REPUBLIC OF KENYA

KENYA POWER COMPANY LIMITED

FEASIBILITY STUDY ON MAGWAGWA HYDROELECTRIC POWER DEVELOPMENT PROJECT

FINAL REPORT

SUPPORTING REPORT (2)

OCTOBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

NAIROBI OFFICE
P.O.BOX 59572
NAIROBI KENYA

TOKYO HEAD OFFICE
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I. INTRODUCTION

1.1 Objectives

The objectives of the Natural Environmental Study (the Study) on the Magwagwa Hydroelectric Development Project (the Project) are as follows:

i) To identify impacts which are expected to cause on the natural environment by the Project,
ii) To evaluate magnitude/significance of the impacts,
iii) To propose countermeasures for mitigating the magnitude of the impacts,
iv) To evaluate the acceptability of the Project through the viewpoint of the natural environment, and to recommend further studies if any.

1.2 Approach of the Natural Environmental Study

Screening and scoping approaches were applied for the Study to ensure time and cost saving for the implementation of Environmental Impact Assessment (EIA) of the Project. Also this is a common approach of EIA in developing countries. The screening was conducted based on the existing guidelines set by the Government of Kenya and the World Bank related to EIA in Kenya, and the scoping was carried out by considering Initial Environmental Examination (IEE) for the Project.

IEE is essentially an initial examination of the environmental effect potentials for the proposed Project based mostly on the preliminary information which can readily be obtained in the first stage of the Study period. Thus IEE is the first approach of EIA by scoping, which determines whether or not a detailed EIA will be required.

As for the screening, the environmental management guidelines in the Environmental Management Report prepared by National Environment Secretariat (NES), Ministry of Environment and Natural Resources in 1982 and the Operational Directive 4.00, Annex A: Environmental Assessment set by the World Bank were used as the criteria for screening of the types of the projects which EIA needs to be conducted and for the selection of environmental aspects to be assessed. These guidelines concluded the Project implementation should include the environmental assessment.

1.3 General Features of the Project

The Project area lies in the middle to lower reaches of the Sondu River which has a catchment of about 3,470 km^2 at the estuary. The proposed dam site is situated at a narrow gorge near Magwagwa village about 5 km downstream from the confluence of the Kipsonoi and Yurith rivers. The reservoir area occupies the land below the elevation of 1,670 m which is the selected dam crest elevation, and the waterway constructed on the left bank of the Sondu River leads water to the powerhouse with an 8 km headrace tunnel and penstock. The general features of the Project are as follows:

Catchment area	:	3,160 km^2 at the damsite
Average inflow	:	42.0 m^3/sec (at the 1JG1 gauging station)
Dam crest elevation	:	El. 1,670 m
Dam height	:	110 m
Full supply level	:	El. 1,665 m
Minimum operating level	:	El. 1,609 m
Total storage volume	:	808 million m^3
Active storage volume	:	701 million m^3
Reservoir surface area for the dam crest elevation	:	26 km^2
Plant discharge	:	82.0 m^3/sec
Maintenance flow	:	0.5 m^3/sec.

After generating power and energy at the power plant of the Project, water returns to the Sondu River and is diverted to the Kano plain for the power generation at the Sondu/Miriu scheme and for the Kano irrigated agriculture development.

II. EXISTING CONDITIONS OF THE NATURAL ENVIRONMENT

2.1 Geographic Conditions

(1) Topography

The major part of the Project exhibits undulating to rolling topography that gives way to flat terrain in some parts. This type of topography has obviously facilitated the diversification of agriculture. The overall slope of the area which varies from 2 to 30 % is towards the west.

The Sondu River originates from the western slope of the Mau Escarpment at an elevation of about 2,800 m above sea level. The Sondu River flows down westwards gathering such major tributaries as the Yurith and Kipsonoi rivers, and comes into the narrow gorge penetrating the Nykach Escarpment with scenic waterfalls called the Odino Falls. The river finally drains into the Winam Gulf of Lake Victoria through flood plains consisting of alluvial deposits. At a piedmont of the escarpment near the proposed Sondu/Miriu power station, extensive gully erosion appears due to rush of stream flows from hillsides.

(2) Geology

The geological formation of the Project area falls into three principal categories; Pre-Cambrian rocks, Tertiary lavas and Quaternary volcanics. The heterogenerous geological formations of them have contributed to differential erosion and weathering processes and to formation of meander and falls along the Sondu River system.

Major formations of the Pre-Cambrian rocks are the Kavirondian system, Nyanzian system and Bukoban system in the basin. Tertiary lavas, which are formed as a result of tectonomagnetic activities connected with the Rift system, widely cover the basin including isolated areas around the Winam Gulf. Quaternary formations cover the most areas where the Pleistocene sediments, which include lake and river deposits forming semi-consolidated layer of clay, sand and gravel, are exposed.

(3) Soil and erosion

Soils in the basin can be classified into several groups with different characteristics and fertility such as Vertisols, Nitosols, Cambisols and Ferralsols. The distribution of those soil types is complex by receiving influence of extensive variations of

topography, climate, volcanic activity, underlying rock types, and weathering and erosional processes. The soil classification also provides important soil characteristics in terms of land use requirements.

Although several types of erosion can be found around the Project area, no severe erosion has been reported in the basin mainly due to its high vegetation coverage by forests and tea plantations. Annual sediment loads are estimated at about 531,000 m^3 at the dam site, or 0.168 mm/km^2/year in terms of the denudation rate. But recent increase of human activities such as agricultural intensification, monoculture, overgrazing and human settlement is accelerating soil erosion in the basin.

2.2 Climate

The climate of the Project area located in the highlands varying from 1,500 m to 2,000 m above sea level is moderate with relatively small variation in temperature, ranging from 19°C to 25°C throughout a year, while daily temperature varies considerably, ranging from 15°C to 30°C. In the uppermost area of the basin, however, the mean minimum temperature is very low, varying from 6.0°C to 10.9°C. Although night temperature is considerably low, frost and hail have rarely been experienced.

Rainfall is abundant with an average annual value of 1,500 mm to 1,600 mm, varying from 2,000 mm in highlands to 1,200 mm in lowlands. The Project area generally experiences a bimodal rainfall distribution pattern, and the over-year variation is considerably large despite the absence of remarkable dry months.

2.3 Water Quality

There exists no available water quality data in the Sondu River and its tributaries. Water sampling and water quality analysis were thus carried out in this Study. The location of sampling stations and the results of water quality analysis are shown in Figure 2.1 and Table 2.1, respectively.

All analysed physio-chemical parameters show clean river water although its colour is light brown. Water temperature in the Yurith River is slightly lower than that of the Kipsonoi River, and it is almost 20°C at the dam site. Total Dissolved Solids (TDS) and Turbidity are rather high due to the existence of fine sediments in water. Dissolved Oxygen (DO) is almost at the saturated level, and Biochemical Oxygen Demand (BOD) and

Phosphate are low, showing that there is no severe threat of organic pollution in the river at present.

2.4 Wildlife and Nature Conservation

(1) Vegetation

Natural vegetation covers almost 50% of the basin as shown in Table 2.2, in which trees, bushes and grasses are included. Natural as well as planted forests can be found almost extensively in the South Western Mau. However, the vegetation coverage around the Project area is less than 30% mainly due to intensive land use by cultivation.

(2) Aquatic flora

Aquatic weeds of nuisance such as the Nile cabbage (Pistia stratiothes), the water hyacinth (Eichorumia crassipes) and the water fern (Salmenia molesta) were not found in the upstream areas of the dam site, even in the reservoir areas of the existing small dams, i.e. the Jamji and Chagaik dams. However, those weeds are commonly found in the swamp areas of the Nyando River, which neighbours the Sondu River in the north, and in the lagoons around Kisumu city.

(3) Terrestrial fauna

According to the inquiry survey, only common animals such as rats, squirrels, lizards and snakes can be found in and around the Project area due to intensive land use and low vegetation coverage, although several species of big animals can be found in the uppermost areas covered by the dense forests.

(4) Aquatic fauna

The field survey on aquatic fauna revealed that the actual densities of macro-invertebrates were very low and varied greatly from place to place along the rivers probably due to fast flowing in most places of the rivers and little opportunity for benthic invertebrates to establish. In the Jamji and Chagaik dams, however, macro-invertebrates were plentiful due to their stagnant water conditions.

Several groups of macro-invertebrates were found at the Magwagwa dam site including may-fly nymphs (Ephemeroptera), dragonfly nymphs (Odonata), crabs,

water beetles and Hemiptercus especially neotonectidae and corixidae. The survey results of the aquatic fauna are shown in Table 2.3.

(5) Fish and fishery

The upper reaches of the Itare and Kitoi rivers are known as the habitat of the introduced rainbow trout, Salmo gairdneri, which is a cold water fish in the temperate zone and was introduced to the high mountain rivers of Kenya. The trout fish are recorded in small numbers in both the Chagaik and Jamji reservoirs located in the Yurith River, but not able to live downstream of those reservoirs because water temperature usually rises above 20°C which is the upper limit in temperature for survival.

Other fish species found in the upstream river courses are the large mouth black bass, Micropterus salmoides, Clarias mossambicus, several species of tilapias, Oreochromis spp. The Jamji and Chagaik dams are rich communities of tilapia fish, Oreochromis spp., Barbus, and mosquitoe fish, Lebistes, as well as cat fish, Clarias. The black bass was introduced in the Sondu River and is recorded all the way down to Lake Victoria.

