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GILGEL GIBE HYDROELECTRIC PROJECT

ENVIRONMENTAL ASSESSMENT

MAIN REPORT

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ETHIOPIA

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1. INTRODUCTION

1.1 Purpose

The purpose of the environmental assessment (EA) is to predict the negative impacts that are likely to occur as a result of preparing, constructing and operating the Gilgel Gibe Hydroelectric Project (GGHP). The assessment also identifies mitigative measures required to avoid, reduce or compensate the identified negative impacts. This EA defines environment broadly to include human social aspects as well as the biophysical effects.

Since certain construction activities have already taken place at GGHP, during the assessment, the environmental conditions of the existing works were evaluated. The scope of the EA also includes preparing an environmental management plan. A comprehensive resettlement plan has been prepared as a separate document and a summary of the main points of the plan is included in this report.

1.2 Background

Ethiopia has an abundance of rivers which provide the country with the potential for large sustainable energy resources in the form of hydropower. Recent power planning studies have estimated that Ethiopia's hydroelectric potential is in the order of 30,000 MW, a potential greatly in excess of foreseeable domestic demand. Currently only about one per cent of the available total is being harnessed for generating hydroelectric power. Preliminary investigations have indicated that the most promising sites could be developed at lower costs than other power generation options.

Ethiopia's 10 year perspective plan for the period 1984 to 1993 recognized the importance of low cost energy as an incentive to industrial and economic development. At the same time, the plan realized that export sales could provide an attractive long term development opportunity. Neighboring countries are poorly endowed with water resources that can be converted to inexpensive energy and they face the continuing prospect of increasing oil imports in order to meet their own domestic demand.

The Gilgel Gibe project is one of the most attractive potential hydroelectric developments in the country. The first studies of a hydroelectric plant on the Gilgel Gibe River were initiated in 1963 by the Yugoslav Electroproject Company. Subsequently, a Chinese technical mission and the Electric Power Development Corporation of Japan were also involved in the project (1974). In 1981 another investigation was conducted by a team of experts from the Democratic People's Republic of Korea which proposed a 94 MW hydroelectric project on the Gilgel Gibe River at the proposed site.

A Power Planning Study carried out by ACRES International Ltd. of Canada in 1982 reviewed the Korean scheme, and in 1984 ENEL (Ente Nazionale per l'Energia Elettrica, Italy) prepared a feasibility report for the Gilgel Gibe project, taking into account the conclusions of the

ACRES study. At that time, a scheme with one single plant was foreseen, with 285 MW installed capacity. The main structures of that particular scheme included:

- a 40 m high rockfill dam with asphalt concrete facing, creating a reservoir with a 860 million m^3;
- a power tunnel 9.1 km long and 6.6 m in diameter along the left bank of the river, with terminal surge shaft and penstocks;
- a powerhouse equipped with six 50 MW Francis units; net design head of about 205 m and an average energy production of 851 Gwh/y;

At a 1984 unit price level, the scheme was estimated to cost about $US 305 million over a construction period of approximately six years.

Following the submission of the 1984 ENEL feasibility report, further studies were developed, and initial activities for constructing the Gilgel Gibe Hydroelectric Project were started in 1988 through a cooperation established between the Government of Ethiopia and the Democratic People's Republic of Korea. Further assistance for project implementation was obtained from the governments of Italy and Austria.

Due to difficulties and delays experienced during the initial construction works; a lower power demand than originally expected; and the country's financial capacity; the initial single plant scheme was abandoned for a two plant arrangement with an upstream and a downstream plant.

The upstream plant was to have the following features:

- a 38 m high rockfill dam with asphalt concrete facing, creating a reservoir with 717 million m^3 live storage (essentially equal to the original ENEL solution);
- a power tunnel 3.4 km long, developing along the left bank of the river, with a terminal surge shaft and two outdoor penstocks;
- an outdoor powerhouse equipped with two 45 MW Francis units, with a net design head of about 98 m and designed to yield average energy production of 402 GWH/y.

The downstream plant was to be characterized by the following works:

- a diversion weir located about one km downstream of the powerhouse of the upstream plant and creating a daily compensating pondage with 240,000m^3 of live storage;
- power waterways developed along the right bank of the river, partially as a cut-and-cover pressure conduit and partially in tunnel with terminal surge shaft and two outdoor penstocks;
- an outdoor powerhouse equipped with two Francis units with a net design head of about 98m, and an average energy production of 388 GWH/y.

