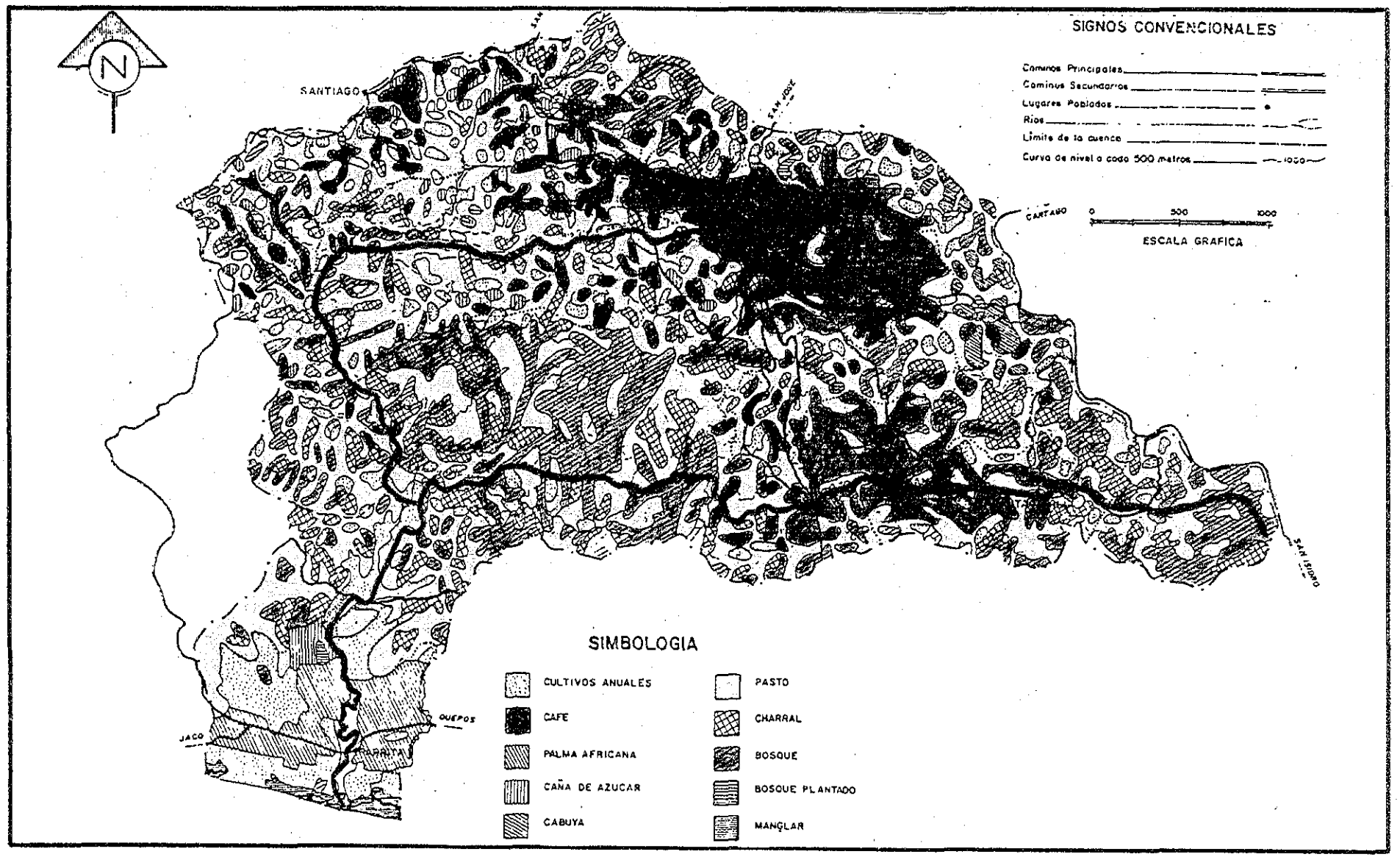


Fig.13-19 Satellite Photograph of Pirris River Basin

This is a photograph which was purchased from EOSAT company (located in Lanham, Maryland) in the United States.

Fig. 13-20 Land Utilization



Source: Plan de manejo de la cuenca del Rio Parrita
Ministrio de Agricultura y Ganaderia 1985.5

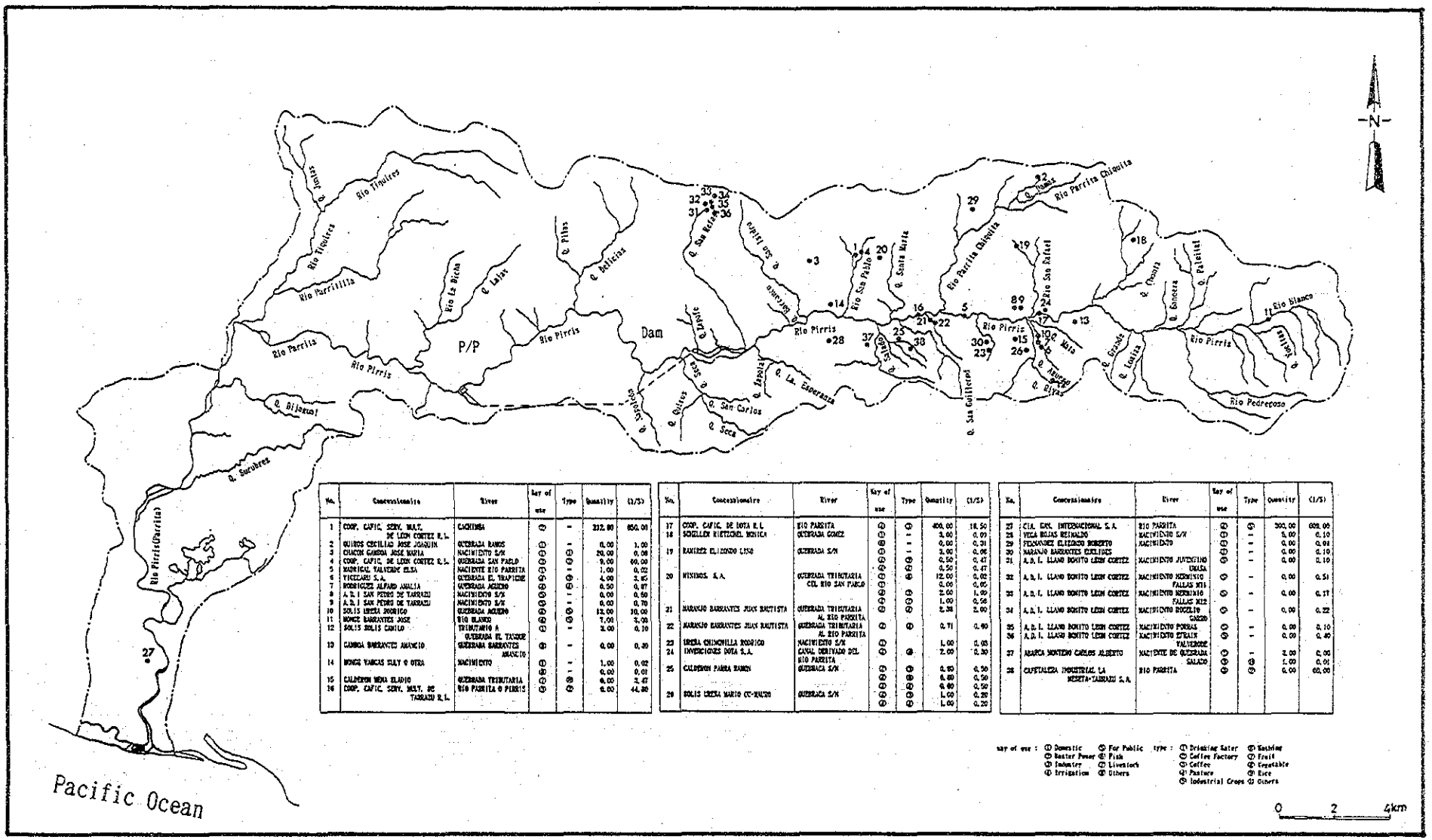
Table 13-12 Land Utilization in Pirris River Basin

Administrative Sectors			Annual Crops	Permanent Crops			Pastures		Forest	Planted Forest	Urban Area
				Coffee	Sugar Cane	Others					
Copey ①	ha	6,147	163	***	***	***	2,583	657	2,698	39	7
	%	100	2.7	0	0	0	42.0	10.7	43.9	0.6	0.1
San Marcos ②	ha	7,858	258	3,697	***	***	2,806	214	775	8	100
	%	100	3.2	47.1	0	0	35.7	2.7	9.9	0.1	1.3
Chonta ③	ha	8,675	197	492	38	***	3,959	1,408	2,550	31	***
	%	100	2.3	5.7	0.4	0	45.6	16.2	29.4	0.4	0
San Carlos I ④	ha	5,577	261	1,141	11	***	3,188	427	549	***	***
	%	100	4.7	20.5	0.2	0	57.1	7.7	9.8	0	0
San Carlos II ⑤	ha	1,563	27	570	33	***	749	27	157	***	***
	%	100	1.7	36.4	2.1	0	48.1	1.8	10.0	0	0
Tiquires ⑥	ha	22,082	510	201	***	***	8,656	3,014	9,691	10	***
	%	100	2.3	0	0.9	0	39.2	13.6	43.9	0.1	0
Bijagual I ⑦	ha	7,030	1,326	***	5	***	3,723	912	1,047	17	***
	%	100	18.4	0	0.1	0	53.0	13.0	14.9	0.2	0
Parrita ⑧	ha	10,460	3,842	***	550	3,644	305	***	1,112	56	124
	%	100	37.0	0	5.2	34.8	2.9	0	10.6	0.5	1.1

* See Fig. 13-8 about Administrative Sectors

Source: Plan de manejo de la cuenca del Rio Parrita
Ministerio de Agricultura y Ganaderia Direccion General Forestal
Conservacion de Recursos Naturales 1985.5

Fig. 13-21 Water System Utilization (Pirris River Basin)



No.	Concessionaire	River	Use of use	Type	Quantity	(l/S)
1	COOP. CAFIC. SERV. MULT. DE LEON CORTEZ R.L.	CACHIMBA	⑦	-	212.80	850.00
2	QUIROS CECILIA JOSE JOAQUIN	QUEBRADA RAMOS	①	-	0.00	1.00
3	CHACON CAMPOS JOSE MARIA	NACIMIENTO S/N	①	-	20.00	0.06
4	COOP. CAFIC. DE LEON CORTEZ R.L.	QUEBRADA SAN PABLO	⑦	-	0.00	60.00
5	MADRIGAL VALVERDE ELSA	NACIENTE RIO PARRITA	①	-	1.00	0.02
6	VICCARI S.A.	QUEBRADA EL TRAPICHE	⑦	-	4.00	3.85
7	RODRIGUEZ ALFARO AMALIA	QUEBRADA AGUERO	①	-	0.50	0.87
8	A.D.I SAN PEDRO DE TARRAZU	NACIMIENTO S/N	①	-	0.00	0.50
9	A.D.I SAN PEDRO DE TARRAZU	NACIMIENTO S/N	①	-	0.00	0.70
10	SOLIS UREÑA RODRIGO	QUEBRADA AGUERO	①	-	12.00	10.00
11	MONGE BARRANTES JOSE	RIO BLANCO	①	-	7.00	3.00
12	SOLIS SOLIS CAMILO	TRIBUTARIO A QUEBRADA EL TAJUDE	①	-	3.00	0.10
13	CAMBRA BARRANTES AMANCIO	QUEBRADA BARRANTES AMANCIO	⑧	-	0.00	0.30
14	MONGE VARGAS SULY Y OTRA	NACIMIENTO	①②	-	1.00	0.02
15	CALDERON MENA ELADIO	QUEBRADA TRIBUTARIA	⑧	-	0.00	0.01
16	COOP. CAFIC. SERV. MULT. DE TARRAZU R.L.	Río PARRITA Y PIRRIS	⑧	-	0.00	2.45
					0.00	44.80

No.	Concessionaire	River	Use of use	Type	Quantity	(l/S)
17	COOP. CAFIC. DE DOTA R.L	RIO PARRITA	⑦	-	400.00	18.50
18	SCHELLER RIETZCHEL MONICA	QUEBRADA GOMEZ	①②③④⑤⑥⑦⑧	-	3.00	0.09
19	RAMIREZ ELIZONDO LUIS	QUEBRADA S/N	①②③④⑤⑥⑦⑧	-	0.00	0.31
					3.00	0.06
20	MINEROS, S.A.	QUEBRADA TRIBUTARIA DEL RIO SAN PABLO	①②③④⑤⑥⑦⑧	-	0.50	0.47
					0.50	0.47
					12.00	0.02
					0.00	0.00
21	NARANJO BARRANTES JUAN BAUTISTA	QUEBRADA TRIBUTARIA AL RIO PARRITA	①②③④⑤⑥⑦⑧	-	2.00	1.00
					1.00	0.56
					0.36	2.00
22	NARANJO BARRANTES JUAN BAUTISTA	QUEBRADA TRIBUTARIA AL RIO PARRITA	①	⑥	0.71	0.40
23	UREÑA CHAMORRO RODRIGO	NACIMIENTO S/N	①	-	1.00	0.05
24	INVERSIONES DOTA S.A.	CANAL DERIVADO DEL RIO PARRITA	①	⑥	2.00	0.30
25	CALDERON PARRA RAMON	QUEBRADA S/N	①②③④⑤⑥⑦⑧	-	0.50	0.50
					0.00	0.50
					0.00	0.50
26	SOLIS UREÑA MARIO (C-MAIZ)	QUEBRADA S/N	①②③④⑤⑥⑦⑧	-	1.00	0.20
					1.00	0.20