The fish communities are poor not only in the Kipsonoi and Yurith rivers but also at the reaches after their confluence, i.e. the proposed damsite area. Only a few specimen of Clarias mossambicus, Oreochromis species are found, but Barbus sp., Labeo sp. and Lebistes sp. are recorded in this area. The fish communities upstream of the Odino Falls are not rich and the species variety is low due to the fact that the Odino Falls act as a permanent physical barrier for fish migration from Lake Victoria to the upstream areas of the Sondu River.

Substantial river fishery activities are not conducted by the local people in and around the Project area due to rapid river flow of the Sondu River, although small scale fisheries are found in the lower reaches of the Sondu River and the lake shore areas of Lake Victoria.

(6) Nature conservation

Although no national parks and game reserves have been designated, several gazetted and ungazetted forests can be found in the basin. Gazetted forests are South Western Mau, and Western Mau in the upper reach areas of the basin, and

the ungazetted forest is Miriu. The location and area of those forests are shown in Figure 2.2 and Table 2.4.

2.5 Public Health

Generally, the geographical and climatic conditions of the Project area, which are high in altitude and cool with ample rainfall, are favourable for environmental health particularly in regard to prevention of some vector borne diseases, nutrition and water accessibility.

(1) Water use

Water for domestic use is usually collected from small rivers and springs near villages, most cases within 500 m in distance, which are also used for watering for their livestock. Sanitation is rather poor and a few households use pit latrine. Thus, water from rivers and springs is often contaminated with human and livestock fecal bacteria.

(2) Morbidity and vector borne diseases

Morbidity patterns in and around the Project area were collected from health institutions as given in Table 2.5, showing high malaria transmission throughout a year. Malaria occupies one of two in the out-patient disease frequency in the area.

The most common vector in the area is Anopheles gambiae which is known as one of mosquitoe vectors of malaria. Major breeding sites of this mosquitoe are not rainpools formed by surface water, but small exposed slow moving springs and streams because of the well drained conditions in the area. The Study area has been reported to be free from the dengue fever.

Several species of snails which are known as vectors of Schistosoma mansoni were found around the Project area through the field survey, resulting in potential of a threat to the health of local people. Simulium neavei which is known as a vector fly of onchocerciasis was not found in and around the Project area. It is reported that the onchocerciasis was eradicated in 1952 in Kenya, resulting in no threat for this disease in and around the Project area at present.

(3) Health facilities

The number of the existing health facilities in Kericho and Nyamira Districts is shown in Table 2.6. In Kericho District, the facilities located near the Project area, within 10 km of the reservoir area, are two (2) health centres, two (2) sub-health centres and eleven (11) dispensaries. Although the constraints on budget and skilled personnel are noted, the local people lived on the right bank of the Kipsonoi River appear well served with health facilities.

In Nyamira District, the facilities near the Project area are three (3) health centres and two (2) dispensaries. Since Nyamira District was established in 1989, those facilities are far from satisfactory and their services are also in course of development and reorganization. Thus, the health facilities near the Project area are considered inadequate for the present population of the area.

III. INITIAL ENVIRONMENTAL EXAMINATION (IEE)

3.1 Methodology of IEE

IEE is the first approach of EIA by scoping, and the results of IEE should lead the detailed Environmental Impact Assessment (EIA) carried out in the next study stage.

A checklist method was applied as a basic tool for IEE in this Study because it is one of the useful initial tools for identification of impacts and evaluation of magnitude of them. The checklist was prepared by using items of environmental effects as rows and ecological regions as columns. The expected effects were evaluated with the grade of A to C, each of which has positive and negative for each component. The items of 24 items related to the natural environment were selected as given in Table 3-1 taking into consideration the features of the Project and the Environmental Management Guidelines in Kenya.

3.2 Ecological Regions

In order to specify locations of expected impacts, the study area was divided into the following four ecological regions as illustrated in Figure 3.1 based on the characteristics of impacts caused by the Project:

- Region I - Catchment area:
  This region lies in the upstream catchment area of the dam site including the two sub-basins of the Yurith and Kipsonoi rivers and the South Western Mau Forest zone. The total area is about 3,160 km^2.

- Region II - Inundation area:
  This region occupies the area to be submerged in the reservoir including the quarry sites and access roads. The total inundation area is about 26 km^2.

- Region III - River flow reduction area:
  This region is located in the riverine area extended between the main dam and the power outlet, where the reduction of river flow will be experienced as a result of the diversion of river water.

- Region IV - River flow fluctuation area:

This region comprises the riverine area extended from the power outlet to the intake of the Sondu/Miriu scheme, receiving the influence of flow fluctuation caused by the proposed peaking operation of the Magwagwa power plant.

The area downstream of the intake site of the Sondu/Miriu scheme and the irrigation area of Kano Plain are excluded in this Study, because those areas must be covered by the Environmental Study of those schemes. It is however noted that the construction of the Magwagwa dam will cease the development of sand dunes extended in Nyakach plain due to arresting effects of the reservoir for suspended and bed loads carried from the upstream areas by tractive force of flow.

3.3 Results of IEE

(1) Preliminary assessment of the impacts

The results of IEE are shown in Table 3.1 with the preliminary evaluation of expected effects, and are summarized hereafter:

A) Problems due to the location

Nine environmental items were examined based on the existing data and the field reconnaissance, and no negative effects are expected to cause by the Project except for the health facility utilization.

Watershed erosion, which would bring about increase of sediment inflow into the reservoir, is evaluated as a neutral, because the soil erosion and sediment runoff are not currently serious in the basin, resulting in not causing serious impacts to the Project. No mining, forestry and navigation activities are conducted, and furthermore there are not any important historical remains and assets, precious ecology and nature conservation areas to be affected in and around the Project area.

No effects are expected on fishery and on migrating activities of fish, because the river fishery is not conducted in the upstream area of the Sondu/Miriu intake and because there are not economically and academically valuable fish which would have migrating activities in the river due to the existence of the Odino Falls which has blocked them from Lake Victoria.

Disturbance of health facility utilization for local people is considered to be only one negative impact caused by the Project. Not being enough and adequate, the health facilities are important for the local people because of high morbidity in the area. The proposed dam and reservoir are expected to cause significant effects to the utilization of the existing health facilities.

B) Problems in the construction stage

In general, impacts during the construction stage are temporary, and it is possible to take countermeasures to reduce those effects. Thus, the magnitude of the expected effects is considered relatively low.

Soil erosion and water quality deterioration by various kinds of civil works are expected to cause some effects to the downstream area, especially to the water supply facility near Sondu village. Increase of vehicles during construction and submergence of roads would cause difficulties to the existing transportation systems. A lot of workers and labours coming from other regions would also raise the potential of communicable disease prevalence. However, those impacts are unavoidable during the construction of the dam, so that effective and practical countermeasures such as regreening of sites, preparation of sediment ponds, relocation and reconstruction of roads and other public facilities should be taken to reduce the magnitude taking inconvenience of the local people into account.

C) Problems in the operation stage

Among eleven environmental items examined in this Study, the spread of vector borne diseases, especially malaria, is expected to cause serious effects in and around the Project area.

Change of water temperature, water quality deterioration in the downstream area due to the reduction and fluctuation of river flow, and eutrophication in the reservoir are considered to be the major impacts caused by the Project. Since there is the intake of the Nyakach water supply project which would be affected by the Project, a new intake facility is needed to be constructed to ensure its function. Also the maintenance flow of 0.5 m^3 is planned to release from the reservoir for the local use of river water. Therefore, no serious effects are considered in terms of the water use conflicts.

Figure 3.2 shows the expected change of the river flow regime at 1JG1 and the dam site. The existing ecosystem, especially aquatic ecosystem, is expected to be altered drastically due to the change of the existing river flow regime by the Project. However, the biota living in and around the Project area are common in the region and in Kenya, and there are no valuable species economically and academically to be affected in the area. Therefore, the magnitude of the effects on the ecosystem is expected insignificant and is evaluated as neutral.

Channel erosion in the downstream area and riverbed aggradation in the backwater area are expected to cause neutral effects, because the sediment runoff of the Sondu River is not so large, about 531,000 m^3/year at the dam site, and the riverbed gradient is not favourable to cause the riverbed aggradation due to the supercritical flow in the backwater area of the reservoir.

The effects of the micro-climate change due to the reservoir are expected to be negligible, particularly considering the small size of the proposed reservoir area of 26 km^2. Also no significant effects related to the micro-climate change are reported from the existing reservoirs in Kenya. Thus, the effects of the micro-climate change due to the reservoir are evaluated as neutral.

Fishery and recreation are expected to bring about positive effects to local people, because the Project would have the potential of the reservoir fishery and the attractive tourism spot. Since the reservoir fishery is considered important and would be appropriate for economic development around the Project area, the further study is recommended to clarify its potential and to prepare detailed development plan of the reservoir fishery.

(2) Environmental items to be assessed in EIA

Taking the results of IEE into account, the following five environmental impacts are considered to require the more detailed assessment in order to evaluate the magnitude of the effects and to propose necessary countermeasures:

Environmental Item	Impact	Ecological Region
(a) Water Quality	- Change of water temperature	- IV
	- Water quality deterioration in the downstream area	- III, IV
	- Eutrophication	- II
(b) Public Health	- Spread of vector borne diseases	- I, II, III
	- Disturbance of health facility utilization	- I, II

IV. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

4.1 Change of Water Temperature

(1) Stratification in the reservoir

A formation of water temperature stratification would be considered in the proposed reservoir because its retention time (Annual inflow/Active storage volume = 1,324 x 10^6 m^3 / 625 x 10^6 m^3) is about 2.1 times/year and the existing Jamji reservoir located about 20 km upstream of the Project site shows clear stratification (refer to Table 4.1.).