The cost of the upstream plant was estimated (1994 unit price level) at approximately $US 106 million. Under the initial agreement between the Government of Ethiopia and the Democratic People's Republic of Korea, the upstream plant was expected to come on line in 1993. No definite schedule was established for the downstream plant.

Due to the very limited progress achieved in construction, Ethiopia decided to interrupt the co-operation agreement with the Koreans in 1994, and to revert to a typical western project management and tendering practice to assure the completion of the project.

The ENEL/Elc consortium was retained as the engineering consultant for the project in June 1995 and was given the responsibility to upgrade and complete the design, based on the selected two plants. They were also responsible for detailed design, construction supervision and the commissioning of both plants.

Final design resulted in a design based on a single power plant without the downstream weir.

- . a 40 m rockfill dam with bituminous upstream facing with a crest elevation of 1,675m a.s.l.
- . a 8.9 km concrete lined, underground power tunnel with surge shaft
- . a single underground powerhouse
- . Three, 67 MW vertical Francis turbines and synchronous generators
- . a 530 m tailrace tunnel.

1.3 Policy and Legal Framework

Electrical power in Ethiopia is administered by the Ethiopian Electric Light and Power Authority (EELPA) which is an executing agency of the Ministry of Mines and Energy (MME) of the Government of Ethiopia (GOE). EELPA is responsible for the generation, transmission and distribution of electricity throughout the country.

Concern for environmental degradation in Ethiopia has been growing in recent years. The Ethiopian Federal Democratic Republic Constitution provides the basic and comprehensive principles and guidelines for environmental protection and management. The Constitution states that everyone has the right to live in a clean and healthy environment and the Government will make every effort to provide such an environment. The constitution holds the Government and the people of Ethiopia responsible for the preservation of natural resources and maintenance of ecological balances. A number of proclamations and supporting regulations reflect the principles of the Constitution and the most relevant of these are described briefly in the following.

The penal code and civil code of 1957 and 1960, respectively, contain provisions that hold individuals liable for various actions causing environmental damage. Further proclamations issued in 1965 were aimed at the protection, conservation, creation, maintenance and development of forests. This was the first concerted and directed effort towards the sustainable management of forests and the proclamations were intended to ensure land fertility and stabilized soil conditions for present and succeeding generations. These proclamations were subsequently succeeded by proclamations providing for the conservation and development of forests and wildlife and to regulate forest conservation, development and utilization. At about the same time, proclamations were introduced to empower the Ministry of Agriculture to issue regulations and directives concerning the tenure, distribution, utilization and administration of land. These regulations were intended for the fair distribution and proper utilization of land to ensure its protection.

Throughout the 1970s and 1980s a number of proclamations were made that contain provisions for the protection and management of the environment as this relates to water resources.

Later in 1984 a proclamation provided the National Committee for central planning the mandate to formulate policies and issues regarding environmental concerns. In 1987 a proclamation created the Ethiopian Valley Development Authority and provided it with the mandate to initiate policy and the means for planning and implementation for purposes of environmental management.

In 1995 The Environmental Protection Authority (EPA) was made responsible for the protection of the environment and was given the mandate to prepare environmental protection policy and laws. It is also charged with the responsibility of preparing directives and systems necessary for the evaluation of environmental impacts of development projects. The authority is also responsible for the preparation of standards to be used for the protection of soil, water, air and biological systems. The authority is still in it's infancy and is building both staff and capacity in order to carry out it's mandate.

Prior to the approval of a development loan for a project such as the Gilgel Gibe Project, the World Bank and other potential donors require that a comprehensive environmental assessment be conducted. World Bank outlines the EA requirements in Operational Directive 4.01, Environmental Assessment. The Government of Ethiopia agreed to follow OD 4.01 as the EA standard for GGHP.

2. PROJECT DESCRIPTION

2.1 Project Location

The Project is located in the Kefa province about 260 km south-west of Addis Ababa and about 70 km north-east of Jimma (7°50'N, 37°20' E). The project area is shown in Fig.1.

The area is a fairly flat plateau about 1,650 m a.s.l. and consists of a series of gentle sloping low hills and broad plains surrounded by hills or mountains. The Gilgel Gibe (Little Gibe) River, which flows through Kefa province from south-west to north-east, is a tributary of the Great Gibe River (known as the Omo River further downstream) and is extremely variable in course and gradient.