No.	Concessionaire	River	Use of use	Type	Quantity	(l/S)
27	CIA. ENV. INTERNACIONAL S.A.	RIO PARRITA	①②	⑤	300.00	600.00
28	VEGA ROJAS REINALDO	NACIMIENTO S/N	①②③④⑤⑥⑦⑧	-	5.00	0.10
29	FERNANDEZ ELIZONDO ROBERTO	NACIMIENTO	①②③④⑤⑥⑦⑧	-	0.00	0.04
30	NARANJO BARRANTES GUILLERMO		①②③④⑤⑥⑦⑧	-	0.00	0.10
31	A.D.I. LLANO BONITO LEON CORTEZ	NACIMIENTO JUVENTINO UMAÑA	①②③④⑤⑥⑦⑧	-	0.00	0.10
32	A.D.I. LLANO BONITO LEON CORTEZ	NACIMIENTO HERMINIO FALLAS MIR	①	-	0.00	0.51
33	A.D.I. LLANO BONITO LEON CORTEZ	NACIMIENTO HERMINIO FALLAS MIR	①	-	0.00	0.17
34	A.D.I. LLANO BONITO LEON CORTEZ	NACIMIENTO ROGELIO GARRO	①	-	0.00	0.22
35	A.D.I. LLANO BONITO LEON CORTEZ	NACIMIENTO PORRAS	①	-	0.00	0.10
36	A.D.I. LLANO BONITO LEON CORTEZ	NACIMIENTO EFRAIN VALVERDE	①	-	0.00	0.40
37	ARAYA MONTERO CARLOS ALBERTO	NACIENTE DE QUEBRADA SALADO	①	-	2.00	0.06
			⑦	-	1.00	0.01
38	CAPITALEJA INDUSTRIAL LA MESETA-TARRAZU S.A.	RIO PARRITA	⑦	⑤	0.00	60.00

use of use : ① Domestic ② For Public ③ Water Power ④ Fish ⑤ Industry ⑥ Livestock ⑦ Irrigation ⑧ Others

type : ① Drinking Water ② Coffee Factory ③ Coffee ④ Pasture ⑤ Rice ⑥ Industrial Crops ⑦ Washing ⑧ Fruit ⑨ Vegetable ⑩ Rice ⑪ Others

13.3.16 Public Health

The infant death rate of people younger than one year of age increased up to 25% early in this century, but has remarkably improved in recent years, reaching 17.7 persons per 1,000 persons at birth. The largest cause of the death of infants was diarrhea, but this has changed because of the improvement of hygiene and education. The main causes of their death have now been replaced with diseases of the respiratory organs. According to question-answer investigations on data at clinics, the diseases at higher frequency in the Parrita River basin are children's helimithiasis, diseases of the bronchia or the lungs, alcoholism, etc. A lot of patients of gastric cancer are seen, and their stress to live in remote and mountainous areas and their peculiar food are imagined to be related to this disease. The occurrence of diseases such as measles, tuberculoses, poliomyelitis, diphtheria, etc., has been controlled by the spread of protective inoculation. Malaria is sometimes brought from its neighbor countries, but all the patients of this disease have been completely cured previously inside Costa Rica.

13.3.17 Energy

The consumption and sources of energy in main cities of Costa Rica are shown in Table 13-13. Data collected in 1979 is slightly old, but these rates are expected to be almost the same as the present ones. As for energy sources, electricity only accounts for about 20% of the total amount of energy sources while firewood and oil account for about 40% and about 30% of the total amount respectively. As for energy consummation, firewood accounts for 75% of the total consumption for living use. Electricity is mostly used for living use such as residential, commercial and public facilities, etc. The contents of the total electric consumption in the entire county consist of 45% for living use, 33% for industrial use, 19% for commercial use and 3% for others.

13.3.18 Cultural Assets and Recreation

Investigations of archaeologically-and-historically-important cultural assets, which should be protected, are not being conducted now in the vicinity

of the power station project site. There are no recreational activities at all in Pirris River near the project site. There are also no sightseeing and recreational activities either in the vicinity of the project site.

Table 13-13 Energy Consumption and Sources for 1979.

SECTOR	TEP×10^3	%
Residential, Commercial		
and Public	555	100.0
Firewood	416	75.0
Electricity	89	16.0
Kerosene, etc.	20	3.6
Others	30	5.4
Transportation	463	100.0
Diesel & Gas Oil	286	61.8
Gasoline	154	33.3
Kerosene	22	4.8
Electricity	1	0.2
Industry & Agriculture	385	100.0
Animal & Vegetable Combo	136	35.3
Heavy Oils	124	32.2
Firewood	19	4.9
Others	106	27.5
Other Sectors	4	100.0
Electricity	4	100.0
Total	1,407	
SOURCE		
Petroleum Importation	404	32.8
Firewood Production	458	37.2
Hydroelectricity Production	229	18.6
Others/Animal & Vegetable	139	11.3
TOTAL	1,230	100.0
National Production	826	67.2

* Tons Equivalent of Petroleum, 1 TEP = 7 barrels of petroleum,
1 TEP = 10 ^{10} Calories.

Source: Costa Rica, Country Environmental Profile, A Field Study
United States Agency for International Development,
Tropical Science Center, 1982. 12

13.4 Measures for Environmental Conservation and Environmental Impact Assessment

After studying measures for reducing the impact of the establishment of the power station on the environment, the environmental impact was assessed based on the results of them. Secondary benefits expected to be produced by the results of the establishment of the power station or environmental measures were also mentioned.

13.4.1 Matters Following Completion of the Project

1) Natural Conservation

There are no forest reserves at all in the vicinity of the project site. If the expansion plan of Caraigures Forest Reserve which is located about 6 km north of the dam site is realized, this area will include a part of the power station and the pipe line. However, since Caraigres Forest Reserve was established to maintain water sources, it would not restrict the power station project. And, since the development size is small, the environmental impact will also be small. Since the transmission line is planned to run through the eastern part of Caraigres Forest Reserve for about 1 km, the deforestation of the route should be minimized and measures for preventing soil from flowing out should be taken.

2) Natural Scenery

The 100 m-long dam and the artificial reservoir planned to appear in the valley of Pirris River will considerably change a monotonous scene with pastures and thickets of assorted trees. A new aesthetic scene will be created by the integration of the lake into a panorama of neighbor mountains. The power station, the conduit and the transmission line are relatively-small structures and will have almost no impact on the neighbor scenery. A new scene to be created by the dam and the reservoir will have potential value as a sightseeing resource.

3) Topography

The surface of land will be altered by the establishment of the power station only on a small scale, and it will be altered mainly in coffee plantations and pastures. Since soil flows out severely from these places, the change of the surface of land and the space of excavation should be minimized, target places should be altered by excavating them at a slope of compensation and laying earth on the ground to prevent soil from flowing out.

4) Vegetation

Since the area to be submerged as the reservoir is used as pastures and cultivated land without any forests, the reservoir will have no impact on natural vegetation in its vicinity. It is desirable to cut down trees planned to be submerged, such as coffee trees, shrubs, etc., to prevent undesirable environmental impacts for the future, such as gate obstruction due to floating trees, water quality deterioration due to the decomposition of trees, scenic deterioration due to dead trees, etc. If floating plants such as water hyacinths once appear inside the reservoir, it is possible for them to increase rapidly since water in the reservoir contains a lot of nutrient salts. Therefore, floating plants should be removed as soon as they are found. Floating plants covering the surface of water in the reservoir are in danger of causing a lot of water to evaporate, and contaminating water after dying and becoming decayed at the bottom of the lake finally. If trees are planted around the reservoir at a certain distance from the edge of the water in the same way as Cati Reservoir, it is expected to prevent earth and sand from flowing into the reservoir, producing a good result from the viewpoint of scenery. Roads will be improved or newly constructed to excavate the conduit tunnel. Since the area from the power station site to the surge tank has secondary forests and much remaining natural vegetation, the deforestation of the area should be minimized and afforestation construction work should be conducted to promote the recovery of nature. It is necessary to monitor and restrict the deforestation of this area more strictly since trees in its vicinity may be cut down without any order after roads are improved

together with the electric power development project. The river flow rate in the section with a length of about 15 km from the dam to the power station toward the lower reaches of the river will decrease compared with before. Since this section is a steep valley and vegetation in the vicinity of the river is imagined to be largely dependent on rainfall and underground water, the change of the river flow rate is expected to have less impact on vegetation in the vicinity of the river.

5) Animals

Since there are no big forests in the vicinity of the project site, the phase of animals is also poor. The section with an area of 1.10 km^2 along Pirris River is planned to be submerged by the construction of the reservoir, but no forests are included in this section. The reservoir will provide the waterside while destroying a part of the habitable foundation for land animals. The bank of the lake can be a new living environment, but is expected to have no big impact on the living conditions of animals by giving consideration to the gradient of the slope and the size of water-level changes. Animal trails are not in danger of being blocked off since the reservoir is expected to be relatively small having an area of 1.10 km^2, the conduit is planned to be constructed completely under the ground and almost no trees under the transmission line are required to be cut down.

6) Aquatic Organisms

As for aquatic animals, both habitable types and individuals in Pirris River are small in number according to site and question-answer investigations. It is difficult for aquatic organisms to live in the river since its water is very contaminated. Since the reservoir is generally a still-water area, the number of aquatic organisms indigenous to torrents is expected to decrease while the number of aquatic organisms suitable for still-water areas is increasing. However, it is inevitable for water quality and bottom sediment to deteriorate due to pollutant matter flowing into the reservoir from the upper reaches of the river. It is almost impossible to improve the

living conditions of aquatic organisms unless some measures for improving water quality are taken in the catchment area upstream from the reservoir. On the contrary, water quality in the section from the dam to the power station is expected to improve since the reservoir will prevent pollutant matter from flowing into this section. But it seems hardly possible for aquatic organisms to increase remarkably since the river flow rate is expected to decrease. It is quite possible for aquatic organisms to increase in the area downstream from the power station since a certain river flow rate is maintained all the year around and the amount of pollutant matter flowing into the river will decrease.

7) Water Quality

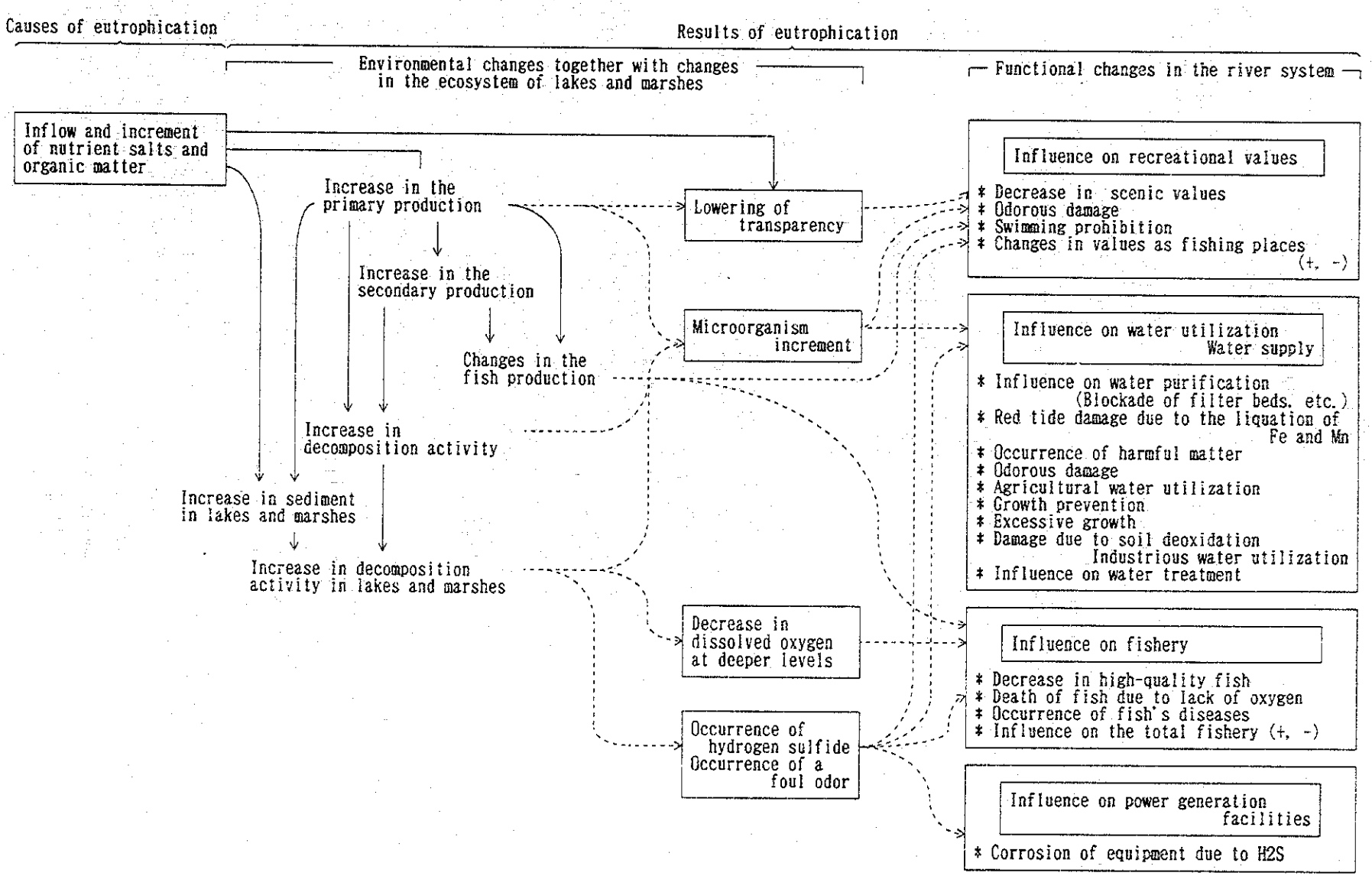
<1> Present Situation

Water in Pirris River at the project site is contaminated by organic matter discharged from coffee factories, and water quality is so bad that it emits a foul odor. Fertilizer and livestock manure, which are discharged respectively from coffee plantations and pastures upstream from the project site, have become the cause of further water contamination. BOD regarded as the index to water contamination caused by organic matter is extremely high, standing at 50 ppm. Since oxygen is generally consumed to decompose organic matter in this environment, fishes can not live there. However, considerably-large fishes such as 30 cm-long ones have been observed at the power station project site. It is imagined that the river is so steep that a lot of oxygen is provided from the surface of water and organic matter does not accumulate at the river bed. It is characteristic of water quality to become the worst in the dry season which falls at the time to reap and process coffee fruits, and to improve considerably in the rainy season.