(2) Change of water temperature

In the case of the Jamji dam, water temperature of the surface area is 21.5°C, but is declined by 4.3°C in 3 m deep, resulting in 17.2°C. Water temperature of inflow into the reservoir is 17.1°C, and therefore water temperature of outflow from the reservoir is assumed to be almost the same as that of inflow when water is withdrawn from the bottom area of the reservoir.

Water temperature of outflow from the Magwagwa reservoir would be around 18°C, because the intake facilities which would be constructed at its bottom area could catch the layer of colder water. Water returned from the power plant to the Sondu River would flow down about 15 km to the Sondu/Miriu intake and would be expected that water temperature goes up by about 1°C. Consequently, water temperature released from the Sondu/Miriu power outlet would be around 18°C to 19°C.

(3) Effects on water uses

In the ecological regions III and IV, river fishery is not conducted, so that no serious effects are expected by this small change of water temperature caused by the Project. Therefore, the major effects due to the change of water temperature would not occur on the fishery in and around the river mouth area and the project area of the Kano irrigation scheme. Since the magnitude of those effects depends on the existing conditions and the features of the scheme, the evaluation of the impact caused by the change of water temperature should be conducted on the environmental study of respective schemes; the Sondu/Miriu and the Kano irrigation.

4.2 Water Quality Deterioration in the Downstream Area

In the operation stage of the Project, the deterioration of water quality in the downstream area, especially in the ecological region III, is expected due to the reduction of river flow.

(1) Assessment of BOD concentration at 1JG1 after the completion of the reservoir

Average river flow at 1JG1 (near Sondu village) is now 42.0 m^3/s, but would be reduced to 0.7 m^3/s by the Project. According to the existing water quality data shown in Table 2.1, BOD concentrations at the dam site and 1JG1 are 1.0 mg/l and 2.7 mg/l. Therefore, the concentration of BOD at 1JG1 after the completion of the dam would be roughly estimated at 6.8 mg/l by using the following equation under the complete mixture concept without any consideration of self-purification effect:

$$Co = (L1+L2)/Qo = 6.8 \text{ (mg/l)}$$

where:

Co (mg/l)	:	BOD concentration at 1JG1 after the completion of the dam,
Qo (m^3/s)	:	River flow at 1JG1 after completion of the dam. It is about 0.7 m^3/s including the maintenance flow of 0.5 m^3/s from the reservoir.
L1 ($g/m^3.s$)	:	BOD load from the reservoir, given by 0.5 (m^3/s) x C1,
C1 (mg/l)	:	Bod concentration at the dam site, 1.0 mg/l,
L2 ($g/m^3.s$)	:	Additional BOD load between the dam site and 1JG1. It is given by (C2 - C1) x (Q2 - Q1).
C2 (mg/l)	:	BOD concentration at 1JG1, 2.7 mg/l,
Q1 (m^3/s)	:	Average river flow at the dam site, 38.5 m^3/s,
Q2 (m^3/s)	:	Average river flow at 1JG1, 42.0 m^3/s.

Thus, the concentration of BOD at 1JG1 could be expected to increase to about 4 mg/l after the completion of the Project.

(2) Effects on water uses

The expected BOD concentration at 1JG1, 6.8 mg/l, is considered to be in the acceptable level as a source of drinking water if treated by normal treatment facilities. No river fishery is conducted in the ecological region III, resulting in no expectation of effects on water uses in the downstream area by the Project.

However, the potential of water contamination by human and livestock fecal bacteria could be increased considerably, so that it is recommended that the existing intake facility of the Nyakach Water Supply Project at Sondu village be replaced to the power outlet site.

As for the effects in the ecological region IV, water is returned to the river channel from the power outlet, so that any significant effects are not expected besides flow fluctuations.

4.3 Eutrophication

A drastic change of water body from lotic to lentic condition in the proposed reservoir area, i.e. the ecological region II, would be caused by the Project. Although eutrophication of water body is a process of natural limnological phenomenon, the exceeding eutrophication of the reservoir may cause some damage on use of water for drinking by occurrence of odor or increase of Manganese concentration, and on operation of reservoir and fishery in the reservoir by proliferation of phytoplankton, fresh water bloom and occurrence of anaerobic conditions.

(1) Assessment of eutrophication in the reservoir

The potential of eutrophication normally depends on the inflow of nutrients and the characteristics of the reservoir. Therefore, preliminary assessment was conducted by using Vollenweider Model given by the following equation:

$$Lc = [P]c\ (Z \times @ + Z \times Vp)$$

where:

Lc ($gP/m^2.yr$)	:	Annual phosphate surface load,
Pc (g/m^3)	:	Concentration of total phosphate of inflow,
Z (m)	:	Average depth of the reservoir, given by V/A,
V (m^3)	:	Active storage volume, 625 million m^3,
A (m^2)	:	Surface area of the reservoir, 20 million m^2,
@ (times/yr)	:	Retention time, given by Q/V,
Q (m^3/yr)	:	Annual inflow to the reservoir,
Vp (m)	:	Sedimentation velocity coefficient, normally given by 10/Z.

The concentration of the total phosphate in the inflow is considered less than 0.03 mg/l, because the concentration data of PO4 obtained from the water quality analysis at the dam site shows about 0.01 mg/l. In the case of assuming the concentration range of 0.01 to 0.03 mg/l, the annual phosphate surface load (Lc) is estimated to be fallen in the range of 0.65 to 1.95 $gP/m^2.yr$. Plotting the estimated range on the Vollenweider Model Figure as shown in Figure 4.1 reveals that the proposed reservoir is not likely to be eutrophicated so long as the inflow of organic pollutants would not be increased rapidly.

At present, large scale development projects which could bring about serious water pollution are not planned in the catchment area, i.e. ecological region I. Moreover, the experiences in other dams of Kenya which were constructed in similar conditions such as Masinga dam, Kamburu dam and Kirandich dam, also support that the Magwagwa reservoir would not be eutrophicated seriously causing problems, because no serious effects caused by eutrophication have been experienced on those dams. Consequently, it is expected that the potential of eutrophication would be low and no significant effects would be caused by the Project.

(2) Other consideration related to eutrophication

The riverine vegetation would be submerged over about 3 km^2 by the reservoir. The submerged vegetation would soon start to bio-degrade, and there will be rapid increase in nutrient to the water from the decomposition of the vegetation, detritus and nutrient rich soils of the former farm lands. Since it could bring substantial increase in levels of organic matters, the concentration of the dissolved oxygen would drop precipitously, and the water in the reservoir would probably start the occurrence of hydrogen sulphide and methane associated with anaerobic conditions. Although this effect is difficult to assess the magnitude qualitatively at present, the cutting and removal of the existing vegetation are recommended to reduce such a negative potential.

4.4 Vector Borne Diseases

Since the potential of prevalence of vector borne diseases is considered rather high through IEE, more detailed field survey was conducted with the assistance of the Division of Vector Borne Diseases (DVBD) of the Ministry of Health to specify the diseases and vectors to be spread in the ecological regions I, II and III.

4.4.1 Vectors in the study area

Table 4.2 shows a list of mosquitoe, mollusc and simulium fly species found in the survey. Among the identified mosquitoes, only Anopheles gambiae is a common vector of malaria and several various diseases. Considering high morbidity from malaria in the area, this mosquitoe must be one of the major transmitters of malaria. Small exposed springs and slow moving streams are considered to be the major breeding sites of them in the ecological regions I and II, because those regions are rather well drained as a result of slopy terrain, and the mosquitoes are rarely found in rain pools formed by surface water.

Two species of molluscs were found in the field survey. One of them, Biomphalaria pfeifferi, is an intermediate host of the human intestistical bilharzia worm, Schistosoma mansoni, and the other one, Lymnia natolensis is the intermediate host of the liver parasite, Fasciola hepatica. However, recalling the low morbidity, none of these two mollusc borne diseases is a great threat in the area at the moment. Although three species of Simulium flies were found in the field survey, they are not linked with transmission of human diseases.

4.4.2 Effects on morbidity by the Project

(1) Mosquitoe vectors

Anopheles gambiae was confirmed during the field survey in slow moving streams in the area. A. gambiae breeds in any collection of water, if exposed to the sun, such as puddles, pits, wells and pools in river beds. The expected fluctuation pattern of the water level in the proposed reservoir as shown in Figure 4.2, and the reduction of the river flow in the downstream area, i.e. the ecological region III, would favour the proliferation of this mosquitoe. Therefore, the morbidity of malaria would be expected to increase and the effective countermeasures are needed to reduce its magnitude for local people.

(2) Schistosomiasis

Schistosomiasis would not seem to be a serious threat to the health of local people in spite of the recovery of transmitter snails in the area. The cold climate in the area presumably slows down the development of the snail stages of the worm and eliminates the water stages rapidly. However, it is recommended that the improvement of a state of hygiene and sanitation in the area, especially during the construction stage, be conducted because the vector, Schistosoma mansoni, could be spread through fecal contaminated water.