In the proposed reservoir area, the stretch of river between Asendabo and the Deneba waterfall has a winding and relatively flat course. The right bank is more or less flat with some small hills, while the left bank is steeper. The terrain is suitable for the construction of a reservoir with a capacity sufficient to regulate most of the river flows and ensuring that unusable spills are kept to a minimum. The river banks near the Deneba waterfalls become steeper and this section of the valley is suitable for the construction of water retaining structures. A dam of limited height is sufficient to obtain a reservoir with the required storage capacity.

Downstream of the 20 m high Deneba waterfall, which is immediately downstream of the dam site, the river narrows and the gradient increases to about 1.4-1.5 per cent. The river in this area is straight and swiftly flowing interspersed with some meandering slower flow sections. Within a few kilometers below the waterfall, the river drops considerably in elevation, which in conjunction with the drop at Deneba Falls, represents the sizable hydroelectric potential of the project.

Highway #7 is located within a few kilometers of the right bank of the Gilgel Gibe River and links Addis Ababa to Jimma. The project site can be reached from Addis Ababa via Highway #7 in approximately five hours, a fact that should facilitate the construction program of the project. Approximately 15 km of this road will be inundated at full service level of the reservoir and will need to be re-routed. The road is scheduled for upgrading in the near future and the replacement segment will be constructed at that time.

2.2 General Project Description

The final scheme selected, based on the feasibility study and the various studies carried out in the past, includes a single power plant design. The scheme consists of a rockfill dam with asphalt concrete facing; a power tunnel along the left bank of the river, including a terminal surge shaft and an underground penstock; and, an underground powerhouse equipped with three power units. The main technical and physical features are provided in Table 2.1.

Table 2.1: Technical and Physical Features of Hydroelectric Scheme

Feature	Specification
Reservoir	
.maximum normal water level	1,671.00m asl
.average water level	1,665.00m asl
.95% water level	1,656.00m asl
.minimum normal water level	1,651.00m asl
.total storage	839 million m^3
.live storage	711 million m^3
Temporary Diversion Works	
.design flood	$700m^3/s$
.diversion structure	
.type	culvert divided in three equal conduits
.conduit dimensions	5.00x5.50x232.50m
.coffer dams	
.type	rockfill and clay embankment
.max. ht. (U/S, D/S, R.bank)	13.5/8.0/4.5m
Bottom Outlet	
.location	central conduit of the diversion culvert
.discharge capacity	$100m^3/s$ at minimum normal reservoir level

Dam	
.type	rockfill with bituminous upstream facing
.crest elevation	1,675.00m asl
.maximum height	40m
.crest length	1,600m
.slopes of upstream and downstream faces	2H : 1V
.embankment volume	2.5 million m^3
Spillway	
.peak design outflow	2,570m^3/s
.type of structure	gated crest, open chute and terminal ski jump
.crest sill level	1,665.00m asl
.gates	
.type	piston operated flat gates
.number	four
.dimensions (w x l)	12.00m x 5.80m
.chute dimensions	57.10/35.00m/598m
Power Intake	
.design flow	102m^3/s
.type	tower with access bridge
.gate type and dimensions (w x h)	cylindrical, 4.00m high x 6.50m diameter
Concrete Lined Power Tunnel	
.length	8,950m
.diameter	5.50m
Invert elevations	
.at the intake	1,638.00m asl
.at the surge tank	1,605.55m asl
.slope	0.36%
Surge Shaft	
.type	cylindrical, base throttle, upper expansion tank
.shaft diameter	16m
.maximum dynamic level	1,683.00m asl
.minimum dynamic level	1,612.80m asl
Penstock and Terminal Manifold	
.diameter	variable: 5.00/2.80/2.10m
.length	250m
Powerhouse	
.type	underground
.length	78.60m
.width	22.0m
.main floor elevation	1,441.00m asl
.average tailwater level	1,437.90m asl
Downstream Surge Shaft and Tailrace Tunnel	
.Downstream surge shaft	
.diameter	20.0m
.max dynamic level	1,447.70m
.min dynamic level	1,434.20m
.Tailrace tunnel	
.length (including initial manifold)	530m
.diameter	6.50m