<2> Water Quality Changes in the Reservoir

It is obvious that the reservoir, which is planned to appear together with the construction of the dam, will largely change the process of water purification. The reservoir is cone-shaped and deep, and water is expected to be replaced not so often but about ten times a year. Since the temperature at the project site is constant all the year around, a vertical current of water in the reservoir will be difficult to be created by seasonable temperature differences. Since the water intake of the dam is planned to be constructed at a height of about 60 m from the bottom of the lake, water lower than the intake of the dam will also be difficult to be mixed. When organic matter accumulates at the bottom of the lake near the dam in a reservoir of this kind, water in the lower part of the lake loses oxygen together with the decomposition of organic matter. While organic matter decomposes continuously in the anaerobic state, harmful gases such as methane, ammonia, hydrogen sulfide, etc., are expected to be generated by the action of reduction. In addition to the decomposition of organic matter discharged from coffee factories, water containing a lot of nutrient salts (nitrogen, phosphor) due to fertilizer and livestock manure is expected to flow into the reservoir. If these nutrient salts become the cause of water eutrophication in the reservoir and a lot of certain harmful plankton are generated, water will emit a foul odor and cause fishes to die. Fig.13-22 explains the eutrophication of the reservoir.

Fig. 13-22 Causes and results of Eutrophication



[Reference: Modification in Investigation Method of Eutrophication (Teruo Okinogai)] P.126

<3> Estimation of Water Quality in the Reservoir

Since water quality in the reservoir is expected to be deteriorated by water eutrophication caused by the inflow of water with nutrient salts, water quality after the completion of the dam was estimated. The causes of water quality deterioration as well as their contribution rates were researched.

i) Sources of Water-Pollution Matter and its Quantity

The sources of nutrient salts are imagined to be coffee processing factories, cultivated land, non-industrial waste water from homes and other natural cases.

<1> Coffee Processing Factories

The annual production of coffee fruits (before the process) in the catchment area (Los Santos Section) upstream from the dam is about 62.000 tons. Since coffee fruits contain only 18.5% (11.500 tons) of coffee beans and 20% water, 3,800 tons of waste matter discarded from coffee fruits may flow into Pirris River annually. Waste matter discarded from coffee fruits can be classified into fibrous tissue including shells and mucilage surrounding coffee beans. As for these weight ratios, fibrous tissue accounts and mucilage account for 41% and 16% of the entire coffee fruit respectively. Mucilage and water used for washing coffee beans are directly discharged into the river in the production process of coffee beans. After fiber tissue is once stored outside, it is mostly discarded into the river against the law. According to the results of an analysis made by ICE, waste matter discarded from coffee fruits contains 42 mg of nitrogen/g, 3 mg of phosphor/g and 892 mg of water/g. Therefore, 1,500 tons of nitrogen and 110

tons of phosphor are expected to flow into the dam lake.

<2> Cultivated Land

A lot of fertilizer is used for the production of coffee. According to a question-answer investigation at neighbor coffee processing factories, fertilizer is given three times a year. It can be said that fertilizer should be given several times to maintain the effect of fertilizer since waterfall causes it to flow out. About 1,500 tons of nitrogen, about 500 tons of phosphor, about 1,000 tons of potash, about 300 tons of magnesium and about 50 tons of boron are used annually for coffee plantations with an area of about 5,600 hectares. Since 30% nitrogen is said to flow out of cultivated land and soil flows out severely, a considerable amount of fertilizer is expected to flow into the dam lake in the future.

<3> Pastures

As for livestock-farming regarded as the main industry in the vicinity of the project site, 15,500 cattle and 3,050 pigs are raised according to statistics collected in 1984. A head of cattle generally discharges about 300 g of nitrogen and about 50 g of phosphor a day while a pig is considered to discharge about 40 g of nitrogen and about 25 g of phosphor a day. The annual amount of nitrogen and phosphor discharged by livestock is 1,600 tons and 95 tons respectively.

<4> Non-Industrial Waste Water

The vicinity of the project site has a population of about 19,000. Since the amount of nitrogen and

phosphor discharged by a person is believed to be about 12 g and about 1.4 g respectively, the annual amount of nitrogen and phosphor discharged is about 84 tons and about 10 tons respectively. Privies are generally used in neighbor towns and villages, human sewage is discarded by tank rolly at disposal place(s) outside the river basin.

ii) Contribution Rates of Pollutants to Water Contamination

The contribution rate of each pollutant to water contamination in the reservoir was estimated and is shown in Table 13-14. According to the estimation, 2,572 tons of nitrogen and 131 tons of phosphor will flow into the reservoir annually. As for the contribution rate of each pollutant to nitrogen, coffee waste matter is the highest standing at 62%, livestock is the second standing at 21% and fertilizer stands at 18% while coffee waste matter is overwhelmingly high standing at 87% in the case of phosphor. Table 13-14 Loads of Water Quality Contamination Sources

Table 13-14 Loads of Water Quality Contamination Sources

Group		Flow Amount	Flow Factor	Load	Load Factor
Cattle (head)	N P	300g/day・head 50g/day・head	0.3 0.02	509t/year 5.7t/year	20 % 5 %
Pig (head)	N P	40g/day・head 25g/day・head	0.3 0.02	13t/year 0.6t/year	0.5 % 0.5 %
Cultivated Area N, P	N P	1500t/year 500t/year	0.3 0.02	450t/year 10t/year	18 % 8 %
Coffee Refinery	N P		1.0 1.0	1,600t/year 115t/year	61.5 % 86.5 %
Total	N P				2,572 t/year 131 t/year

iii) Comparison with Other Lakes and Marshes

Table 13-15 shows the annual inflow rates of nitrogen and phosphor, the sizes of lakes and marshes and the situation of water contamination in comparison with other lakes and marshes in the world. The rates of nutrient salts flowing into Pirris Reservoir are almost the same as those at Lake Suwa in Japan. Lake Suwa is located at an altitude of 759 m and surrounded by mountains. This is an eutrophic lake which receives waste water from industry and homes in seven municipals with a population of about 180,000 and has anaerobic water generated at and near its bottom.

iv) Estimation of Water Quality

The present concentration of nitrogen and phosphor in the water of Pirris River is high, standing at 2.4 ppm and 8.2 ppm respectively. A nitrogen concentration of 0.3 ppm and a phosphor concentration of 0.015 ppm are regarded as the index to the start of lake eutrophication, and the present concentration of them in the water of Pirris River is so high that the reservoir becomes eutrophic. Similarly to Lake Suwa which is an eutrophic lake in Japan, It is imagined that a lot of phytoplanktons will be generated at the surface of water intercepting the sunshine, oxygen will be consumed by the decomposition of plankton dead bodies depositing at the bottom of the lake and the anaerobic layer at the bottom of the lake will be developed, generating harmful gases. Coffee waste matter, which is the main source of nutrient salts is expected to deposit at the bottom of the lake. Coffee waste matter contains a lot of pulp such as cellulose, lignin, etc., but they are difficult to be decomposed by microorganisms in a short period of time. Since waste matter also contains polyvalent phenol harmful to microorganisms, it will interfere with the activity of organisms. Therefore, coffee waste matter is expected to deposit at the bottom of the lake for a long

period of time and to be decomposed continuously. Since it perhaps takes several years to decompose it into minerals completely, decayed matter at the bottom of the lake is expected to increase year by year. A lot of nitrogen contained in waste matter is expected to deteriorate water quality by changing into NH_4-OH in the anaerobic state. It is necessary to implement further investigation on this matter.

Table 13－15 Inflow Loads on Lakes and Marches and Situation of Eutrophication

	Name of Lake	T－N (g／m³・y)	T－P (g／m³・y)	Surface Area (km²)	Mean Depth (m)	Volume (m³)	Total Phosphoras loading (t/y)	Total Nitrogen loading (t/y)	Degree of Entrophication
Central Europe	Pfaffikersee*1	0.82	0.08	3.31	18	59,580,000	48.66	4.50	High
	Greifensee*1	1.64	0.08	8.56	19	162,640,000	266.22	13.35	〃
	Zürichsee*1	0.52	0.03	65.30	50	3,265,000,000	1710.86	86.20	〃
	Hallwilersee*1	0.46	0.02	10.30	28	288,400,000	131.84	5.77	〃
	Baldeggersee*1	0.61	0.05	5.25	34	178,500,000	108.67	9.19	〃
	Lacke leman*1	0.06	0.00	581.40	155	90,117,000,000	5523.30	406.98	Low
	Boden-Obersee*1	0.21	0.04	476.00	100	47,600,000,000	9900.80	1937.32	〃
North Europe	Lake Norrviken*2	——	0.41	2.70	5.3	14,300,000	——	——	High
North America	Lake Washington*1	0.95	0.04	87.60	33	2,890,800,000	2750.64	117.38	High
	Lake Sebasticook*1	1.12	0.04	17.35	6	104,100,000	116.24	3.64	Very High
	Lake Tahoe*1	0.08	0.01	4.97	3	14,910,000	1.14	0.20	Low
	Lake Mendota*1	0.26	0.01	39.40	12	472,800,000	122.14	6.86	High
Japan	Lake Kasumigaura*3	4.70	0.68	171.00	4	684,000,000	3214.80	461.70	Very High
	Lake Suwa*3	30.90	2.22	14.50	4.1	59,450,000	1837.15	131.95	Very High
	Lake Ohnuma*3	1.74	0.10	8.92	4.7	41,924,000	73.14	4.10	Very High
	Lake Teganuma*4	203.82	41.89	6.5	0.86	5,590,000	1139.35	234.15	Very High
	Lake Nojiri*5	0.25	0.0157	4.56	21	95,760,000	23.61	1.50	Low
Costa Rica	Pirris	86.60	4.41	0.9	33	29,700,000	131	2572	Very High

Reference :

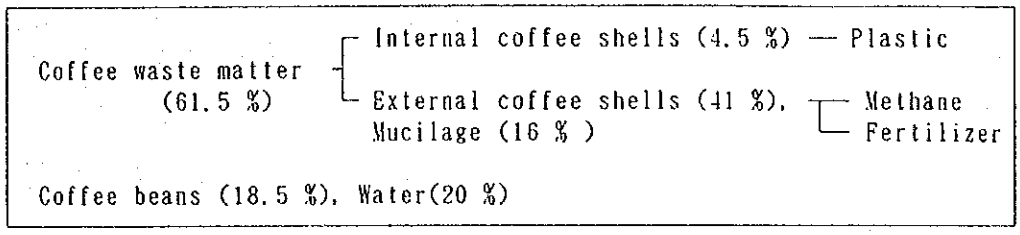
1. Japan Environment Pictorial Book
2. M. Sakamoto, "Countermeasures against the Eutrophication of Lakes and Marshes in Other Countries", Industrial Pollution, V.18, No.9, p.831-842(1982)
3. K. Sakata *et al* ., "Entrophication of Lake Ohnuma", Reported by Hokkaido Pollution Prevention Research Institute, No.13, p.55-65(1987)
4. S. Asama, "Ecology in Lake Teganuma", (1989)
5. M. Kawamura *et al* ., "Water quality and nutrient salts load in Lake Nojiri", Lecture Note at the Water Contamination Study Society, V.19, p.151-152(1985)

v) Water Contamination Prevention Measures

Water quality in the reservoir is expected to deteriorate considerably in the future since a lot of organic matter and nutrient salts flow into the reservoir from the river basin. However, since the contamination load factors of nitrogen and phosphor imposed by coffee waste matter are 62% and 87% respectively, the reduction of coffee waste matter is the most effective water contamination prevention measure (Fig.13-23). Coffee waste matter is discharged from five coffee-processing factories in the river basin. Although there is the law to prohibit the discard of waste matter into rivers, it is freely done in reality. Some factories try to reduce the discharge of waster matter by using it as fertilizer and fuel positively, but it is not enough. Therefore, it is necessary to study countermeasures to avoid discarding waste matters directly into the reservoir. People are taking a great interest in environmental pollution due to industrial waste matter in Costa Rica. Costa Rica National University (Universidad Nacional) is developing the technology of producing plastic from coffee waste matter with the aid of the Japanese Ministry of International Trade and Industry as well as Japan International Cooperation Agency. This plastic is biodegradable in soil and a high value-added product suitable for environmental conservation. A research on the effective utilization of coffee waste matter as fertilizer, fuel and livestock feed is under way, but a large amount of money for research and development as well as technology is required for its practical use. The effect of legal regulations on the discard of waste matter can not be anticipated even from now on, but it is expected to improve the effect of environmental measures by adding value to waste matter and providing its profit to processors. Therefore, this should be regarded as one of the important items in Japan's future development aid. While all the Central American countries have similar water contamination

problems, this new technology is expected to contribute to environmental improvement in the world.