(3) Zoonoses

The transmission of animal diseases communicable to man (Zoonoses) is not expected to be caused much by the Project, because local people have already been living close to their domestic animals and no serious zoonoses has not been reported so far in and around the Project area.

4.5 Disturbance of health facility utilization

(1) Utilization of health facility by local people

The numbers and types of the existing health facilities in both Kericho and Nyamira Districts were described in Section 2.5, Public Health. In order to understand the utilization of those facilities by local people, a questionnaire survey was conducted in the Study. The results are shown in Table 4.3.

The majority (264 in number or 48%) of sampling cases seeks medical services from the health centres, while the second large number (128 or 23%) of cases uses dispensaries. Only the smaller number of cases (60 or 11%) seeking medical service in the District Hospital might be explained by the deterrence of the distance from residence to those hospitals which could be taken to have better services. Thus, the health centres and dispensaries are considered to be important health facilities for the local people in and around the Project area.

(2) Effects on health facility utilization by the Project

Since the disruption of the existing transportation system caused by the Project would cause various kinds of inconvenience for the local people, the relocation and reconstruction of the existing infrastructures should be conducted under the responsibility of the Project formation. The proposed relocation plan should also be prepared taking the existing health facility utilization into account.

Utilization of health facilities is closely related to accessibility of such services to the local people. Figure 4.3 shows the location of the existing health facilities and the alignment of the relocation roads and bridges with careful consideration of accessibility to the health facilities. The proposed alignment is considered acceptable because no serious inconvenience to the local people would be caused through the viewpoint of the utilization of health services.

(3) Effects on the capacity of health facilities

The population movement caused by the Project and the possible increase of vector borne diseases would result in increased utilization of health services. A sudden increase of patients in the area would overwhelm the already strained health facilities. The current dispensaries under poorly staffed and meagre equipment could not cope with the health problems of the area even at present. Therefore, setting up curative and preventive services for workers should be considered to avoid the confusion on the existing health service system for the local people.

V. CONCLUSION AND RECOMMENDATION

5.1 Conclusion of the Natural Environmental Study

Several impacts are expected to cause negative effects on the natural environment through IEE, and the following EIA reveals that only the effect on the public health, especially spread of vector borne diseases, is considered significant, and others are not. However, the effect of the vector borne diseases could be reduced its magnitude by taking appropriate countermeasures. Therefore, it is concluded that the Project would not cause any unavoidable effects on the natural environment in and around the Project area. Consequently, the proposed Project is considered acceptable through the viewpoint of the natural environment.

5.2 Recommendations

5.2.1 Recommendations for countermeasures

The items that countermeasures should be taken to reduce their magnitude are as follows:

- Impacts during the Construction Stage,
- Vector Borne Diseases,
- Health Facilities.

The detailed considerations are described hereafter.

(1) Reduction of magnitude of impacts during the construction stage

During the construction stage, the several effects are expected to be caused by the Project although all effects would be temporary. Since those impacts are not expected so special, it is considered enough to take ordinary and common countermeasures for a dam project. Therefore, regreening and replanting activities in the excavated areas, quarry sites and borrow pits, preparation of grid chambers and sedimentation ponds, and security management of traffic accidents for the local people should be conducted to reduce the magnitude of effects caused by the Project.

(2) Control of vector borne diseases

Malaria is expected to be the main problem caused by the Project. With the confirmation of the presence of the mosquitoe, A. gambiae, it is expected that the incidence of malaria could increase around the Project area. Therefore, a surveillance of diseases, comprehensive control efforts and health education to the local people should be emphasized, and also the diseases among the migrant workers should be paid particular attention.

The malaria control in and around the Project area should include epidemiological surveillance which would also help assess the effectiveness of the control measures to have taken. The surveillance must include a survey of spleen rates, blood parasite rates, fever cases in hospital and clinics, and vector survey including dissection of female mosquitoes for presence of sporozoites. Moreover, the specific malaria control measures such as control of breeding sites, use of insecticides, and use of antimalaria drugs for prophylaxis and treatment should be conducted.

The key points of the malaria control for the Project are summarized hereunder:

- Chemo-prophylaxis and chemotherophy of all migrant workers should be conducted. Chloroquine remains as a drug in Kenya, although some of Plasmodium falciparum, have been noted the low level resistance in the lake shore area of Lake Victoria and the coastal areas of Kenya.

- Indoor spray of residual insecticides such as organochlorine and/or organophosphorous compounds or carbamates must be applied to the houses where mediated mosquitoes are detected about every three months.

- Physical control of breeding places such as elimination of swamps and water pools near the local residences should be conducted.

- Biological control methods must be applied; that is, introducing and seeding of fish, such as Tilapia zilli as a larval eater, in the reservoir would be effective to control the population of mosquitoes.

(3) Improvement of health services

The Project would need to establish its own preventive and curative health facilities especially for the workers engaged in dam construction. This could also absorb some of the pressure of patients in the existing facilities which might in any case be inadequate to cope with further population influx. It would be more effective to establish those facilities in cooperation with the existing health service improvement plan prepared by Ministry of Health, because a new health centre would be needed at Magwagwa where there is only an inadequately facilitated dispensary.

5.2.2 Recommendations for further study

Development of reservoir fishery should be considered in more detail because the proposed reservoir would have enough potential for fishery and because the development of fishery would provide a new protein source and an opportunity of economic activities to the local people. Therefore, the further study related to the development of reservoir fishery would be recommended to increase the positive effects caused by the Project as much as possible.

(1) Potential of the reservoir fishery

The fish species and composition which could be developed in the Magwagwa reservoir are Barbus sp, Tilapia spp., Oreochronims spp., Alestes spp., Labeo spp., Lates niloticus (Nile perch). However, if any introductions of non indigenous fish species such as Tilapia zillii, were made, it could ensure firm production which would have more economic values. In any case, however, the dominant fish species would be determined ecologically by interplay of limnological factors.

The annual potential yield of fish in the lower Sondu River was estimated at about 1,000 tones (Ochumba & Manyalla, op. 1979), so that this would be a good indication of the fish production in the proposed reservoir. Table 5.1 shows the potential fish yield of several man-made lakes in Africa for reference. Based on these data, the potential fish production in the Magwagwa reservoir would be roughly estimated at about 100 tones per year.

(2) Key points of the further study

Since the evaluation of potential described above is only an indicative estimate without any specific data related to the reservoir fishery, further studies focussed on

the following points should be conducted to evaluate the potential in more detail and clarify the optimum level of the fishery in the reservoir:

- Available fishery area in the reservoir taking the fluctuation of water level into account,

- Determination of fish species to be introduced in the reservoir and the ecological characteristics of them,

- Estimation of the production yield in the reservoir and recommendation of practical and effective fishery methods,

- Evaluation of the economic values of the fishery activities in the reservoir with consideration of the market survey and the habits of the local people,

- Preparation of the reservoir fishery development plan including necessary infrastructures and cost-benefit analysis.

Tables

Table 2.1 Results of Water Quality Analysis in the Sondu River

No.	Item	St. No / Unit	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10	St.11
1	Time	-	16:30	16:00	15:30	15:00	13:05	14:30	14:00	12:12	11:50	11:00	10:00
2	W. Temp.	°C	21.0	20.0	20.1	20.9	17.4	20.1	18.0	15.5	17.1	16.7	14.0
3	pH	-	7.6	7.5	7.5	7.7	7.2	7.8	7.7	7.2	7	7.2	7
4	DO	mg/l	8.9	8.8	8.8	8.6	9.2	8.5	8	9.7	9.2	8.2	8
5	EC	mS/cm	6.8	67	69	95	55	98	90	50	54	48	50
6	BOD5	mg/l	3.0	2.7	1.0	5.2	1.1	2.0	2.1	2.1	2.0	3.2	1.1
7	N-NO3	mg/l	1.2	1.2	0.8	1.8	0.8	1.8	1.9	0.8	0.8	0.5	0.6
8	N-NO2	mg/l	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.0	0.0	0.0	0.0
9	N-NH-4	mg/l	0.9	0.8	0.5	1.4	0.2	1.4	1.2	0.4	0.2	0.2	0.3
10	P-P04	mg/l	0.05	0.01	0.01	0.05	0.02	0.08	0.04	0.01	0.01	0.01	0.04
11	Turbidity	NTU	6.0	6.9	3.5	4.0	2.5	3.0	4.6	6.0	5.8	40.0	5.0
12	Alkalinity	mg/l	28	26	26	20	27	28	26	22	23	23	30
13	Hardness	mg/l	90	105	98	88	80	108	108	80	60	60	65
14	TDS	mg/l	60	170	150	150	60	170	180	170	75	70	90
15	Chlorides	mg/l	n.a.	0.6	0.5	n.a.	0.4	2.0	4.0	2.0	0.5	0.6	0.8
16	Ca	mg/l	90	100	130	190	120	160	140	125	100	96	98
17	Na	mg/l	110	140	160	150	130	100	140	140	120	110	110

Note: St.1: Nyakwere
St.2: Sondu Bridge
St.3: Magwagwa Dam Site
St.4: Kipsonoi River
St.5: Yurith River Bridge
St.6: Kapsimbili Bridge
St.7: Sotik Bridge
St.8: Itare River Bridge
St.9: Kitoi River Bridge
St.10: Kabianga Bridge
St.11: Western Mau Forest

All samplings were conducted on July 27th, 1990.