Main Equipment	
.Number and type of generating units	three vert. Francis turbines & synchronous generators
.Inlet valve, type and diameter	rotary, 2.10m
.Turbine	
.max net head ($Q=Q_{max}/3$)	232.3m
.max net head ($Q=Q_{max}$)	212.8m
.aver. net design head ($Q=0.987Q_{max}$)	207.3m
.95% net design head ($Q=0.967Q_{max}$)	199.2m
.min net head ($Q=0.957Q_{max}$)	194.6m
.rotational speed	428.57rpm
.max cap. (1 unit at max head)	67 mW
.installed cap. (3 units at max head)	183 mW
.Generator	
.maximum capacity	75 mVA
.frequency	50 Hz
.number of poles	14
.Main transformers	
.number	3
.no-lead voltage	220/15kV
.apparent capacity	75mVA
.main cranes, number and capacity	two, 60/5t each

2.3 Existing Works and Available Facilities

Diversion Works

Almost all of the trench excavation works for the 232.5 m diversion tunnel have been completed. The first and second phases of concrete works have been started. Along the left bank of the Gilgel Gibe River an embankment has been constructed in order to protect the excavation works. It is estimated that about 70,000 m^3 of material have been excavated and approximately 2,000 m^3 of concrete poured.

Access Roads

Most of the internal site roads required for the construction of the plant, including a 40 ton ton capacity Bailey bridge across the Gilgel Gibe River for access to the work site and linking the site installations and three quarry areas have already been built. These roads are unpaved but are in good condition.

Power Waterways

The outdoor excavations for the power intake have essentially been completed. The general outdoor excavations at the outlet portal of the power tunnel have also been completed. A general stripping and the common excavation has been carried out along the alignment of the outdoor penstocks, reaching bedrock level. Short stretches of the power tunnel at the inlet and outlet portals have been excavated and some of the required steel supports have been put into place. An intermediate inclined construction adit has been excavated, reaching the tunnel alignment some 1,400 m from the inlet portal.

The outdoor excavations are generally in good condition and the excavation slopes appear to be stable. Part of the excavated material at the downstream portal has been dumped on the slope leading down to the river and this will have to be removed.

Powerhouse

The powerhouse platform has been partially excavated down to bedrock. Some of the excavated material has been dumped into the river and will have to be removed.

Transmission Line

A 230 kV transmission line has been constructed between the powerhouse site and Addis Ababa but it is not operational. Some towers near the powerhouse site have been damaged and others (#15 and #16) have fallen down. Local people have removed some of the members which has weakened the structures. The Gilgel Gibe substation, located close to Highway #7, has been completed and is operational. Two 15 kV lines from the substation are currently supplying power to the construction camp. EELPA has completed a reconnaissance of this line and found illegal encroachment of dwellings. The survey found 280 grass roofed cottages and 87 corrugated metal roofed houses in a total of 96 spans. EELPA will relocate these squatters according to Ethiopian Law and consistent with World Bank resettlement policies before the line can be energized.

2.4 Camps and Construction Facilities

2.4.1 Camps

A number of camp facilities are currently in place in the permanent village located 15 km from the dam site. The main camp is situated at the dam site.The ECAFCO village is a housing complex for contractors during construction and will be used by EELPA staff during the operation of the plant. The village is designed to accommodate 488 people. The village contains duplex blocks of accommodation housing, a canteen, a guest house, and houses for EELPA and consultants. Each house is completely furnished and the complex is supplied with 15 kV service.

The temporary main construction camp near the dam site is fully furnished and is serviced with a water supply, sewerage system, 15 kV electrical service and internal service roads. Housing includes 155 blocks suitable for accommodating 860 workers. Three caravan guest houses are also in place.

Offices and warehouses are also in place and these include administration, technical, construction, geology and design offices; laboratories, workshops and a clinic; and, warehouses, vehicle shades, fuel stations and a garage.

2.4.2 Construction Facilities

A basalt quarry site is situated about 3 km from the dam and can be accessed by the service road from the power house area as well as from the dam site. A crushing and batching plant was installed on site prior to 1990 and was in operation for a short time for the production of concrete for the diversion tunnel. From the existing 130/15 kV substation, a 15 kV power supply system provides power to the camps and the site installations.

2.5 Analysis of Alternatives

Aside from demand management options, the alternatives to be considered would be fundamentally to choose to proceed with the GGHP or to abandon the works to select another power generation option. EELPA has completed demand side management studies and have instituted tariff increases as a result of those studies. The demand forecasts still call for a significant increase in generation capabilities to maintain economic growth and development.