Fig. 13-23 Kinds of Coffee Waste Matter, their Weight Ratios and Effective Utilization

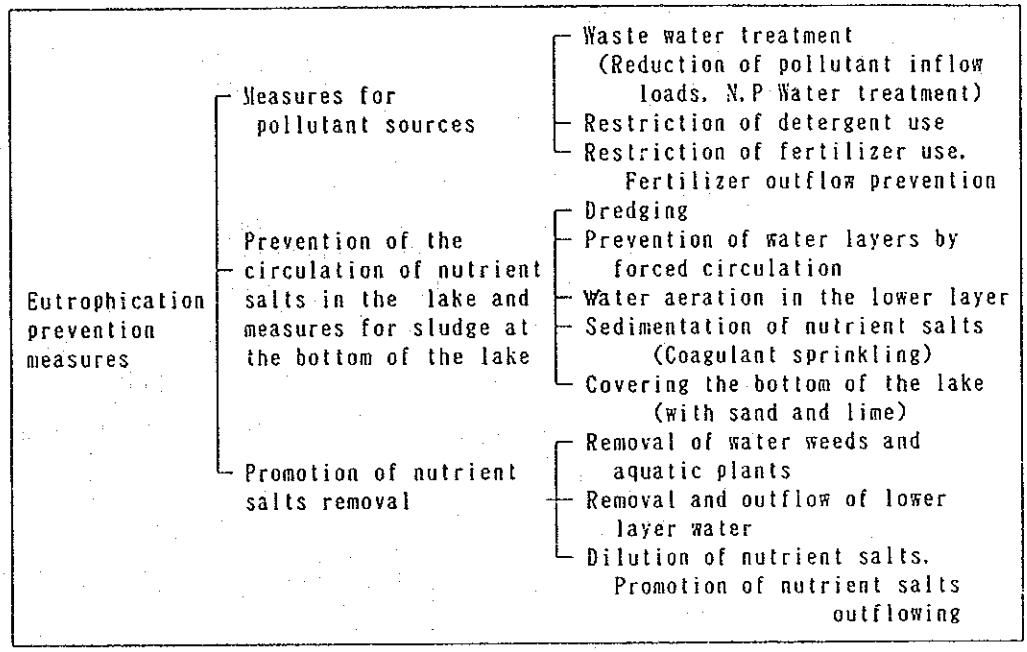


The contribution rate of nutrient salts flowing into the reservoir from pastures and cultivated land to water eutrophication is small compared with that of coffee waste matter, but the total amount is considerably big in weight. Night soil treatment plants should be established and soil outflow prevention measures should be taken with a constant effort to maintain water of good quality for a long period of time by slowing down the progress of water eutrophication. However, in spite of the above-mentioned measures taken with a constant effort, the eutrophication of the lake can not always be avoided when nutrient salts with a higher concentration flow into the lake. In this regard, the methods of preventing the circulation of nutrient salts in the lake, promoting the removal of nutrient salts as well as sludge at the bottom of the lake, preventing the elution of nutrient salts, etc., have been researched in various countries and some places have obtained excellent results by taking their measures. Some examples are shown below. A lot of water-bloom appeared every year, water weeds grew unusually and a lot of fishes died from lack of oxygen in the 1960s in Lake Trummen located in the southern part of Beckshue City, South Sweden. However, sludge 60 cm in thickness was removed from the bottom of the water in a section with an area of 60 hectares in the lake for two years in the 1970s. After

that, water quality in the lake improved and TN and TP drastically decreased to 1/5 and 1/10 respectively. Dredged organic sludge was also sold as fertilizer. The strategy of recovering this lake from water eutrophication in dredging it on a large scale for the first time in the world drew considerable attention. The same team which carried out this project won success in other projects in many countries such as Iran, Tunisia, Brazil, Jamaica, Zimbabue, etc. In Japan, sludge started being dredged up in Lake Suwa and Teganuma Pond in the Showa 50s (a decade from 1975 to 1985), but the effect of this project has been to maintain the present situation. The concentration of phosphor in water has been successively reduced and water quality has been considerably improved by forced aeration and forced mixture in Lake Boldic, a small lake near Luzerun, Lake Semaback whose water is anaerobic water in its lower part due to its topographical factors, Lake Tirler, etc., in Switzerland. As for aeration and circulation in dam reservoirs in Japan, pilot experiments have been carried out since several years ago by different types of aeration/circulation methods in four dams under the direct supervision of the Ministry of Construction and under the management of Water Resources Development Public Corporation, and some results have been obtained so far. Besides that, various other methods have been attempted; coagulating sedimentation by using coagulants to remove phosphor; the method of covering sludge at the bottom of the lake with lime, sand, fly ash, etc., to reduce the elution of ammonia nitrogen and phosphate; the method of using the fact that the elution of chemical elements decreases when the lake is filled with water after emptying the lake and drying sludge at the bottom of the lake; the method of removing algae and water weeds which have increased absorbing nutrient salts in water, etc. However, the problem of water eutrophication has not yet been solved fundamentally. Researches on the uptake of nutrient salts by algae and the removal of nutrient salts by

sedimentation, which are still in the stage of study, are conducted by establishing a relatively-shallow (usually about 3 m) pre-dam with an average water convection time of 2 to 3 days at a place a little upstream from the lake or reservoir. However, various countermeasures against water eutrophication are taken, but the most effective method is to reduce pollutant inflow loads as mentioned above. The general methods of preventing the eutrophication of lakes and marshes are as follows:

Fig.13-24 General Eutrophication Prevention Measures



8) Noise

There are hydraulic turbines and generators regarded as noise sources, but they seem to have no impact on the neighbor environment since they are installed indoors.

9) Vibration

There are hydraulic turbines and generators regarded as vibration sources, but they seem to have no impact on the neighbor environment since they are installed on a solid foundation.

10) Local Communities

There are many problems in the vicinity of the power station project site, such as river contamination due to waste matter discarded by coffee factories regarded as the main industry, soil outflowing from the surface of land whose vegetation has been stripped by the excessive expansion of pastures, the outflow of younger people from this region, etc.

(1) Water Contamination

As for the relationship between river utilization and the power station project, the power station project is possible to coexist with its local communities and existing industries since water utilization in Pirris River is conducted only in the river basin upstream from the reservoir. Coffee regarded as the cause of water contamination is the main industry in Costa Rica and an important foreign money acquisition source. At present, the coffee industry is economically stable since the coffee processing stage does not include waste disposal treatment costs. It is necessary for the coffee industry to introduce a waste disposal treatment system into the processing stage in trying to prevent waste matter from flowing into the reservoir and water quality from deteriorating. Since the discard of waste matter into rivers is legally prohibited, the coffee industry is considered to be primarily responsible for environment problems, but it is obvious that the electric power developer should be in charge of the reservoir and the developer, who changes the existing natural purification system with the appearance of the reservoir, should take the same responsibility for these problems. It is also obvious that the electric power developer should be responsible for the management of the reservoir. The problem of water quality in the reservoir is possible to be solved with a constant effort, and the method of solving this problem should be studied together with the development of the power station. During the operation of the power station, the

environmental impact of the project should be grasped by environmental monitoring as well.

(2) Soil Outflowing

Soil outflowing in the area upstream from the reservoir is not desirable since this becomes the cause of sand accumulation in the reservoir. Since fertilizer flowing out together with soil contains a lot of nutrient salts (nitrogen, phosphor), it is possible to further promote the eutrophication of the lake. Soil outflowing is closely related to industries in this region. Coffee plantations have been rapidly expanded by deforestation in Los Santo Area since 1980, and all the land suitable for coffee plantations seems to have already been developed. A lot of soil flows out at the time of weeding or in the rainy season since coffee is cultivated by completely removing weeds under coffee trees. Surface soil in coffee plantations developed on steep slopes was originally thin, its thickness decreased further year by year due to lack of cultivation management technology and finally it will be converted into land insufficient for coffee cultivation. Land of this kind will be insufficient to be used for anything, but as pastures. As mentioned in Chapter 2, pastures become terraced fields starting from passages for livestock, surface landslide occur, soil flows out in the rainy season and the land becomes bared at last. Coffee plantations, which are possible to be permanently cultivated, are expected to concentrate in gently-sloping areas while the amount of fertilizer used there is imagined to increase at the same time. Soil outflowing is a fatal and structural problem in this region when industrial activities are conducted in mountainous areas. Villages in the vicinity of the project site are making a living in industries which are largely dependent on soil, such as coffee cultivation and livestock farming. Measures for minimizing the progress of soil outflowing should be taken to develop this region continuously in the future. However, great care will be definitely given to the problem of soil outflowing in the construction of the power station.

(3) Communities

The hydraulic power station is located at a distance of more than 5 km from the nearest village and has no big relationship directly with their social life in the region. The power station will not give the opportunity to employ a lot of people since it is operated and managed by few experts.

11) Transportation and Public Facilities

Parts of the roads from the power station to its neighbor villages are in a very bad condition, and it becomes impossible to go through the roads at some places especially in the rainy season. Since roads are expected to be improved and newly constructed together with the construction of the power station, the situation of roads in this region is expected to be drastically improved. As for the establishment of a road for construction and management purposes, great care should be given to the route and structure of the road to avoid letting it become the cause of soil outflowing since there are a lot of places with much rainfall in the neighbor area. Since the reservoir is expected to become a lake with a submerged area of 1.10 km^2 and the suspension bridge between San Carlos and Trinidad is planned to be submerged, a bypass and a water-borne traffic system using the surface of water in the lake should be prepared. Since the road from the power station site to the dam site is not expected to be used for the transport of equipment and materials and a part of the transmission line is planned to be constructed along the road, the road should be improved enough to go through in the rainy season and avoid interfering with the management of the transmission line. Since the siphon culvert located at the power station site becomes impossible to go through due to higher water levels changed by water discharged from the power station, the culvert should be shifted toward the upper reaches of the river or a new bridge should be constructed there.

12) Land Utilization

What the power station is expected to influence land utilization most in its vicinity is to submerge land by the storage of water. Coffee plantations and pastures with a total area of 1.10 km^2 are expected to be submerged, but they account only for a small part of the entire space and the power station will have no impact on land utilization in the region.

13) Water System Utilization

The power station will have no impact on water utilization since it is conducted only in the area upstream from the reservoir. Most water utilization facilities consist of coffee processing factories and all the water utilized is returned to Pirris River. The river flow rate in the section from the dam site to the power station site will decrease together with the construction of the power station. Since there are two tributaries such as Seca River and Napoleon River, the contribution rates to the section with its future lower flow rate should be grasped by estimating those flow rates correctly. The minimum rates of water required to be discharged from both rivers into the section with its lower flow rate should be studied based on the results of the river flow rate measurement. Since water utilization is not conducted in this section, the minimum rates should be considered from the viewpoint of natural environmental conservation. The two rivers should not be used as the sources of water required for power generation. The construction of the dam seems to have almost no impact on the change of the river bed since the base rock is exposed. No fishery is conducted in the vicinity of the power station project site.

14) Public Health

Care should be given to the occurrence of diseases brought by intermediate hosts which live in still-water areas since the reservoir becomes a still-water area. If floating-leaf plants and plants indigenous to the bank of lakes increase, those plants will not only become homes for snails regarded as an intermediate host having

haematozoa but also promote the occurrence of insects bringing diseases. Especially, if waste matter discharged from coffee factories accumulates on the bank of the lake, harmful insects are in danger of increasing due to decayed organic matter. In fact, the mass occurrence of harmful insects on the river banks is seen in the vicinity of the power station site. Since the appearance of the reservoir is expected to give residents in this region the opportunity to use water at least more easily than before, compared with water in other rivers, proper educational activities may be necessary to be conducted to teach the method of water utilization in the reservoir.

15) Cultural Assets and Recreation

Identification investigations of archaeologically-and-historically important cultural assets have not been conducted in the vicinity of the power station project site, and reports on the existence of important cultural assets have not been made either. In Costa Rica, the undertaker is supposed to conduct an identification investigation of cultural assets before starting the construction of the power station. If important cultural assets are found, proper measures such as their protection, transfer, etc., will be taken. Since the project site is located at a place which is not far away from San Jose, the capital, and it takes about two or three hours to get to the city by car and there are relatively-good scenes of rivers and mountains in the area upstream from the site, the dam can be used for recreational activities.