Table 2.2 Vegetation Coverage of the Sondu River Basin

Item / River	Tree		Bush		Grass		Tea Plantation		Others		Total	
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%
1) Itare R.	33,986	35	15,424	16	15,903	16	7,216	7	24,053	25	96,582	100
2) Kitoi R.	15,453	39	4,149	10	3,570	9	9,611	24	6,831	17	39,614	100
3) Kabianga R.	1,485	7	272	1	2,342	11	1,835	9	15,459	72	21,393	100
4) Sisei R.	5,521	10	1,621	3	16,452	29	1,239	2	31,145	56	55,978	100
5) Kipsonoi R.	18,713	18	6,109	6	16,176	16	5,674	6	54,521	54	101,193	100
6) Sondu R.	2,193	7	3,512	11	8,479	26	286	1	17,770	55	32,240	100
Basin Total	77,351	22	31,087	9	62,922	18	25,861	7	149,779	43	347,000	100

Source: Integrated Land Use Survey, 1983, LBDA.

Table 2.3 Aquatic Fauna in the Sondu River

Sampling St. / Taxonomic Group	St.1	St.2	St.3	St.4	St.5	St.6	St.7	St.8	St.9	St.10	St.11
Adults:											
- Comixids	+	+	+	+	+	+	+	+	+	+	+
- Nofonectids	+	+	+	+	+	+	+	+	+	+	+
- Beetles	2+	2+	+	+	+	+	+	+	+	+	+
Molluscs:											
- Biopnphalaria Sp.	-	-	-	-	-	-	-	-	-	-	-
- Lymnea Sp.	+	-	-	-	-	-	-	-	-	-	-
- Bulinus Sp.	+	-	-	-	-	-	-	-	-	-	-
Crustacea:											
- Potamon Sp. (crab)	-	+	+	+	+	+	+	+	+	+	+
Copepoda:											
- Thermocychops	+	+	-	-	-	-	-	-	-	-	-
- Mepocychops	+	+	+	+	-	-	-	+	-	-	+
- Diaptomus	+	-	-	-	-	-	-	-	-	-	-
Insect Lavaes and Nyumphs:											
- Ephemeroptera baetis	+	+	+	2+	+	2+	+	2+	+	+	2+
- Chironomids	2+	+	+	+	+	+	+	+	+	+	-
- Plencoptesa	+	+	+	+	-	-	-	+	-	-	+
- Culicidae	+	+	-	-	-	-	-	-	-	-	-
- Odoneta											
- Lubellula	+	+	+	+	+	+	+	+	+	+	+

Note : The name of stations corresponds to Figure 2.1.
- : Not fond or absent
+ : Present
2+ : Common

Table 2.4 Gazetted and Ungazetted Forests in the Sondu River Basin

Forest Name	Area (ha)	District	Status
South Western Mau (Itare)	86,870.9	Kericho	(G) Government
Western Mau	19,833.3	Kericho	(G) Government
Miriu	171.0	South Nyanza	(UG) Trust

Note : G = Gazetted, UG = Un-gazetted

Source : Forests of Kenya, Forest Department.

Table 2.5 Out-patient Morbidity of Kericho and Nyamira District Hospitals

Out-patient Morbidity Returns	Kenya Totals (1987)			Kericho District Hospital (1989)			Nyamira District Hospital (1989)		
Top Ten Diseases	Number of Cases	Rank	Rate %	Number of Cases	Rank	Rate %	Number of Cases	Rank	Rate %
Malaria	4,067,572	1	24.41	18,522	2	19.94	15,690	1	n.a
Dis.of Respiratory system	3,643,164	2	20.97	24,011	1	25.85	12,906	2	n.a
Dis. of the skin (incl. ulcers)	1,295,042	3	7.45	5,794	4	6.24	3,611	7	n.a
Intestinal worms	823,689	4	4.74	n.a	n.a	n.a	8,371	4	n.a
Diarrhoeal diseases	823,595	5	4.74	3,579	7	3.85	1,758	10	n.a
Eye infections	463,209	6	2.67	7,409	3	7.98	9,928	3	n.a
Accidents (incl. fractures, burns, etc.)	393,472	7	2.67	3,028	9	3.26	1,830	9	n.a
Rheumatism, Joint pains, etc.	344,451	8	1.98	2,519	10	2.71	n.a	n.a	n.a
Ear infections	294,928	9	1.70	3,358	8	3.62	2,803	8	n.a
Irinary tract infections	272,576	10	1.57	5,559	5	5.98	6,874	5	n.a
Dental disorders	147,720	14	0.85	3,641	6	3.92	n.a	n.a	n.a
Cataract	10,196	26	0.06	n.a	n.a	n.a	5,864	6	n.a
All other dieseases	4,779,555	n.a	27.51	15,465	n.a	16.65	n.a	n.a	n.a
TOTAL NEW CASES	17,373,882	n.a	100.00	92,885	n.a	100.00	n.a	n.a	n.a

Source: Kenya Totals from the Ministry of Health; others from Kericho and Nyamira District hospitals.

Table 2.6 Number of Health Facilities

Owner	Hospital	Health Centre	Dispensary Home	Nursing	Total
Kericho District					
- Government	3	11	53	0	67
- Mission	3	4	2	0	9
- Company or Private	1	0	51	2	54
Sub-total	7	15	106	2	130
Nyamira District					
- Government	1	6	15	0	22
- Mission	0	6	4	0	10
- Company or Private	1	0	2	0	3
Sub-total	2	12	21	0	35
Total	9	27	127	2	165

Source: Ministry of Health (1987)

Table 3.1 Results of IEE

Environmental Item	Ecological Region			
	I Catchment	II Inundation	III Reduction	IV Fluctuation
A) Problems due to the Location				
1. Inundation of mineral resources	*	0	*	*
2. Repreciation of forestry	*	0	*	*
3. Historical remains/Assets	*	0	0	0
4. Watershed erosion	*	=	*	*
5. Navigation	*	0	0	0
6. Migrating valuable fish	*	0	0	0
7. Precious ecology	0	0	0	0
8. National park/game reserve	0	0	0	0
9. Disturbance of health facility use	-/B	*	0	0
B) Problems in Construction Stage				
1. Soil erosion	*	-/C	*	*
2. Water quality deterioration	*	*	-/C	=
3. Disturbance of transportation	-/C	-/C	*	*
4. Communicable diseases	0	-/C	0	0
C) Problems in Operation Stage				
1. Micro-climate change	*	=	*	*
2. Change of water temperature	*	*	-/C	-/C
3. Deterioration of water quality	*	0	-/C	-/C
4. Eutrophication	*	-/B	0	0
5. Precious ecology	0	=	=	=
6. Fishery	*	+/B	0	0
7. Downstream erosion	*	*	=	=
8. Aggradation of in riverbed	*	=	*	*
9. Water use conflict	*	*	=	0
10. Vector borne diseases	*	-/A	-/B	0
11. Recreation	*	+/C	=	=

Note:

(1) l : Upper side is the expected effect, and lower side is its magnitude.

(2) * : No relation considered.
0 : No effect expected.
+ : Positive effect expected.
- : Negative effect expected.
= : Neutral effect expected, i.e. there may be a change but such change will be neither benefitial nor harmful.

(3) A : Effect which has relatively high level of magnitude,
B : Effect which has relatively medium level of magnitude,
C : Effect which has relatively low level of magnitude.

(4) The following items are to be examined in the Social Environmental Study of the Project.
- Resettlement, Cultural tribes, Loss of community, Compensation, Land use, and Land value.

Table 4.1 Vertical Distribution of Water Quality in the Jamji Reservoir

Item	Unit	Depth						
		0 m	0.5 m	1.0 m	1.5 m	2.0 m	2.4 m	3.0 m
W. Temp	°C	21.5	19.1	18.6	17.7	17.6	17.5	17.2
pH	—	7.0	7.1	7.1	7.1	7.0	7.0	7.0
DO	mg/l	8.6	8.9	8.8	8.8	8.8	8.9	8.9
BOD5	mg/l	2.0	2.1	2.1	2.0	2.1	2.2	2.2
N-NO3	mg/l	1.9	2	2	2.1	1.9	1.9	1.8
N-NO2	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N-NH-4	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01
P-PO4	mg/l	0.01	0.01	0.01	0.01	0.01	0.01	0.01
TDS	mg/l	190	170	190	180	170	190	190

Source : JICA Study Team

Table 4.2 A List of Vectors in the Project Area

Sampling Place	Spring	Slow Stream	Swamp	Rainpool & River
Mosquitoe				
-Anopheles gamiae	9	Nil	Nil	Nil
-A. christyi	39	Nil	1	Nil
-A. demeillon	8	Nil	Nil	Nil
-An. cinereus	Nil	1	Nil	Nil
-A. symesi	Nil	Nil	1	Nil
-C. charleyi	2	Nil	9	Nil
-C. tigripes	3	Nil	4	Nil
-C. perfuscus	Nil	Nil	2	Nil
-C. duttoni	Nil	Nil	18	Nil
-C. rubinotus	Nil	Nil	14	Nil
-C. vansomerini	15	Nil		Nil
-Others	Nil	Nil	9	Nil
Mollusc (snails)				
-Biomphalaria pfeifferi	22	Nil	Nil	Nil
-Lymnea natalensis	15	50	Nil	Nil
Simulium Fly				
-S. medusaforme	Nil	17	Nil	41
-S. cerriconutum	Nil	1	Nil	Nil
-S. vorax	Nil	Nil	Nil	8