The high costs of importing fossil fuels to land-locked Ethiopia preclude thermal power options that would depend on foreign fuels. Currently, fossil fuel resources in Ethiopia have not been developed or proven to the extent that a thermal station would be feasible. Studies have shown that the potential for relatively low cost hydropower is the least cost option for Ethiopia at this time.

Nearly US$ 90 million have been invested in the GGHP thus far which would be lost if another hydropower project were to be substituted for GGHP. In addition, any new hydropower site would be a "greenfields" site. In terms of environmental preference, it is clearly preferable to continue with construction at GGHP rather than substitute a new and undeveloped site. Other sites are being evaluated, not as a substitute for GGHP, but for future power generation.

Wind and solar power generation potential is good in Ethiopia, but costs for these systems are not competitve for contributions to the national grid.

3. METHODOLOGY

3.1 Impact Assessment Responsibility

The ENEL/ELC Consortium was charged with the responsibility of preparing the EA and to predict the likely environmental consequences of implementing project activities. World Bank guidelines for preparing environmental assessments were followed (Operational Directive 4.01). The EA has also been based on the previous environmental studies including the Gilgel Gibe Hydroelectric Scheme - Feasibility Study (January 1994) and on the Gilgel Gibe Hydroelectric Project - Public and Environmental Health Implications (UNDPH/WHO, April 1986.

3.2 Assessment Team

A team consisting of the consulting consortium, members of EELPA, and seconded individuals from various relevant government ministries and agencies were assembled and given the responsibility for conducting the EA and preparing the draft and final reports. The team was comprised of the following members.

Mr. Guido Chiesa (Civil Engineer, ENEL)
Mr. Romeo Cironi (Biologist, ENEL)
Mr. Maurizio Perotti (Agronomist, ENEL)
Mr. Sergio D'Offizi (Geologist, ENEL)
Mr. Georgio Galeati (Hydraulic Engineer, ENEL)
Mr. Alberto Bonafe (Hydraulic Engineer, ENEL)
Mr. Guiseppe Stevanella (Civil Engineer, Elc)
Mr. Paulo Pallavicini (Civil Engineer, Studio Pietrangeli)
Mr. Abdulhakim Mohamed (Project Manager)
Mr. Teferra Reyene (Civil Engineer, EELPA)
Mr. Kidane Gizaw (Sanitation Engineer, EELPA)
Mr. Degefu Abebe (Health Officer)
Dr. Aynalen Abebe (Environmentalist)
Mr. Arefeayne Zekariau (Agronomist)
Mr. Fetene Hailu (Biologist)
Mr. Petros Germew (Lawyer)
Mr. Temesgen Gebru (Environmental Health Expert)
Mr. Feleke Afework (Civil Engineer)

The activities performed in the Gilgel Gibe area were assisted by the acting site manager, Mr. Dagnew Zeleke. Mr. John Ambrose assisted the GGHP team in drafting and editing the draft EA report.

3.3 Sources of Information

The team conducted a preliminary literature review in Ethiopia. The team made numerous visits to the project area. During the visits the team relied on direct observations, interviews, questionnaires, surveys and measurements in the project area at selected localities. They conducted interviews with knowledgeable people, NGOs (notably the peasant associations from each kebele), health officials and natural resources specialists working in the relevant fields. The team also reviewed articles from international scientific journals and official data and reports.

3.4 Bounding and Scoping

The bounds of the EA follow the general project area as indicated in Figure 1. In addition, the assessment considers the effects that the project might have further downstream as far as the point where the Omo River enters Lake Turkana. Given the reduction in flow to the Omo River as a result of project implementation is so small, it was not necessary to pursue consideration of the

Lake Turkana ecosystem which is already changing rapidly. To a lesser extent, consideration was given to some upsteam areas, most notably, the proposed resettlement area.

Scoping has included the most important and major environmental components, in particular, water quantity and quality of the Gilgel Gibe River, riverine vegetation and other vegetation that might be affected by construction activities, terrestrial and aquatic fauna, aquatic ecosystems, the people of the area, particularly those who will have to be involuntarily resettled, and the health aspects of the project.