13.4.2 Matters Concerning Period of Construction Work

Alterations in the natural environment can not be avoided together with the construction work regardless of their sizes. They can be divided into permanent alterations such as topographical and vegetational ones and temporary alterations such as noise and vibration which occur only during the period of the construction work. As for the former, the area of altered places should be minimized as the most fundamental policy and various measures should be taken promptly without leaving the altered places as bared land. As for the

latter, it is necessary to select the best construction work methods and the best construction work machines. Since the survey is a feasibility study, the fundamental policy of environmental conservation measures is indicated and the power station's own problems are estimated here based on the past experience in the construction of existing power stations in trying to estimate the impact of the construction work on the environment and to examine its measures.

1) Natural Conservation

Various sites such as temporary facility sites, aggregate-collecting sites, spoil banks, etc., required for the construction work should be arranged and reduced to the irreducible minimum of necessity as far as possible. It would be possible to use river-bed sediment and muck as concrete aggregates and dam-construction materials to minimize the collection of aggregates from those sites. In addition to measures such as the reinforcement, tree-planting, etc., of the slopes of spoil banks to prevent earth and sand from flowing out of there in the future, the possibility of using earth and sand inside the extrados of the dam and for public facility sites as construction materials, should be considered as well.

2) Topography

Concrete aggregates and dam-construction materials should be collected from the submerged area of the reservoir as far as possible in place of aggregate-collecting sites to avoid damaging its neighbor natural scenery. Since the project site is located in a very steep area, the reasonable route lines of roads should be selected and slope protection work and drainage work should be conducted sufficiently in trying to construct new roads or improve existing ones.

3) Vegetation

As mentioned in the paragraph on Natural Conservation, the area of altered land surface in construction should be reduced as far as possible to minimize the impact of the construction work on vegetation.

4) Animals

Since it is imagined that animals in this region may temporarily evacuate from the vicinity of the project site in the construction of the power station, its artificial impact on the natural environment should be minimized during the period of the construction work and the impact should be removed as a temporary matter in trying to recover the natural environment swiftly after the completion of the power station. The concrete measures are as follows:

(1) Prevent noise, vibration and night lighting in construction from affecting the ecology of animals badly.
(2) Educate construction-related people on the protection of animals, prohibit them from bringing hunting tools such as snares, etc., in the construction area and prevent them from catching animals unnecessarily.
(3) Restore order inside the construction area and clean it up, remove construction materials and waste matter at the completion of the power station and keep the river in good condition to protect the ecology of animals.

5) Aquatic Organisms

Since the impact of the construction work on aquatic organisms is caused mainly by water quality deterioration, waste water discharged from the construction work site should be properly managed.

6) Water Quality

Muddy water caused by earth excavation, treated-waste water from concrete plants and non-industrial waste water from the site office can be imagined to be the causes for changes in water quality. Muddy water is expected to occur when earth and sand which is discharged from earth excavation, transport and dumping work in the construction of the dam, the tunnel and roads, makes contact with underground water and rainwater and flows into rivers. In the construction of the dam, the occurrence of muddy water on a large scale can be avoided in trying to

discharge clean water directly into the river downstream from the dam site by letting river water pass through the bypass tunnel to prevent it from flowing into the construction work section before the construction work starts. It is desirable to treat muddy water in the sedimentation pond, which is caused by underground water and rainwater, and discharge its supernatant water into the river. It is also desirable to discharge water into the river, after muddy water discharged from the construction of the tunnel and aggregate plants, waste water from concrete plants and water used for washing concrete mixer cars, are treated in the sedimentation pond in the same way. After treating waste water discharged from construction-related people in the sedimentation pond and the filtrate pond, it will be discharged into the river. It is desirable to treat excrement in the purification facilities. But if it is impossible, waste matter should be prevented from flowing directly into the river by impregnating it in the ground.

7) Noise

The machines regarded as the sources of noise during the construction period consist of the aggregate plants, concrete plants and construction machines, but since the construction work section is considerably away from houses, the construction work is expected to have almost no impact on residents. Dynamite should be set in the time zone other than early morning and night time. It can be imagined that wild animals may temporarily evacuate from the construction area, but the construction work is expected to have almost no impact on them in the long run.

8) Vibration

Dynamite setting is regarded as one of the sources of noise during the construction period, but it is expected to have almost no impact in the long run in the same way as other sources of noise.

9) Transportation and Public Facilities.

(1) Transportation

The volume of traffic is expected to increase rapidly after the construction of the power station starts, since people, equipment and materials are required to be transported frequently. Traffic safety measures such as the observance of safety speed, etc., should be taken since the road from San Francisco to the dam site is in bad condition.

(2) Public Facilities

A lot of people are expected to engage in the construction work in a short period of time. Therefore, public facilities such as hospitals, meeting places, etc., required for workers as well as people related to the construction, who will sometimes come and go, seem necessary to be constructed. These facilities will be provided to residents, therefore they are expected to contribute to the improvement of their living conditions.

10) Water System Utilization

Since the power station project site and rivers in its vicinity are not used for fishery, agriculture, water-borne traffic, etc., the construction work will have no impact on them.

11) Public Health

During the construction work, the maintenance, inspection and management of construction machines should be carefully conducted, workers should be educated on safety and they should be appointed as persons in charge of dangerous work such as dynamite setting, etc. Workers should be sufficiently educated on fires, fire-fighting equipment should be prepared and walk-around checks should be made to prevent a forest fire from breaking out. Workers should be educated on the sanitation of drinking water facilities, food, clothes, houses,

etc. Puddles suitable for the breeding of harmful insects should be eliminated to prevent a lot of workers from falling ill at one time.

13.5 Monitoring

Based on the estimation of the present environmental situation or the environmental impact, water quality is the most important problem among the problems of the environment in the vicinity, which may be caused by the establishment of the power station. In this regard, it is necessary to monitor the environment after the startup of the power station and during the construction work, in trying to confirm the effects of various measures or in getting the feedback of those measures.

13.5.1 Matters Following Completion of the Project

1) Living Organisms

Since fishes (Types of fishes, No. of fishes) in the reservoir are the effective indexes to changes in water quality, including nutrient salts, and plants (floating plants, plants at the waterside) tend to become homes for harmful insects, the situation of both occurrences should be surveyed according to the circumstances.

2) Water Quality

Flow duration in the river will change together with the construction of the power station. The reservoir will create a large still-water area, and a section whose flow rate is expected to increase and a section whose flow rate is expected to decrease, in the river downstream from the power station, will appear. In these sections, water examinations should be made according to the circumstances to confirm that water quality has not deteriorated. In addition to the same items of site investigations as water temperature, turbidity, hydrogen ion exponents(pH), electric conductivity, dissolved oxygen, nutrient salts, etc., photo-plankton should also be investigated. The

Japanese water and environmental quality standards of rivers, lakes and marshes are shown in Appendix as a reference.

3) Bottom Sediment

Since a lot of organic matter is expected to accumulate at the bottom of the reservoir, the situation of bottom sediment, such as particle composition, ignition loss, BOD, COD, nutrient salts, etc., should be investigated according to the circumstances.

13.5.2 Matters Concerning Period of Construction Work

1) Water Quality

As a water quality maintenance measure during the construction period, turbidity, hydrogen ion exponents(pH), etc., should be measured at the outlet of the temporary sedimentation pond and at the outlet of the filtrate pond for non-industrial waste water. The quality of waste water of these kinds should be controlled by determining the concentration of elements in water as standards.

2) Noise and Vibration

It is desirable to confirm the situation of noise and vibration by establishing measuring points in its neighbor villages, etc.

13.6 Compensation

1) Land Purchase

Land prices in Costa Rica are determined depending on the situation of land - sizes, geographical - locations, utilization - purposes, transportation services, public facilities as well as value added to land as private property. However, there are manuals, regulations, etc., used by private and public organizations which are required to

state real estate prices clearly. As for an organization included in the national bank network, that is, Banco Nacional de Costa Rica for example, the prices of land per hectare, which have been accepted by this bank's local branch office, are as follows: Pastures and weed-grown land: 100,000 C/ha Sugar cane plantations: 300,000 C/ha Coffee Plantations: 400,000 C/ha Where ICE, which is a national enterprise, conducts electric power development and can not reach an agreement with land owners on the procedural matters of land purchase to the end, the Compulsory Purchase of Land Act applies to this matter and the land price is determined in court. (Law No. 6313 of January 4, 1979; On Acquisitions, Expropriations and Construction for the Instituto Costarricense de Electricidad) According to village people, the market price of coffee plantations on the bank of Pirrs River is 400,000 colons/ha to 700,000 colons/ha since the quality of coffee is good there.

2) Target Land to be Purchased

There are four houses required to be transferred and one suspension bridge. As for houses, ICE will purchase substitute land and provide it to them. The area of land required for each family is 400 m2 and the total area is 1,600 m2. The substitute land should consist of already-cultivated places, requiring 1 million colons. 8 million colons are required for the housing construction costs. The means of a transportation substitute for the suspension bridge, which is expected to be selected from a new bridge, a bypass road, ferry service, etc., remains undecided, but this should be included in the project costs after all.

3) Size of Purchased Land

The total area of land required for the project is 150 ha. The contents of land utilization purposes are as follows: 125 ha - Reservoir and protected zones around it, 15 ha - Land for temporary facilities at the dam site, 10 ha - Land for temporary facilities at the power station site, 5 ha - Others. If the presumed land unit price is considered to be 500,000 C/ha, the total land acquisition cost is 75 million colons.

4) Compensation Costs

The total compensation cost required for the project is 84 million colons, and the cost of a new bridge substitute for the suspension bridge should be added to this amount of money. The accurate compensation costs will be determined in estimating the process of land planned to be purchased by ICE and negotiating with landowners in the execution process of the project. The survey methods as for the environmental impact assessment, for the site investigation, was conducted by grasping the present environmental situation and the characteristics of the region where the project site is located. And by selecting environmentally-important items and items considered to have a big environmental impact, from existing and newly-obtained materials with reference to manuals, guidelines, etc., prepared by the World Bank, Japan International Cooperation Agency, etc. The survey was conducted in cooperation with neutral organizations such as a national university, etc., in Costa Rica to make the survey and its environmental impact assessment fair. In this survey, materials were collected, the site investigation was conducted in cooperation with Instituto Costarricense de Electricidad (I.C.E.). Since the hydraulic power station is located more than 5 km away from the nearest village, it will have no big direct relationship with social life in this region although employment and consumption are expected to increase temporarily. Roads in its vicinity will be improved or newly constructed by the establishment of the power station, and the situation of transportaion in this region will be improved.

CHAPTER 14 ECONOMIC AND FINANCIAL EVALUATION

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CHAPTER 14 ECONOMIC AND FINANCIAL EVALUATION

14.1 Economic Evaluation

14.1.1 Methodology

(1) Basic Approach

In general, economic evaluation of a development project is designed to measure its socio-economic impacts on the country as a whole by comparing two cases; the project is implemented and the project is not implemented.

The economic evaluation employs indices such as net present value of the project, benefit/cost ratio and economic internal rate of return, which are calculated from benefit and cost of the project by using the Discounted Cash Flow method.

To obtain economic benefit and cost of a project, market prices should be converted to real benefit and cost, since market prices are generally distorted due to taxes, government subsidies, import control, import duties, public charges, minimum wages, and other government intervention and monopolistic pricing.

The World Bank and other international financing organizations employ border prices to estimate real project cost and benefit. A method of economic evaluation employed by the World Bank and other international financing organizations may be summarized as shown in Fig. 14-1.

Phase 1: To exclude items to be transferred to national income from market prices

Phase 2: To convert market prices of traded goods, non-traded goods, skilled labor, unskilled labor and other items to real (border) prices

Phase 3: To calculate the internal rate of return on the basis of economic benefit and cost, and compare it with opportunity cost of capital in the country

Phase 4: To carry out socio-economic evaluation in consideration of national saving and income distribution.

For the Project, economic evaluation up to the Phase 3 is carried out (See Fig. 14-1), using the alternative plant approach due to the following reason.