Source: JICA Study Team

Table 4.3 Results of Questionnaire Survey of Health Facility Utilization

Type of facility	No. of episodes of illness	Total (%)
1) Health Center	264	48.2
2) Dispensary	128	23.4
3) District Hospital	60	11.0
4) Self medicated	40	7.3
5) No medication	18	3.3
6) Traditional Healer	8	1.5
7) Not specified	7	1.3
8) Other services	22	4.0
Total	547	100.0

Source: JICA Study Team

Table 5.1 Potential Fish Yeild ub Several Reservoirs of Africa

Name of Dam	Yield(kg/ha.yr)
1) Volta dam (Ghana)	32.77
2) Nasser-Nubia (Egypt & Sudan)	40.40
3) Kainji (Nigeria)	34.60
4) Kariba (Zimbabwe & Zambia)	23.20
5) Mwenje (Zimbabwe)	42.10
6) Darwendale (Zimbabwe)	53.60
7) McIlwaine (Zimbabwe)	54.10
8) Claw (ZImbabwe)	54.20
9) Mazoe (Zimbabwe)	75.20
Average	45.57

Source: Adopted from Kapetsky & Petr (1984)

Figures

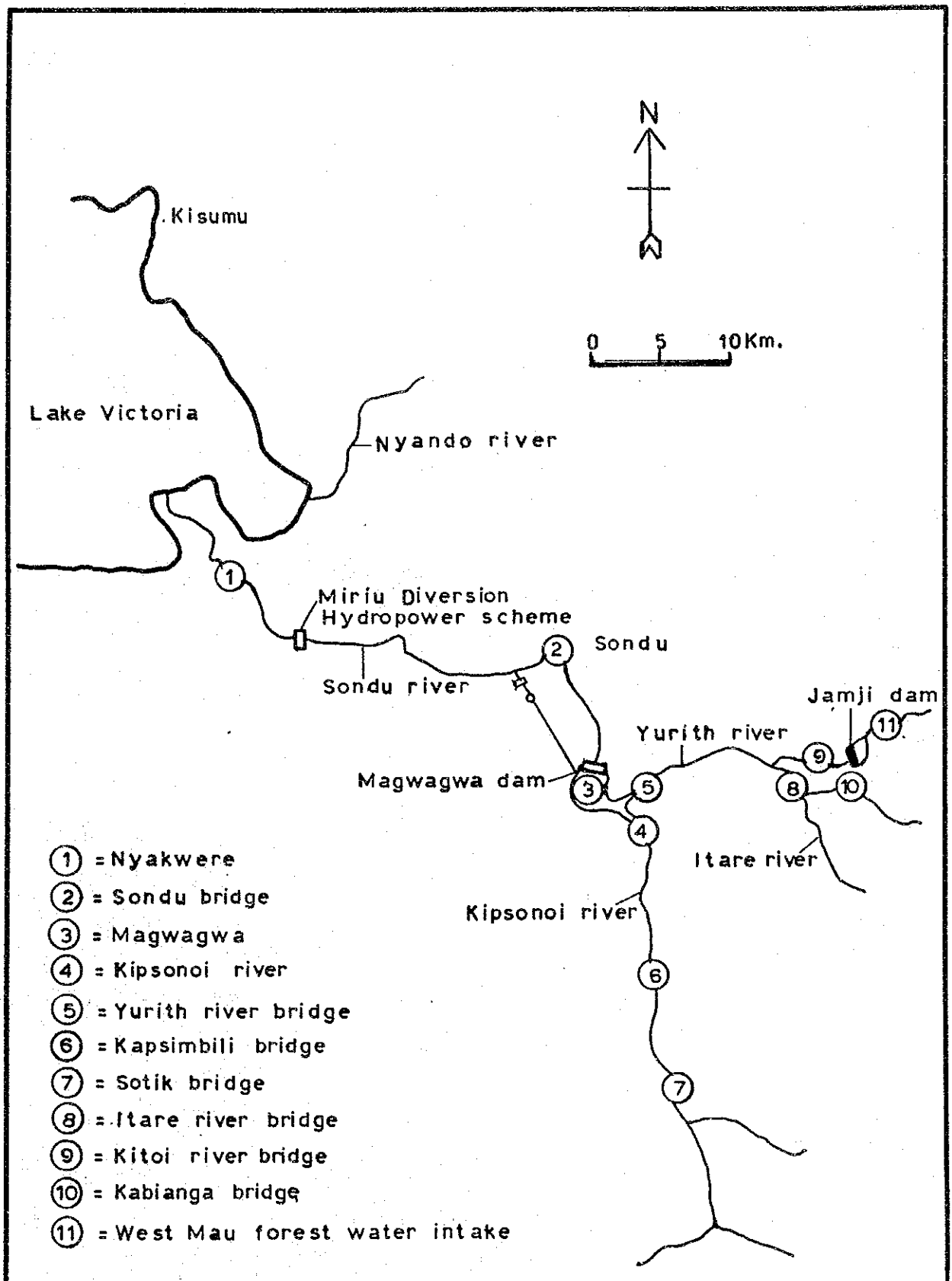

Figure 2.1 Sampling Station of Water Quality and Aquatic Fauna

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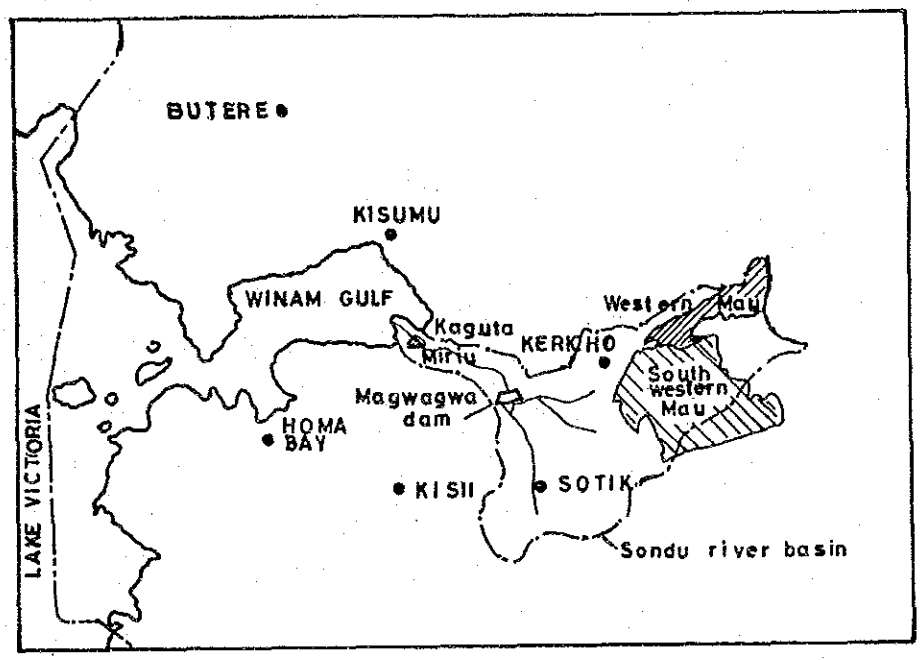

Figure 2.2 Gazetted and Ungazetted Forest Areas in the Sondu River Basin

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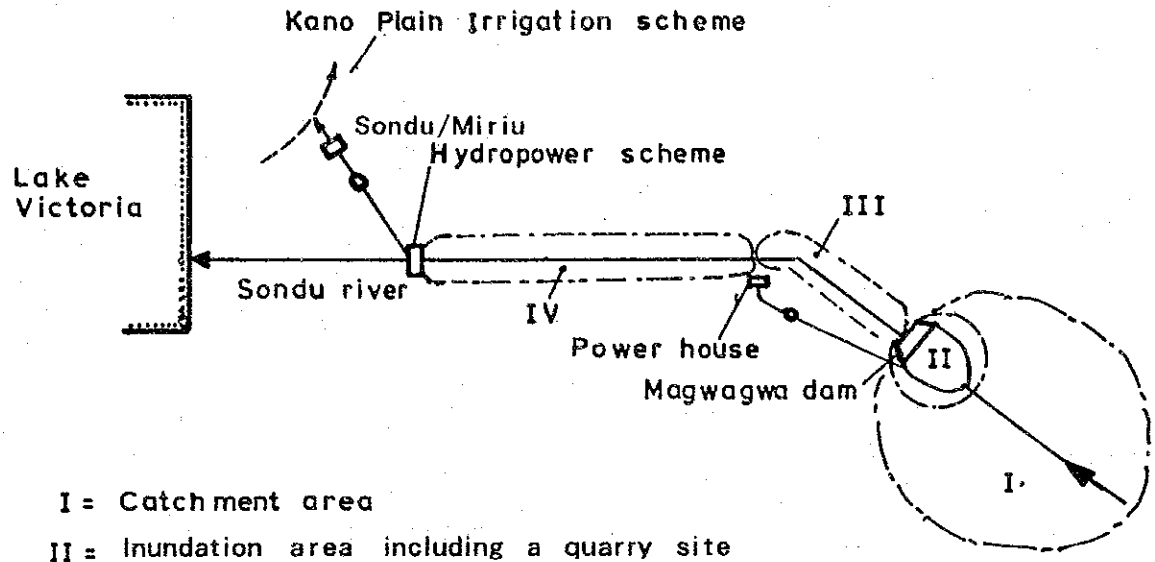