3.5 Baseline Information

3.5.1 Physical and Natural Environment

Climate

The study of the rainfall distribution over a year was based on data from the stations of Abelti, Asendabo, Jimma and Sekoru using the Thiessen method, which assumes that the total amount of rainfall in any station can be applied half-way to the next station, in any direction. At the suggestion of the Ethiopian Mapping Authority, the monthly data was grouped into three seasons:

- .the transitional period of February-May, known as the ***Belg*** rain
- .the rainiest period between June and September, known as the ***Kiremt*** rain period
- .the dry period of October-January

Water quality

Water sampling was conducted on the Gilgel Gibe River in May 1982 and in October 1995. Samples were taken at a depth of about 20 cm under the surface. A selected number of chemical and bacteriological tests were conducted on the water which will feed the reservoir. Chemical, physical and bacteriological parameters were measured and these included temperature, pH, conductivity, oxygen content, turbidity, faecal and total coliform bacteria. Some of the 1995 samples were sent to the ENEL Central Laboratory in Piacenza, Italy for additional tests. The 1982 the measurements and samples were taken several times on two successive days along the section of the river between the future dam site and the Deneba Falls.

As well, samples were taken during three consecutive days at two different points along the Gilgel Gibe River and at one point on the Chilelo River, a tributary entering the right side of the Gilgel Gibe River approximately one kilometer below the dam site.

The pipette method (Walton 1978) was used to evaluate the grain size of the particles suspended in the Gilgel Gibe water sample taken on two periods.

Vegetation

A phytosociological survey was conducted on the vegetation in the future reservoir site. This survey was directed at analysis of the plant associations and communities rather than a species inventory and checklists. Information gained will be useful for future restoration programs that will occur in the proposed buffer area adjacent to the reservoir. Some plants were identified in situ. In other cases samples were classified with the help of the Tropical Herbarium in Florence. Silvicultural methods of calculating the number of trees per hectare (Loetsch and Haller, 1973) and the corresponding amount of ground covered (Prodan, 1968) were applied.

Fauna

The local fish population was investigated by direct sampling on the site. Samples were taken by trawl-net, fyke-net and dragnet near the dam site, in 1982 and by trawl net in three station along the river in 1995. The results of this survey are shown in detail in Table. A.5 (Appendix). Species caught were studied for quantity and total weight. Sub samples of each species were sexed and examined for weight and length.

The qualitative census of the local terrestrial fauna was carried out through an inquiry amongst the local population of Koticha Kesi, Inkure and Bore kebele. Species identified through this approach are listed in Table A.6. This survey was supplemented by surveys conducted by personnel in the Department of Wildlife in the Ministry of Agriculture which verified local reports, but did not add further information.

3.5.2 Socioeconomic Studies

Population and general socioeconomic profile

The data collection to study the human environment within the project area, has been conducted in 1994 by a task groups, each composed by members of the Gilgel-Gibe Project Office and relevant Regional Government Office. The survey was carried out by assessing the composition of the population broken down into the different kebeles (villages) in each wereda (administration unit).

The collection of the data by each task group is based on:

- registration documents proposed by the project since 1977
- region demarcation cornerstone (bench marks) made during 1977
- 1:500.000 scale region boundary map.

Registration of affected populations, inventory of their fixed permanent properties and collection of documents has been conducted by several task groups, each composed of representation from the following:

- project field office
- administration office from each wereda
- Agricultural Bureau of each wereda
- Natural Resources and Coffee and Tea Bureau from each wereda
- kebele farmer associations

Land

During registry, data regarding land area was collected using the local unit of measure (Fechasa) and later converted to hectares by the Ministry of Agriculture.Assistance was provided to the farmers by the Ministry of Agriculture to ensure the recording of accurate information, and that property values and compensation could be accurately determined.

3.6 Public Participation

Throughout the process of the assessment, meetings were held with a number of agencies, including the area health clinics, and with members of affected households.