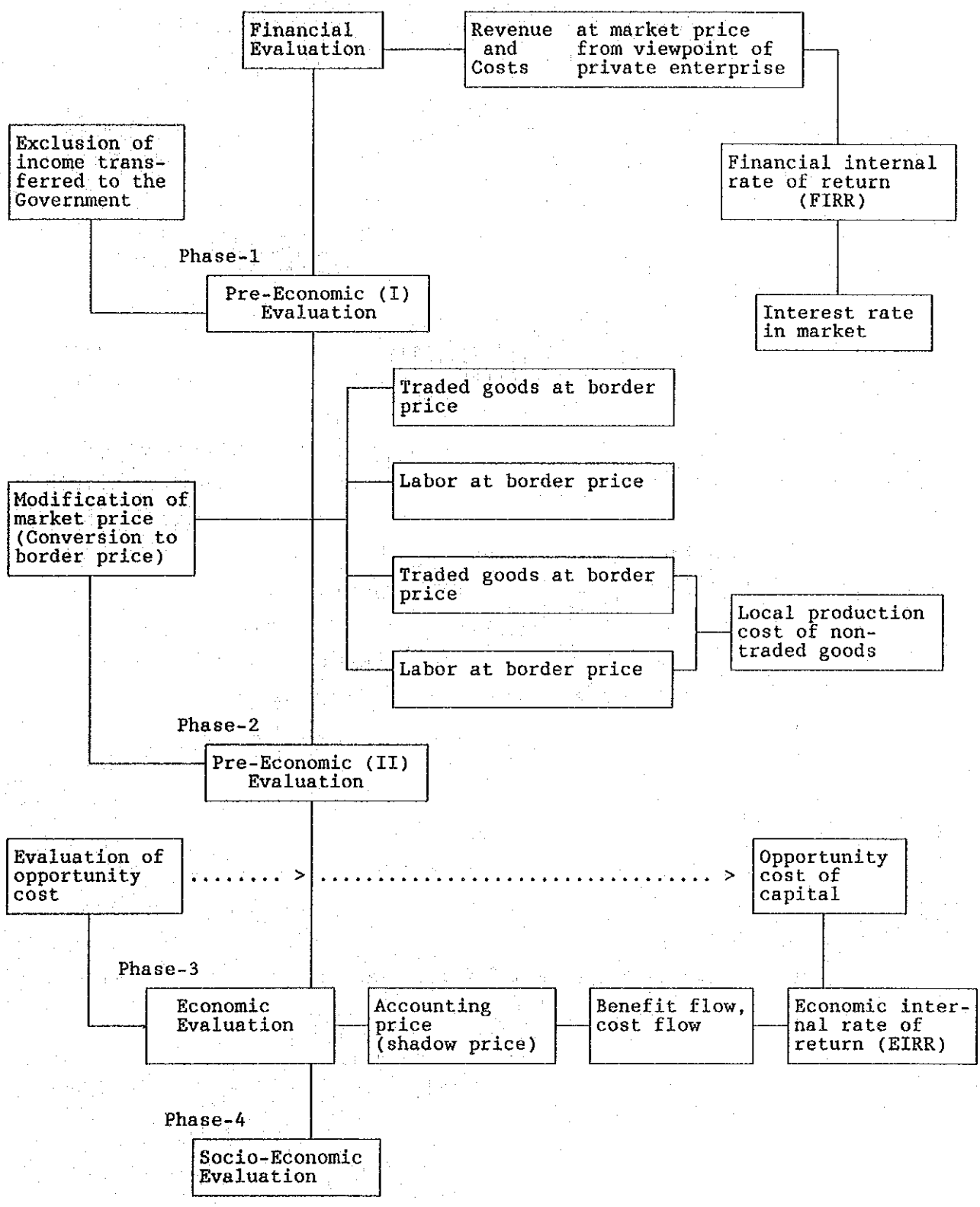
If a project is incorporated in a long range electric power development program which is a part of national socio-economic development policy to satisfy future power demand (i.e., if the project is not implemented, it will be substituted for by other means of power supply), an alternative plant approach will be employed to measure and evaluate economic cost of the proposed project and the alternative project.

(2) Conversion Factors to Determine Economic Cost

When benefit and cost of a project are evaluated at real (border) price, market prices of goods and services consumed for the project are converted to border prices. In simple terms, a border price for imported goods is expressed as CIF price at an unloading port and that for exported goods as FOB price at a shipping port.

The conversion factors are calculated in proportion to weighted average of values of major export and import items, import duties, export subsidies, and import control. The standard conversion factor determined from total values of major export and import items is used as a general indicator to show distortion of domestic prices from real (border) prices.

Fig. 14-1 Flow Chart of Economic Evaluation of Project



Each different conversion factor is used to obtain border price for consumer, intermediate and capital goods. Shadow wage rate is used for labor cost. Omission of these factors does not affect so much economic pricing. Therefore, a standard conversion factor (SCF) will be used in this study. The SCF is 0.83, which is commonly used by ICE as of 1991.

(3) Selection of Alternative Thermal Plant

Combination of two gas turbines and a diesel engine is selected as the alternative thermal facilities to the Pirrís Project, considering the following situation:

Thermal power facilities such as oil fired, coal-fired, or nuclear are generally considered to be alternative facilities to a hydroelectric power project. Energy resources in Costa Rica are not so abundant except for lignite (reserves not known), geothermal and hydropower (potential is approx. 9,000 MW). Therefore, it is considered that future power supply will rely on coal and oil-fired thermal after development of hydropower and lignite. As of January 1991, Costa Rica has an installed capacity of 743.3 MW by hydro and 254.3 MW by thermal. And future power development plan includes development of oil fired gas turbine and diesel engine. Therefore, combination of gas turbine and diesel engine is selected as an alternative thermal facility.

14.1.2 Economic Cost of the Project

The economic cost of the Project is obtained by applying the economic cost conversion factor (0.83) to the financial cost that was obtained in Chapter 12 "Construction Planning and Cost Estimation", according to the method described in 14.1.1. The economic cost of the Project thus obtained is presented below.

The operation and maintenance cost is obtained by applying the following rates to the economic construction cost.

Civil facilities construction cost 0.5%
Hydraulic equipment cost 1.5%
Electro-Mechanical equipment cost 1.5%
Transmission line and sub-station cost 1.5%

Economic Cost of the Project

As indicated in Table 14-1, the initial investment in the economic cost of the Project is 179,831 x 10^3 US$.

The total cost throughout the project life (315,246 x 10^3 US$) and the flow of economic costs in each year are as presented in Table 14-2.

14.1.3 Parameters and Economic Costs of Alternative Thermal Power Plant

As discussed earlier, a combination of thermal power plant is assumed as alternative facilities with which the economic benefit of the Project is calculated. In this evaluation method, the cost of this alternative thermal power plant is regarded as the benefit of the Project, and such benefit is compared with the economic cost of the Project.

Most of the output of the Project will be transmitted to the large load centers around San Jose. Therefore, the alternative thermal power plant which is taken as the basis of the economic evaluation is assumed to be located at Caldera on the coast of the Pacific Ocean, approximately 78 km west of San Jose. The output of the alternative thermal power plant is also assumed to be transmitted to San Jose. The alternative thermal power plant is assumed to be capable of supplying power at the same service level as the Project (in terms of effective dependable capacity and annual available energy).

In addition, it is assumed that the reference point at which the Project and the alternative thermal power plant are compared is San Jose to which the output of the Project is to be supplied. The basic criteria used in this evaluation are presented in Table 14-3.

Table 14-1 Economic Cost in Initial Stage

F.C; Foreign currency, L.C; Local currency, T ; Total

Unit;10^3 US$

Item		-1st year	1st year	2nd year	3rd year	4th year	5th year	6th year	Total	Remarks
1. Civil Works										
Care of River	F.C.		639.6	491.6			58.4	0.0	1,189.6	Coffer dam and
	L.C.		315.0	473.7			79.1	0.0	867.7	Diversion tunnel
	T		954.5	965.2			137.5	0.0	2,057.3	
Dam	F.C.			1,026.0	5,525.2	8,090.5	4,263.8		18,905.5	Dam,Spillway and
	L.C.			401.3	4,780.8	7,644.8	3,926.5		16,753.3	Outlet works
	T			1,427.3	10,306.0	15,735.4	8,190.2		35,658.9	
Waterway	F.C.		2,561.5	4,807.8	6,937.1	3,080.1	1,418.5		18,805.0	Intake,Headrace
	L.C.		912.4	1,891.1	3,457.6	2,483.8	939.1		9,683.9	tunnel,Surge
	T		3,473.9	6,698.9	10,394.6	5,563.9	2,357.6		28,488.9	tank & Penstock
Powerhouse &	F.C.		249.1	638.0	1,365.8	1,241.8	181.5		3,676.2	
Switchyard	L.C.		110.3	391.1	1,256.0	935.2	100.4		2,793.0	
	T		359.4	1,029.2	2,621.8	2,177.0	281.9		6,469.2	
Disposal Area	F.C.		331.9	580.2	582.4	20.7	0.0		1,515.2	Dam,Waterway and
	L.C.		127.4	214.7	205.3	6.9	0.0		554.2	Powerhouse
	T		459.3	794.8	787.7	27.6	0.0		2,069.4	
Preparatory	F.C.	7,002.6	2,944.6	144.9	144.9	144.9	144.9		10,526.7	Access rord,
Works	L.C.	4,512.2	1,861.0	120.2	120.2	120.2	120.2		6,854.1	Camp facilities,
	T	11,514.8	4,805.6	265.1	265.1	265.1	265.1		17,380.8	T.L for Const.
a) Sub-Total	F.C.	7,002.6	6,726.8	7,688.4	14,555.2	12,578.0	6,067.1	0.0	54,618.2	
(Direct Cost)	L.C.	4,512.2	3,325.9	3,492.1	9,819.9	11,190.9	5,165.3	0.0	37,506.4	
	T	11,514.8	10,052.8	11,180.5	24,375.1	23,768.9	11,232.4	0.0	92,124.5	
b) Compensation for Civil Works										
	F.C.	0.0	140.6	0.0					140.6	
	L.C.	791.3	149.7	0.0					941.0	
	T	791.3	290.3	0.0					1,081.6	
c) Project Control	F.C.	246.3	212.5	235.5	522.5	516.0	243.3	0.0	1,976.2	
(T.C.W. x 18 %)	L.C.	1,654.0	1,427.3	1,581.7	3,508.5	3,465.2	1,634.2	0.0	13,270.9	
	T	1,900.3	1,639.8	1,817.3	4,030.9	3,981.2	1,877.6	0.0	15,247.0	
d) Contingency for Civil	F.C.	724.9	693.9	792.4	1,507.8	1,309.4	631.0	0.0	5,659.4	
Works	L.C.	616.6	475.3	507.4	1,332.8	1,465.6	680.0	0.0	5,077.7	
(a*10 %)	T	1,341.5	1,169.3	1,299.8	2,840.6	2,775.0	1,311.0	0.0	10,737.2	
e) Sub-Total	F.C.	7,973.8	7,773.9	8,716.3	16,585.5	14,403.5	6,941.5	0.0	62,394.3	
(a+b+c+d)	L.C.	7,574.1	5,378.2	5,581.2	14,661.2	16,121.7	7,479.5	0.0	56,796.0	
	T	15,547.9	13,152.1	14,297.5	31,246.7	30,525.2	14,421.0	0.0	119,190.3	
2. Hydraulic Equipment										
a) Hydraulic Equipment	F.C.				1,365.6	7,479.3	6,300.7	0.0	15,145.6	Gates,Valve and
	L.C.				0.0	1,465.9	1,283.1	0.0	2,748.9	Penstocks
	T				1,365.6	8,945.1	7,583.8	0.0	17,894.5	
b) Project Control	F.C.				27.0	183.1	155.4		365.5	
(a * 18 %)	L.C.				181.6	1,229.3	1,043.3		2,454.2	
	T				208.6	1,412.4	1,198.7		2,819.7	
c) Contingency	F.C.				71.0	392.3	330.6		793.8	
(a*5 %+b*10%)	L.C.				18.2	196.2	168.5		382.9	
	T				89.1	588.5	499.1		1,176.7	
d) Sub-Total	F.C.				1,463.6	8,054.6	6,786.6		16,304.9	
(a+b+c)	L.C.				199.7	2,891.4	2,494.9		5,586.0	
	T				1,663.4	10,946.0	9,281.5		21,890.9	
3. Electromechanical Equipment										
a) Electromechanical	F.C.			3,200.0	838.0	15,680.0	470.0	0.0	20,188.0	Turbines,
Equipment	L.C.			0.0	0.0	435.8	1,426.8	137.0	1,999.5	Generators etc.
	T			3,200.0	838.0	16,115.8	1,896.8	137.0	22,187.5	
b) Project Control	F.C.			63.4	16.6	320.9	43.3	3.3	447.4	
(a * 18 %)	L.C.			425.5	111.4	2,154.7	291.1	21.9	3,004.6	
	T			488.9	128.0	2,475.6	334.4	25.2	3,452.1	
c) Contingency	F.C.			166.3	43.6	816.1	27.8	0.3	1,054.1	
(a*5 %+b*10 %)	L.C.			42.5	11.1	237.3	100.4	9.0	400.4	
	T			208.9	54.7	1,053.3	128.3	9.4	1,454.6	
d) Sub-Total	F.C.			3,429.7	898.2	16,816.9	541.2	3.6	21,689.6	
(a+b+c)	L.C.			468.0	122.6	2,827.7	1,818.3	167.9	5,404.5	
	T			3,897.7	1,020.7	19,644.7	2,359.5	171.5	27,094.1	
GENERATING FACILITY										
Total (1+2+3)	F.C.	7,973.8	7,773.9	12,146.0	18,947.2	39,275.0	14,269.3	3.6	100,388.8	
	L.C.	7,574.1	5,378.2	6,049.3	14,983.5	21,840.9	11,792.6	167.9	67,786.5	
	T	15,547.9	13,152.1	18,195.3	33,930.8	61,115.8	26,061.9	171.5	168,175.3	
4. Transmission Line										
a) Transmission Line	F.C.			1,090.0	4,995.0	849.0	637.0	0.0	7,571.0	Steel towers,
	L.C.			0.0	533.7	711.3	533.7	0.0	1,778.7	Conductors etc
	T			1,090.0	5,528.7	1,560.3	1,170.7	0.0	9,349.7	
b) Compensation	F.C.	0.0	0.0						0.0	
(Land)	L.C.	102.8	102.8						205.7	
	T	102.8	102.8						205.7	
c) Project Control	F.C.			21.6	111.6	33.8	25.3	0.0	192.3	
(a * 18 %)	L.C.			144.9	749.7	226.8	170.2	0.0	1,291.6	
	T			166.5	861.3	260.6	195.5	0.0	1,484.0	
d) Contingency	F.C.			56.7	260.9	45.8	34.4	0.0	397.8	
(a*5 %+c*10 %)	L.C.			14.5	101.7	58.2	43.7	0.0	218.1	
	T			71.2	362.6	104.1	78.1	0.0	615.9	
e) Sub-Total	F.C.	0.0	0.0	1,168.2	5,367.5	928.6	696.7	0.0	8,161.1	
(a+b+c+d)	L.C.	102.8	102.8	159.4	1,385.0	996.4	747.6	0.0	3,494.1	
	T	102.8	102.8	1,327.7	6,752.5	1,925.0	1,444.3	0.0	11,655.2	
5. Grand Total	F.C.	7,973.8	7,773.9	13,314.2	24,314.8	40,203.6	14,966.0	3.6	108,549.9	
(Project Cost)	L.C.	7,676.9	5,481.1	6,208.7	16,368.5	22,837.3	12,540.2	167.9	71,280.6	
	T	15,650.7	13,254.9	19,522.9	40,683.3	63,040.9	27,506.3	171.5	179,830.5	