Figure 3.1 Schematic Distribution of Ecological Regions

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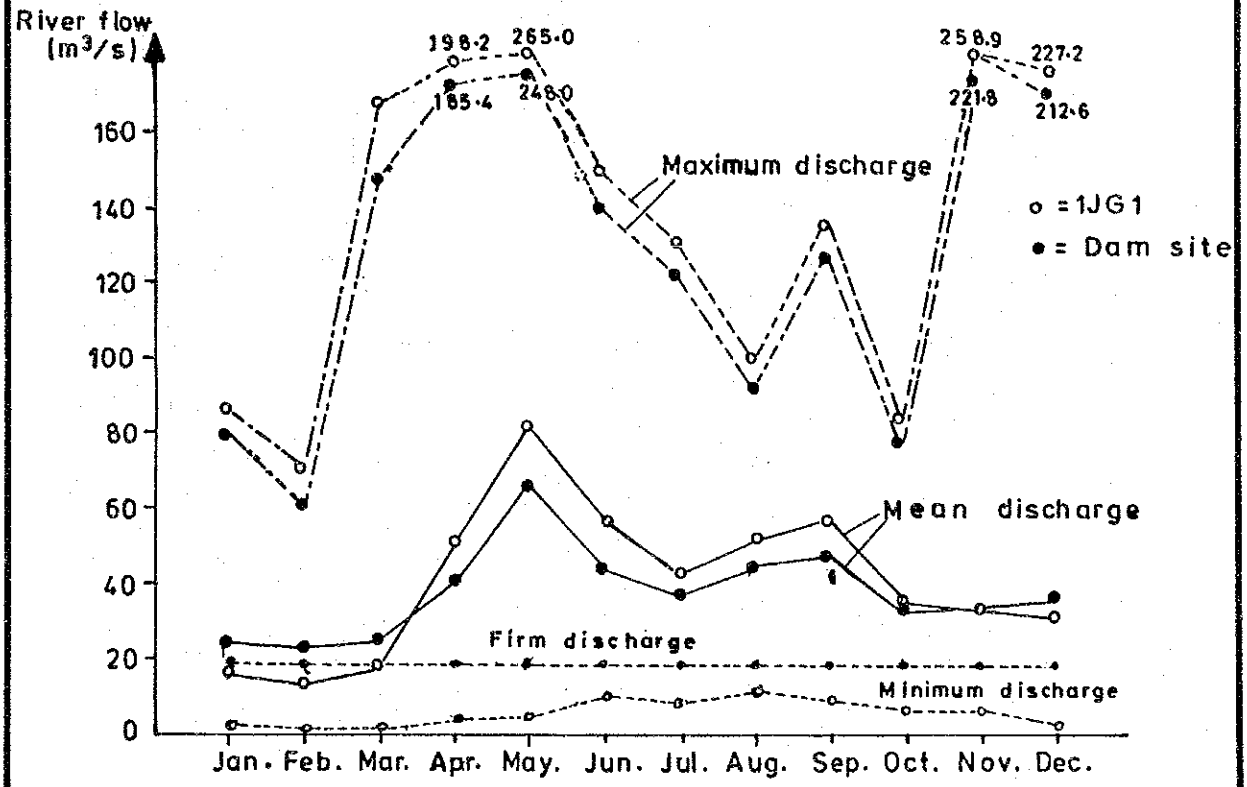

Figure 3.2 Expected Change of River Flow Regime at 1JG1 and the Dam Site

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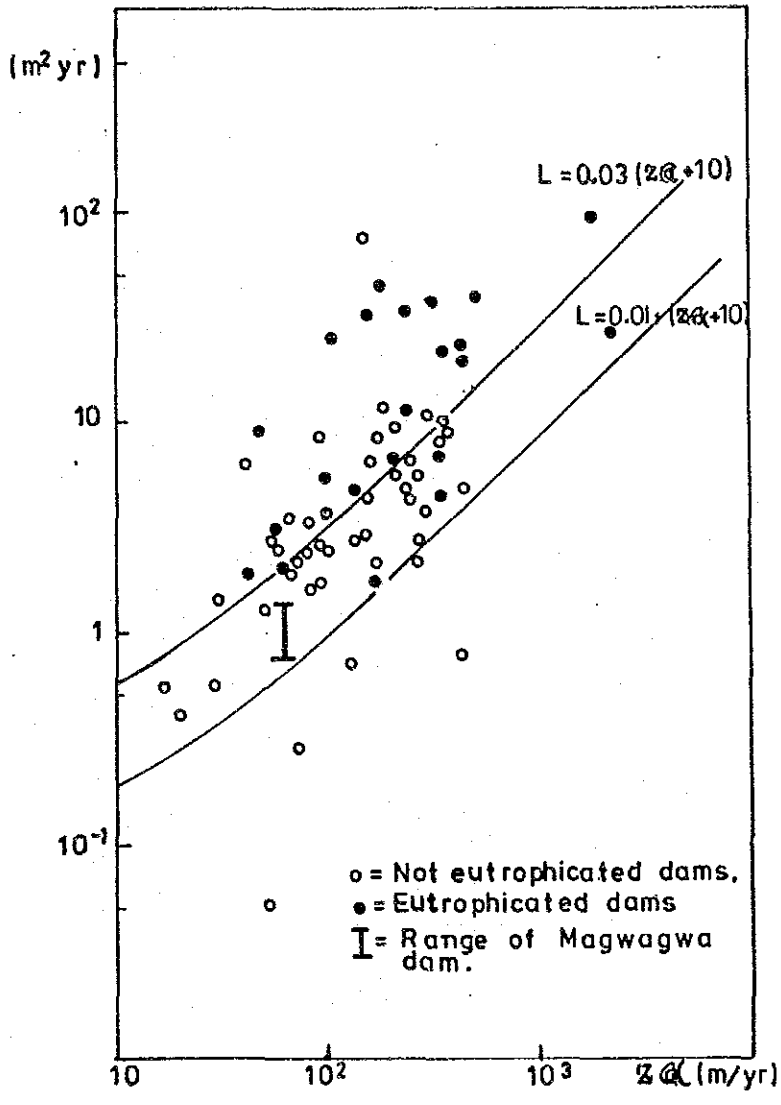

Figure 4.1 Magwagwa Dam on the Vollenweider Model

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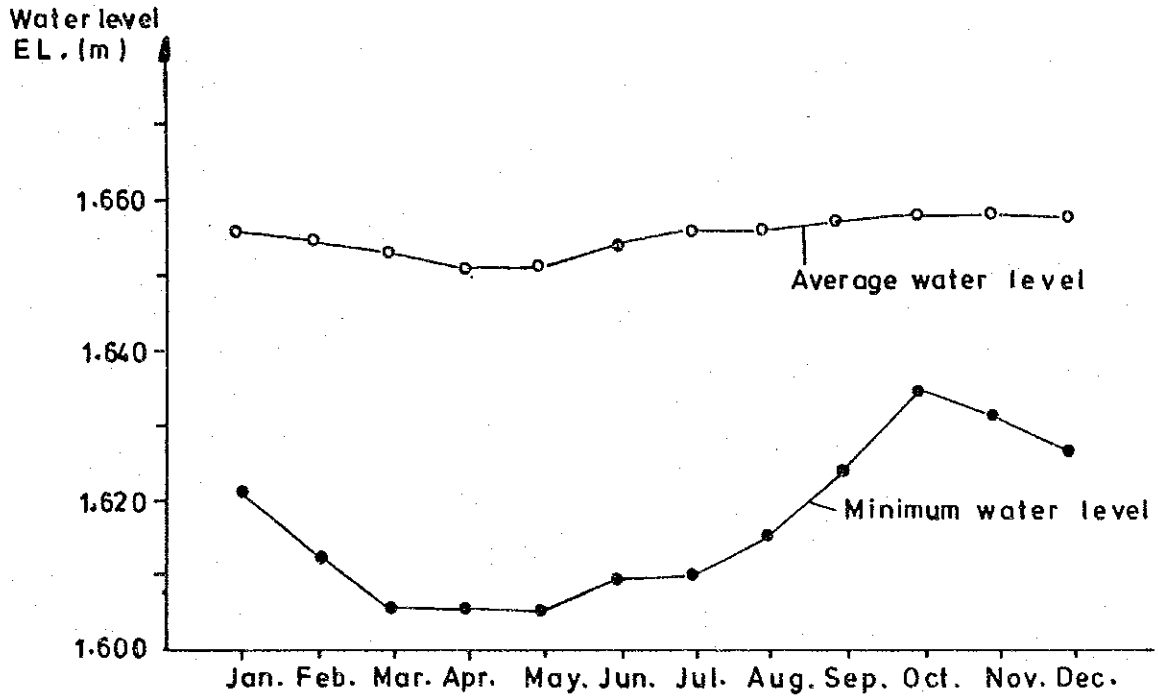