The people in the project area have been aware of an impending move since construction started in 1986. Social surveys conducted at that time no longer had validity, so a new survey with more participation was carried out. A comprehensive public participation program was carried out during the preparation of the resettlement plan, which is a subcomponent of the EA. The people to be resettled have been continually represented by their respective Kebele farmer associations throughout the planning process. The farmer associations are NGOs which best represent the affected populations. Initially, during registration of all families and properties, people were informed that they would be required to move as a result of the project. Through a series of meetings with each of the 18 Kebele farmer associations, local people were able to express their opinions on a number of concerns including area to be resettled, forms of compensation, structures and facilities required, and administration of the compensation program. Initially four unoccupied candidate areas for resettlement were identified by a technical committee. After detailed evaluation, the committee rejected two areas because of prior rinderpest infestations in those areas and rejected a third area because of a greater distance from the project area. The selected area was presented to the affected people through their farmer association representatives. The Environmental Protection Authority (EPA) was invited to evaluate the site and one staff member did an environmental reconnaissance.There was consensus among the affected people that the area selected was the most suitable location for resettlement. The associations indicated a number of concerns, including the fertility of the new site, suitability for grazing and receptivity of the host community. The host society was given the opportunity to provide input regarding the acceptability of the settlers to the area. The host community indicated that they would accept the newcomers willingly. Members of the affected population, including women and young people, visited the proposed site and held meetings with the host communities. Given the ethnic, cultural and religious similarities of the two populations, neither group felt that there would be serious constraints to acceptance of relocation.

3.7 Assessment

The characteristics of the foreseeable impact have been based on the following:

- the nature of the actions which are potential sources of impact and which have been taken from the " The Feasibility Study of the Gilgel Gibe Hydroelectric Scheme";

- basic environmental data derived from research carried out on the field;

- surveys and censuses carried out among the population and service structures present in the area;

- information gathered from scientific publications available and information from similar hydroelectric projects;

A matrix was constructed from these four elements (Figures 8,9 &10) which relates project activities to the environmental components which these activities may affect (both positive and negative). The activities, as well as the social-environmental components, have been divided into actions with the aim of emphasising the mechanisms and times during which the impacts occur on particular aspects of the different components while the project is being carried out and these are provided in the Figures. The Figures also indicates relative values that have been determined for each of the potential impacts.

Sources of impact - general

The sources of impact (actions) are defined as anything which directly or indirectly interacts appreciably with the environmental context affected by the project. These include the three main project phases of construction, preparation and operation.

Source of impact - during construction

Figures 8-10 shows the potential environmental effects corresponding to the various actions foreseen while carrying out the construction works, together with an indication of the importance of these effects and the measures to be taken in order to avoid, reduce or compensate them.

The building activity, which is forecast for a three year period, will initially be limited to the project area. The main environmental effects will be associated with excavation and earth dumping activities, the construction of large structures and the increase in heavy traffic.

Sources of impact - preparation and filling of the reservoir

The reservoir preparation activity may be divided into three main actions: occupation of the area, clearing of woody vegetation, and filling the reservoir.

Sources of Impact - during operation

The operating activity can be divided into two main actions: reservoir operation and operation of the power stations which are interlinked.

Once the reservoir has been filled, the level of the reservoir will change throughout the year, with a maximum at the end of the rainy season and minimum at the end of the dry season, owing to the flow of water for electricity production. The difference in the normal operating reservoir level (18 m) will create an exposed drawdown area of approximately 27 km^2. The full service level is at

1671 m a.s.l. and the minimum operating level is 1653 m a.s.l. instead of the listed 1651 m a.s.l. for the absolute minimum level.

4. DESCRIPTION OF THE ENVIRONMENT

4.1 Physical Environment

4.1.1 Geology

The Gilgel Gibe project area is situated on the southwestern Ethiopian plateau. The area is characterized by a series of basic and subsilicic effusive volcanic rocks, frequently inter-layered with reddish paleosols of Tertiary age. The rocks of the area are tentatively ordered as following, beginning with the youngest rocks:

Trachytic tuff,
Vesicular basalt,
Aphyric augite basalt,
Welded tuff (Rhyolitic ignimbrite),
Augite basalt,
Augite trachyte,
Augite basalt.

In some locations, particularly in the area of the upper reservoir, these rocks are covered with fluvio-lacustrine sediments.

The entire volcanic sequence is frequently blanketed by thin, residual, subtropical lateritic soils, which have been formed on hill and ridge foot slopes. As well, they are covered with thick, black, plastic clay deposits on the flatter areas and valley. The hills on the right side of the Gilgel Gibe River, downstream of the waterfalls, are mostly covered to an elevation of about 1,800 m a.s.l. by thick colluvium deposits together with deeply weathered landslide and/or rockslide material.