Table 14-2 Economic Cost and Benefit Flow

Pirris Project ECONOMIC EVALUATION (Original Case)

(Unit : 10^3 US dollars)

No.		Year	Pirris Hydro Power Project				Alternative Thermal Power Project										(B) Total Cost	(B) - (C)
							Gas Turbine (109.9MW)				Slow Speed Engine (Diesel) (48.9MW)				Transmission Line			
			Construct. Cost	Trasm. Line Cost	O & M Cost	(C) Total Cost	Construct. Cost	O & M Cost	Fuel Cost	Sub Total Cost	Construct. Cost	O & M Cost	Fuel Cost	Sub Total Cost	Construct. Cost	O & M Cost		
-1		1995	15,548	103		15,651									188		188	-15,462
1		1996	13,152	103		13,255									1,865		1,865	-11,390
2		1997	18,195	1,328		19,523									8,692		8,692	-10,831
3		1998	33,931	6,753		40,683									5,400		5,400	-35,283
4		1999	61,116	1,925		63,041	4,842			4,842	6,837			6,837	2,246		13,924	-49,117
5	0	2000	26,062	1,444		27,506	27,890			27,890	39,864			39,864	1,873		69,626	42,120
6	1	2001	172	0	1,004	1,175	7,381	1,219	10,897	19,497	18,224	1,060	3,831	23,115	562	208	43,383	42,208
7	2	2002			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
8	3	2003			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
9	4	2004			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
10	5	2005			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
11	6	2006			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
12	7	2007			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
13	8	2008			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
14	9	2009			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
15	10	2010			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
16	11	2011			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
17	12	2012			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
18	13	2013			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
19	14	2014			1,506	1,506	29,041	1,829	16,346	47,216		1,591	5,746	7,337		312	54,865	53,360
20	15	2015			1,506	1,506	11,071	1,829	16,346	29,246		1,591	5,746	7,337		312	36,895	35,389
21	16	2016			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
22	17	2017			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
23	18	2018			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
24	19	2019			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
25	20	2020			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
26	21	2021			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
27	22	2022			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
28	23	2023			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
29	24	2024			1,506	1,506		1,829	16,346	18,175	10,258	1,591	5,746	17,595		312	36,082	34,577
30	25	2025		103	1,506	1,608		1,829	16,346	18,175	54,666	1,591	5,746	62,003	282	312	80,772	79,164
31	26	2026		103	1,506	1,608		1,829	16,346	18,175		1,591	5,746	7,337	2,657	312	28,481	26,872
32	27	2027		1,328	1,506	2,833		1,829	16,346	18,175		1,591	5,746	7,337	11,709	312	37,533	34,700
33	28	2028		6,753	1,506	8,258		1,829	16,346	18,175		1,591	5,746	7,337	2,246	312	28,070	19,812
34	29	2029		1,925	1,506	3,431	29,041	1,829	16,346	47,216		1,591	5,746	7,337	2,246	312	57,111	53,681
35	30	2030		1,444	1,506	2,950	11,071	1,829	16,346	29,246		1,591	5,746	7,337	1,686	312	38,581	35,631
36	31	2031	3,898	0	1,506	5,403		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	20,421
37	32	2032	2,684		1,506	4,190		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	21,634
38	33	2033	30,591		1,506	32,096		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	-6,272
39	34	2034	11,641		1,506	13,147		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	12,678
40	35	2035	172		1,506	1,677		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,147
41	36	2036			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
42	37	2037			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
43	38	2038			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
44	39	2039			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
45	40	2040			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
46	41	2041			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
47	42	2042			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
48	43	2043			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
49	44	2044			1,506	1,506	29,041	1,829	16,346	47,216		1,591	5,746	7,337		312	54,865	53,360
50	45	2045			1,506	1,506	11,071	1,829	16,346	29,246		1,591	5,746	7,337		312	36,895	35,389
51	46	2046			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
52	47	2047			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
53	48	2048			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
54	49	2049			1,506	1,506		1,829	16,346	18,175		1,591	5,746	7,337		312	25,824	24,319
55	50	2050			1,506	1,506	-26,741	1,829	16,346	-8,566		1,591	5,746	7,337		312	-917	-2,422
TOTAL			217,160	23,310	74,776	315,246	133,707	90,845	811,851	1,036,403	129,848	79,002	285,385	494,235	41,653	15,516	1,587,807	1,272,560
Present Value I = 12 %						135,536											199,752	64,216
																	E.D.R.	19.27%
																	B/C	1.47

Table 14-3 Basic Criteria for Economic Study

Item	Description
Method of Analysis	Discounted Cash Flow Method
Study Period	50 Years plus Construction Period
Discount Rate	12%
Escalation	Not Considered
Shadow Price Factor (Conversion Factor)	Considered
Service Life of Facilities Dam and Reservoir Hydro-power Plant Thermal Power Plant Transmission Line Exchange Rate of Currency (As of January, 1991)	 50 Years 35 Years 25 Years for Diesel (slow speed), 15 Years for Gas Turbine 30 Years US$1.00 = 105 Colones

(1) Plant Parameters

The plant parameters of the alternative thermal power plant having potentials equivalent to the Project are presented in Table 14-4.

Table 14-4 Alternative Thermal Power Plant for Studying Economic Justification

Item	Unit	Gas Turbine Thermal Power Plant		Diesel Thermal Power Plant		Pirris Hydroelectric Project	
Installed Capacity	MW	109.9		48.9		128.0	
Dependable Capacity	MW	109.9		48.9		126.0	
Losses	%	21.6		25.9		2.9	
Effective Dependable Capacity	MW	86.2		36.3		122.4	
Annual Energy Production	GWh	288.8		350.4		609.3	
Station Service Use	%	kW 5	kWh 5	kW 5	kWh 5	kW 0.3	kWh 0.3
Failure Loss	%	10	--	15	--	0.3	--
Repair Loss	%	8	--	8	--	2.0	--
Transmission Loss	%	0.3	0.1	0.2	0.2	0.3	0.2
Annual Available Energy	GWh	274.1		332.2		606.3	
Annual Plant Factor	%	30.0		81.8		54.3	
Service Life	year	15		25		50 (Civil) 35 (Hydro/Elec. Equip.)	
Thermal Efficiency	%	27.23		34.32		--	
Diesel Calorific Value	kcal/kg	10,248		--		--	
Bunker Calorific Value	kcal/kg	--		10,207		--	
Fuel Consumption Rate	kg/kWh	0.308		0.246		--	
Unit Fuel Price 1/	$/kg ($/ℓ)	0.1838 (0.1529)		0.0669 (0.0657)		--	
"	$/kWh	0.0566		0.0164		--	
Construction Cost 2/ 3/	10^3 US$	40,112		64,924		--	
Unit Construction Cost 3/	US$/kW	364.95		1,327.69		--	
O & M Cost Ratio	%	4.56		2.45		--	
O & M Cost per year 3/	10^3 US$	1,828.9		1,590.6		--	
Fuel Cost per year	10^3 US$	16,346		5,746		--	

1/ : CIF Price, not including taxes

2/ : not included (interest during construction, transmission line cost)
included (project controlling cost)

3/ : Economic price

(2) Initial Investment Cost of Alternative Thermal Plant and Transmission Line

The initial investment cost required for construction of the alternative thermal power plant (Gas Turbine = 109.9 MW, Slow Speed Diesel = 48.9 MW) and transmission line (230 kV x 2 cct x 78 km) was estimated as follows.

(a) Gas Turbine (109.9 MW) Unit: 10^3 US$

Year	1st	2nd	3rd	total
Financial Cost (excluding interest during Construction)				
Foreign Currency	3,944.9	22,724.6	6,013.7	32,683.2
Local Currency	1,080.3	6,223.1	1,646.8	8,950.3
Total	5,025.2	28,947.7	7,660.5	41,633.5
Economic Cost				
Foreign Currency	3,944.9	22,724.6	6,013.7	32,683.2
Local Currency	896.6	5,165.2	1,366.9	7,428.7
Total	4,841.5	27,889.8	7,380.6	40,111.9

(b) Slow Speed Diesel (48.9 MW) Unit: 10^3 US$

Year	1st	2nd	3rd	total
Financial Cost (excluding interest during Construction)				
Foreign Currency	5,928.0	34,566.1	15,802.5	56,296.6
Local Currency	1,094.6	6,382.3	2,917.8	10,394.7
Total	7,022.6	40,948.5	18,720.2	66,691.3
Economic Cost				
Foreign Currency	5,928.0	34,566.1	15,802.5	50,296.6
Local Currency	908.5	5,297.3	2,421.8	8,627.6
Total	6,836.5	39,863,5	18,224.2	64,924.2

(c) Total Cost ((a) + (b)) Unit: 10^3 US$

Year	1st	2nd	3rd	total
Financial Cost (excluding interest during Construction)				
Foreign Currency	9,872.9	57,290.7	21,816.2	88,979.8
Local Currency	2,174.9	12,605.4	4,564.6	19,344.9
Total	12,047.7	69,896.2	26,380.8	108,324.7
Economic Cost				
Foreign Currency	9,872.9	57,290.7	21,816.2	88,979.8
Local Currency	1,805.1	10,462.5	3,788.6	16,056.3
Total	11,678.0	67,753.2	25,604.8	105,036.1

(d) Transmission Line for Alternative Thermal Power Plant
(230 kV x 2 cct x 78 km)

Year	1st	2nd	3rd	4th	5th	6th	7th	total
Financial Cost (excluding interest during Construction)								
Foreign Currency	0	1,380.5	6,942.7	3,857.6	1,097.1	914.8	274.6	14,467.3
Local Currency	226.7	584.0	2,107.3	1,859.0	1,384.5	1,153.9	346.2	7.661.5
Total	226.7	1,964.5	9,050	5,716.6	2,481.6	2,068.7	620.8	22,128.8
Economic Cost								
Foreign Currency	0	1,380.5	6,942.7	3,857.6	1,097.1	914.8	274.6	14,467.3
Local Currency	188.1	487.8	1,749.1	1,542.9	1,149.1	957.7	287.3	6,359.0
Total	188.1	1,865.2	8,691.8	5,400.4	2,246.2	1,872.5	561.9	20,826.3

(3) Annual Operation, Maintenance and Repair Cost

Unit: 10^3 US$

Thermal Power Plant (Gas turbine)	40,112 x 4.56% =	1,829.1
Thermal Power Plant (Diesel)	64,924 x 2.45% =	1,590.6
Transmission Line	20,826.3 x 1.5% =	312.4
Total		3,732.1

(4) Fuel Cost

- Gas Turbine

Unit Fuel Cost (Diesel)	0.0566 US$/kWh
Annual Fuel Cost	$0.0566 \times 288.8 \times 10^6$kWh=$16,346 \times 10^3US

- Slow Speed Diesel

Unit Fuel Cost (Banker)	0.0164 US$/kWh
Annual Fuel Cost	$0.0164 \times 350.4 \times 10^6$kWh=$5,746 \times 10^3US

(5) Economic Cost

The economic cost flow of the alternative thermal power plant, which is the benefit of the Project, is presented in Table 14-2.

14.1.4 Economic Evaluation of the Project

As described in 14.1.1, the economic evaluation of the Project is evaluated with the net present value (NPV), the benefit cost ratio (B/C) and the economic internal rate of return (EIRR) which are calculated by the discounted cash flow method. These indices are obtained with the following equations.