Figure 4.2 Expected Water Level Fluctuation in the Reservoir

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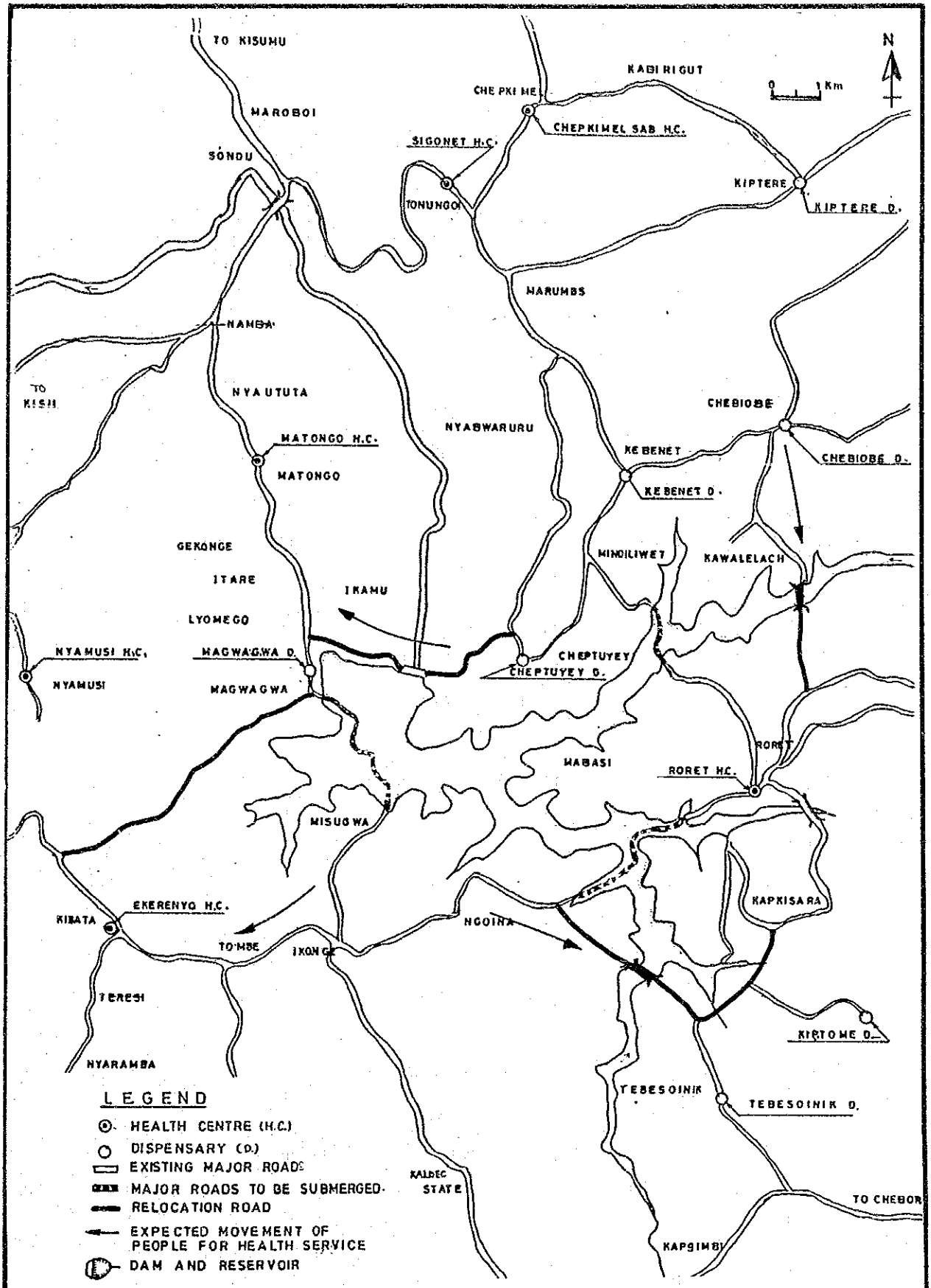

Figure 4.3 Location of Health Facilities and the Relocation Road Alignment

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APPENDIX VI.

SOCIAL ENVIRONMENTAL ASPECT

APPENDIX VI SOCIAL ENVIRONMENTAL ASPECT

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I. INTRODUCTION

1.1 Background

The social environment study (hereafter called "the Study"), as a component of the Feasibility Study on Magwagwa Hydropower Development Project (the Project), is to assess the soundness or viability of the Project from the social, cultural and economic points of view, focussing on the local people directly affected by the implementation of the Project.

One of the most critical issues in the Study is the displacement of the people mainly due to the submergence in the Magwagwa reservoir. There would be considerable numbers of households to be evacuated by the Project, say 700 to 800.

Needless to refer to the recent tendency of dam development in the world, it is a "must" for implementing organization and planners to carefully take care of the displaced people after the evacuation, because those people would be forced to move or involuntarily resettle in other areas. As has been often the case, the minimum requirement for the involuntary resettlement is the provision of alternative land as the compensation grant.

The form of resettlement, or "land for land" approach can be justified also from the legal point of view in Kenya. Resettlement is considered allowable in situations of compulsory land acquisition for the purposes of large development projects like the Project in context of the land-based (i.e., land for land) compensation strategies under the Land Acquisition Act.

Following the above discussions, at least two principles on the involuntary resettlement can be adopted as shown below:

- To improve, or at least maintain, the displaced people's standards of living, and
- To minimize the socio-cultural and mental damages on the displaced people involved with the resettlement.

1.2 Objectives of the Study

As mentioned in the previous sub-section, the Study aims to assess the soundness of the Project from the local people's point of view in terms of socio-cultural and economic aspects. The main objectives of the Study can be summarized as follows:

- To clarify the current conditions of the socio-economic characteristics in the affected areas,
- To analyse social and economic impacts of the Project,
- To provide basic data and information concerning compensation and countermeasures including resettlement, and
- To recommend further studies.

Thus, the Study has a limitation in that it cannot cover all the necessary items to implement the countermeasures including resettlement.

1.3 Methods of the Study

The Study is mainly based on the field surveys in the reservoir and its vicinity areas, which will be defined in Sub-section 2.1. The field surveys mainly consisted of household survey, observation survey, interviews with officers, chiefs and assistant chiefs, etc.

The household survey covered nearly 800 households in the above areas, and each household was asked to answer the questions in structured form of various fields. The interviews covered almost all the households in the reservoir and surrounding areas in Kericho side. In Nyamira side, however, they could cover only a portion of the affected households, estimated at less than 60% of the total.

The Study, especially the household survey, analysis on existing conditions and compensation/resettlement survey, owe much to African Development and Economic Consultants, Ltd., a local consulting firm in Kenya.

II. EXISTING CONDITIONS

2.1 Study Areas

The impact areas, or areas where those who would be affected by the Project, may be categorized into the following five areas:

(1) Reservoir area,
(2) Vicinity area,
(3) Downstream area,
(4) Resettlement area, and
(5) Other areas.

The reservoir area consists of the fully submerged area below the Full Supply Level, FSL, flood space area and buffer area between the flood water level and the dam crest elevation reserved for soil conservation. In the area, all the lands and buildings up to the dam crest elevation of El. 1,670 m are proposed to be acquired for the Project, and all the residents are displaced.

The vicinity area is defined as the one surrounding the reservoir area and downstream of the dam. Furthermore, the waterway route and the powerhouse site would be involved in the vicinity area. The resettlement area is the one where the displaced people would be forced to settle.

Of the above areas, the social environment study covers the reservoir, the vicinity and the resettlement areas. Due to limited time and resources, no detailed Study has been carried out for the downstream and waterway route areas.

Administratively, the reservoir and the vicinity areas belong to Nyamira District of Nyanza Province and Kericho District of Rift Valley Province. The areas may consist of parts of Magwagwa and North Borabu Sub-locations in Nyamira District and of parts of seven sub-locations in Kericho District: Kebenet, Kabianga, Mabasi, Koiwalelach, Roret, Kibugat and Tebesonik.

2.2 Socio-economic Characteristics

In this section, the socio-economic characteristics are described mainly for the reservoir and the vicinity area based on the results of field surveys.

2.2.1 Population

Household distribution by elevation was estimated as shown in Figure 2.1. The households were enumerated at a 25 m interval based on the newly prepared 1:5,000 maps, where the code numbers are plotted on the households as part of the field verification study in the topographic map preparation. The number of households located below E.I. 1,670 m is estimated at about 700 including households affected by the project. It is noted that the population of Magwagwa village is excluded in the above count, since the axis of the saddle dam, which will be built at the topographic depression located in Magwagwa village (refer to Section 6.2.7, Saddle Dam of the Main Report), is designed not to pass the most densely populated area of the village, i.e. the trading centre of the region.

The population in the reservoir area can be estimated at nearly 4,300, multiplying the number of households by the average number of household members of 6.1, derived from the household surveys. With the reservoir area of 26 km^2 including river channels and uncultivated lands (refer to Figure 2.2, Reservoir Area Curve), the population density is estimated at 162/km^2 on an average. However, the population density is quite different between the Nyamira and Kericho sides: 295/km^2 and 92/km^2, respectively. Most of the households reside in footslopes reflecting undulated geographical characteristics in the areas.

Of the total population in the areas, male accounts for 50.6% while female for 49.4%. The population structure by age in the areas is presented in Table 2.1. A striking feature of population structure by age in the areas is the larger share of youth: 63% of the total population is occupied by the group aged under 20-year old. The working age group (15-59 year old) comprises 46% of the population while the elderly (60 year old and over) accounts for 4%. It can be said that the population is characterized by its high dependency ratio.

The household size is 6.1 persons per family, broken down into 6.4 and 5.9 for Nyamira and Kericho respectively as shown in Table 2.2. Over 20% of the households have more than eight members. Most of households appear to comprise nuclear families since 95% of population consists of heads of households, their spouses and their children.