(1) Net Present Value (NPV) Method

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

where, B_t : the benefit in the "t"th year
C_t : the cost in the "t"th year
r : the discount rate
n : the period of calculation

(2) Benefit-Cost Ratio (B/C) Method

$$B/C = \sum_{t=0}^{n} \frac{\frac{B_t}{(1+r)^t}}{\frac{C_t}{(1+r)^t}}$$

where, B_t : the benefit in the "t"th year

C_t : the cost in the "t"th year

r : the discount rate

n : the period of calculation

(3) Economic Internal Rate of Return (EIRR) Method

$$\sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t} = 0$$

where, B_t : the benefit in the "t"th year

C_t : the cost in the "t"th year

r : the discount rate (the internal rate of return)

n : the period of calculation

The amount of benefit and cost expressed for each year throughout the project life is called a cash flow. Cost in the cash flow includes project cost incurred during the construction period, as well as operation, maintenance and fuel cost after the commencement of operation. Capital cost such as interest and depreciation is excluded from the flow. The benefit and cost in the cash flow are expressed by the border prices. When the benefit of a hydroelectric project is not expressed by the amount of electric tariff as the consumers' willingness to pay, but is expressed in the cost of an alternative thermal power plant, the economic internal rate of return of the hydroelectric project is called the equalized discount rate (EDR), as the hydroelectric project cost and the alternative thermal plant cost (benefit) become equal at that discount rate.

Together with the EDR method, the evaluation by the economic internal rate of return was also studied where the benefit of the hydroelectric power was the

assumed expected revenue from the electricity sales (unit sales cost: 0.0533 US$/kWh), as a proxy to the customers' willingness to pay.

(1) Economic Evaluation of the Project

(a) Net Present Value (B-C) and Benefit-Cost Ratio (B/C)

The flow of economic costs of the Project throughout the project life is presented in Table 14-2. The net present value in the first year of the Project is 135,536 x 10^3 US$ (C) at a discount rate of 12%. The present value (B) of an alternative thermal power plant is 199,752 x 10^3 US$. Consequently, the net present value (B-C) of the Project is 64,216 x 10^3 US$, and the Benefit-Cost Ratio (B/C) is 1.47.

As indicated by these two indices, the cost of construction and operation of the Project is smaller than that of an alternative thermal plant which can provide equivalent service, and it can be concluded that the Project is superior than the alternative thermal plan plant.

(b) Economic Internal Rate of Return (EDR and EIRR)

The discount rate at which the present values of the investments on the Project and on the alternative thermal power plant becomes equal in the first year of the projects (that is, EDR), is 19.27% as indicated in Table 14-2. Thus it can be concluded that the Project is superior unless the discount rate does not exceed 19.27%. On the other hand, if the expected electricity sales revenue is to be used in estimating the benefit of the Project for calculation of the economic internal rate of return, the amount of revenue is 32,315.8 x 10^3 US$/year. The value of the economic internal rate of return based on this revenue is 12.85% as indicated in Table 14-5.

This rate exceeds the capital opportunity cost 12% in Costa Rica. Thus the Project can be regarded to have sufficient economic value for investment.

Table 14-5 Economic Internal Rate of Return

Pirris Project (EIRR) (unit: 10^3 US dollars)

No.	Year	Pirris Hydro Power Project				Electric Tariff Revenue	
		Construct. Cost	Trasm. Line Cost	O & M Cost	(C) Total Cost	(B) Benefit	(B)-(C)
-1	1995	15,548	103		15,651		-15,651
1	1996	13,152	103		13,255		-13,255
2	1997	18,195	1,328		19,523		-19,523
3	1998	33,931	6,753		40,683		-40,683
4	1999	61,116	1,925		63,041		-63,041
5	0 2000	26,062	1,444		27,506		-27,506
6	1 2001	172	0	1,004	1,175	21,544	20,369
7	2 2002			1,506	1,506	32,316	30,810
8	3 2003			1,506	1,506	32,316	30,810
9	4 2004			1,506	1,506	32,316	30,810
10	5 2005			1,506	1,506	32,316	30,810
11	6 2006			1,506	1,506	32,316	30,810
12	7 2007			1,506	1,506	32,316	30,810
13	8 2008			1,506	1,506	32,316	30,810
14	9 2009			1,506	1,506	32,316	30,810
15	10 2010			1,506	1,506	32,316	30,810
16	11 2011			1,506	1,506	32,316	30,810
17	12 2012			1,506	1,506	32,316	30,810
18	13 2013			1,506	1,506	32,316	30,810
19	14 2014			1,506	1,506	32,316	30,810
20	15 2015			1,506	1,506	32,316	30,810
21	16 2016			1,506	1,506	32,316	30,810
22	17 2017			1,506	1,506	32,316	30,810
23	18 2018			1,506	1,506	32,316	30,810
24	19 2019			1,506	1,506	32,316	30,810
25	20 2020			1,506	1,506	32,316	30,810
26	21 2021			1,506	1,506	32,316	30,810
27	22 2022			1,506	1,506	32,316	30,810
28	23 2023			1,506	1,506	32,316	30,810
29	24 2024			1,506	1,506	32,316	30,810
30	25 2025		103	1,506	1,608	32,316	30,707
31	26 2026		103	1,506	1,608	32,316	30,707
32	27 2027		1,328	1,506	2,833	32,316	29,483
33	28 2028		6,753	1,506	8,258	32,316	24,058
34	29 2029		1,925	1,506	3,431	32,316	28,885
35	30 2030		1,444	1,506	2,950	32,316	29,366
36	31 2031	3,898		1,506	5,403	32,316	26,913
37	32 2032	2,684		1,506	4,190	32,316	28,126
38	33 2033	30,591		1,506	32,096	32,316	220
39	34 2034	11,641		1,506	13,147	32,316	19,169
40	35 2035	172		1,506	1,677	32,316	30,639
41	36 2036			1,506	1,506	32,316	30,810
42	37 2037			1,506	1,506	32,316	30,810
43	38 2038			1,506	1,506	32,316	30,810
44	39 2039			1,506	1,506	32,316	30,810
45	40 2040			1,506	1,506	32,316	30,810
46	41 2041			1,506	1,506	32,316	30,810
47	42 2042			1,506	1,506	32,316	30,810
48	43 2043			1,506	1,506	32,316	30,810
49	44 2044			1,506	1,506	32,316	30,810
50	45 2045			1,506	1,506	32,316	30,810
51	46 2046			1,506	1,506	32,316	30,810
52	47 2047			1,506	1,506	32,316	30,810
53	48 2048			1,506	1,506	32,316	30,810
54	49 2049			1,506	1,506	32,316	30,810
55	50 2050			1,506	1,506	32,316	30,810
T O T A L		217,160	23,310	74,776	315,246	1,605,018	1,289,771
						E. I. R. R.	12.85%

14.2 Financial Evaluation

14.2.1 Method of Financial Evaluation

In conducting the financial evaluation of the Project, a cash flow expressed at market prices is developed for all costs including the capital invested in the Project, taxes, operation and maintenance cost, replacement cost, project controlling cost, etc. This cost cash flow is compared to the benefit cash flow that is obtained by the expected income from the sales of electricity generated by the Project. Finally the financial internal rate of return (FIRR) is calculated by the discounted cash flow method (DCF method).

The discount rate for the DCF method was determined as 12% in consultation with ICE.

14.2.2 Financial Cost and Benefit of the Project

(1) Financial Cost of the Project

The amount of initial investment and the replacement cost is obtained from Chapter 12, "Construction Planning and Cost Estimation". The following values were selected as the operation and maintenance cost.

Operation and Maintenance Cost:

Civil facilities construction cost x 0.5%
Hydraulic equipment cost x 1.5%
Electro-mechanical equipment cost x 1.5%
Transmission line cost x 1.5%

The total expenditure (the total of cash outflow) of the Project is 337,912 x 10^3US$ as shown in Table 14-6, of which the amount of initial investment is 194,430 10^3US$ (excluding interest during construction). The operation and maintenance cost is as follows:

Civil facilities	130,823 x 0.005 =	654.1 x 10^3 US$
Hydraulic equipment	23,035 x 0.015 =	345.5 x 10^3 US$
Electrical equipment	28,201 x 0.015 =	423.0 x 10^3 US$
Transmission Line and sub-station facilities	12,371 x 0.015 =	185.6 x 10^3 US$
Total:		1,608.2 x 10^3 US$

(2) Financial Benefit of the Project

The financial benefit of the Project is the electricity sale revenue. The revenue is calculated based on ICE's average tariff of 0.0533 US$/kWh as of January 1991.

The evaluation is made at the receiving end of Escazu Substation. It is assumed that the average annual available energy of the Project (606.3 x 10^6 kWh) throughout its life corresponds to the amount of electricity that can be sold.

Thus the revenue was calculated at the average rate of 0.0533 US$/kWh which amounts to 32,315.8 x 10^3 US$/year.

14.2.3 Financial Evaluation of the Project

The discount rate at which the financial cost equals the income (that is, the financial internal rate of return) is 12.02%. When this rate is compared to the expected average interest rates of 8.5% for borrowings for foreign currency, it can be concluded that the Project is sound from the financial point of view.

Table 14-6 Financial Internal Rate of Return

Pirris Project (FIRR) (unit: 10^3 US dollars)

No.		Year	Pirris Hydro Power Project				Electric Tariff Revenue	
			Construct. Cost	Trasm. Line Cost	O & M Cost	(C) Total Cost	(B) Benefit	(B)-(C)
-1		1995	17,099	124		17,223		-17,223
1		1996	14,254	124		14,378		-14,378
2		1997	19,434	1,360		20,795		-20,795
3		1998	37,000	7,036		44,036		-44,036
4		1999	65,589	2,129		67,718		-67,718
5	0	2000	28,477	1,597		30,075		-30,075
6	1	2001	206	0	1,072	1,278	21,544	20,266
7	2	2002			1,608	1,608	32,316	30,708
8	3	2003			1,608	1,608	32,316	30,708
9	4	2004			1,608	1,608	32,316	30,708
10	5	2005			1,608	1,608	32,316	30,708
11	6	2006			1,608	1,608	32,316	30,708
12	7	2007			1,608	1,608	32,316	30,708
13	8	2008			1,608	1,608	32,316	30,708
14	9	2009			1,608	1,608	32,316	30,708
15	10	2010			1,608	1,608	32,316	30,708
16	11	2011			1,608	1,608	32,316	30,708
17	12	2012			1,608	1,608	32,316	30,708
18	13	2013			1,608	1,608	32,316	30,708
19	14	2014			1,608	1,608	32,316	30,708
20	15	2015			1,608	1,608	32,316	30,708
21	16	2016			1,608	1,608	32,316	30,708
22	17	2017			1,608	1,608	32,316	30,708
23	18	2018			1,608	1,608	32,316	30,708
24	19	2019			1,608	1,608	32,316	30,708
25	20	2020			1,608	1,608	32,316	30,708
26	21	2021			1,608	1,608	32,316	30,708
27	22	2022			1,608	1,608	32,316	30,708
28	23	2023			1,608	1,608	32,316	30,708
29	24	2024			1,608	1,608	32,316	30,708
30	25	2025		124	1,608	1,732	32,316	30,584
31	26	2026		124	1,608	1,732	32,316	30,584
32	27	2027		1,360	1,608	2,969	32,316	29,347
33	28	2028		7,036	1,608	8,644	32,316	23,671
34	29	2029		2,129	1,608	3,737	32,316	28,578
35	30	2030		1,597	1,608	3,206	32,316	29,110
36	31	2031	3,994	0	1,608	5,602	32,316	26,714
37	32	2032	2,750		1,608	4,358	32,316	27,957
38	33	2033	31,762		1,608	33,370	32,316	-1,054
39	34	2034	12,524		1,608	14,133	32,316	18,183
40	35	2035	206		1,608	1,814	32,316	30,502
41	36	2036			1,608	1,608	32,316	30,708
42	37	2037			1,608	1,608	32,316	30,708
43	38	2038			1,608	1,608	32,316	30,708
44	39	2039			1,608	1,608	32,316	30,708
45	40	2040			1,608	1,608	32,316	30,708
46	41	2041			1,608	1,608	32,316	30,708
47	42	2042			1,608	1,608	32,316	30,708
48	43	2043			1,608	1,608	32,316	30,708
49	44	2044			1,608	1,608	32,316	30,708
50	45	2045			1,608	1,608	32,316	30,708
51	46	2046			1,608	1,608	32,316	30,708
52	47	2047			1,608	1,608	32,316	30,708
53	48	2048			1,608	1,608	32,316	30,708
54	49	2049			1,608	1,608	32,316	30,708
55	50	2050			1,608	1,608	32,316	30,708
Total			233,295	24,742	79,875	337,912	1,605,018	1,267,106
							F. I. R. R.	12.02%

14.3 Sensitivity Analysis

The sensitivity analysis was implemented for the following cases considering varying financial conditions that will raise Construction Costs of the Pirris Project 5%, 10%, 15% and 20%.

The evaluation of B-C, B/C were calculated on the basis of a Discount Rate of 12%. The Results of each evaluation of B-C, B/C, EDR, EIRR and FIRR are presented in Table 14-7.

Table 14-7 Results of Sensitivity Analysis

Rise of Construction Cost	B - C (10^3US$)	B/C	EDR (%)	EIRR (%)	FIRR (%)
Original Case	64,216	1.47	19.27	12.85	12.02
Case 1: 5% UP	57,439	1.40	18.17	12.33	11.52
Case 2: 10% UP	50,662	1.34	17.17	11.84	11.06
Case 3: 15% UP	43,885	1.28	16.27	11.39	10.62
Case 4: 20% UP	37,109	1.23	15.45	10.96	10.21