The basic and sub-silicic volcanic rocks indicated above are of the Ashangi and Magdala Volcanic Group, and are considered the same as the Omo basalt (Miocene-Oligocene Age) and Jimma volcanites. In places these are overlain by younger rhyolite and rhyolitic tuff flows of Pliocene Age, and are commonly known as Mt. Veca volcanites.

The volcanic layers of the project area generally dip a few degrees in a southwesterly direction and are crossed by minor north-east to south-west and north-west to south-east fractures and faults. The former of these are related to the main tectonic alignments of the region, the Ethiopian Rift. They trend roughly north-east to south-west and are located south-east of the site at a distance of about 140 km (measured from the middle of the rift system). The latter of these fractures and faults could be related to the Bonga fault (or "Gilgel Gibe" fault). The most important fault of the project area is the Ayno fault, and it probably runs along the Ayno stream in close proximity to adit 1.

4.1.2 Seismology

Most of the epicenters of observed earthquakes in Ethiopia are related to major rift structures. The dam site is at least 96 km from the most active seismic centers and any earthquakes originating at these centers would be considerably attenuated at the dam site. Current seismic data available is preliminary in nature, and as such, the value of the horizontal ground acceleration to be considered will necessarily have to be greater than 0.1 g. Since there is a high possibility of relevant earthquakes to be released along the nearest border to the site of the Ethiopia rift active tectonic structure, or one of the faults to it, the adoption of a design earthquake of 0.1g and a maximum credible earthquake of 0.2 g has been considered in dam design.

4.1.3 Hydrology

Only five sets of annual data (1967-1971) from the Deneba hydrometric station which is located near the dam site are available. The data are insufficient for providing an indication of long-term average river flow. These data have been supplemented with the 26 years (1967-1992) of data from the Asendabo station upstream of the dam site. The mean annual discharge for the period between 1967 and 1992 is 36.8 and 50.4 m^3/s for Asendabo and Deneba respectively. The discharge at Deneba corresponds to an annual runoff of 1,578 million m^3 and a total rainfall volume over the corresponding catchment area of 6,485 million m^3. Hydrological data for Deneba station is provided in Table 4.1.

Additional runoff reaches the river between the dam site and the powerhouse site including the Chilelo Tributary. However, while the tributary basin of the upper dam site is 4,225 km^2, the intermediate catchment is only approximately 130 km^2 which is less than three per cent of the upper reservoir catchment. The contribution of this intermediate catchment is, however, important in regards to the biological impacts on this stretch of the Gilgel Gibe River.

Due to the limited historical flood series at Deneba station, an estimate of flood flows with return periods exceeding 100-200 years would be very unreliable. Parameters of the most common probability distributions (Gumbel, GEV, Pearson III etc.) should be determined on the basis of the local data only. A "regional" approach to the analysis was used, based on the concept of hydrological homogeneity of different sites in a particular geographical area. This concept assumes that the probability distribution of hydrological events in a hydrologically homogeneous area is the same, in spite of the scaling factor. In this case it is assumed that the Deneba and Asendabo sites are similar since both are situated along the main course of the Gilgel Gibe River and have comparable catchment areas (4,225 km^2 and 2,929 km^2). At the proposed dam site the flows with return periods of 100 years or more, relevant to the design of the spillway, are provided in Table 4.1.

Table 4.1: Deneba Hydrological Data

Feature	Data
. Catchment area	4,225km^2
. Inflow volume	6,485 x 106m^3

. Outflow volume	1,587 x 106m^3
. Runoff coefficient	0.25
. Average annual flow	50.4m^3/s

Table 4.2: Discharges

Tr (Years)	Discharge (m^3/s)
100	890
500	1,070
1,000	1,150
10,000	3,495

4.1.4 Water Quality

Table 4.3 shows the results of the analyses carried out in the two periods of sampling. Quantities are expressed in meq/l (milligram equivalent per litre) and mg/l, together with values registered in four regional rivers, expressed in mg/l.

The low level of orthophosphates and trace metals indicate that there is little influence on water quality by humans, either in terms of agricultural practices or industrial development. Low total nitrogen content is typical of natural situations or those only slightly altered by low organic inputs.

Salinity is only slightly higher than that of the Zambesi River above the Kariba dam (33.18 mg/l) (Balon and Coche 1974) and almost identical to that recorded below the dam (46.6 mg/l) (Coche 1968). The salinity levels are lower than the salinity registered in many rivers in Ethiopia at similar elevations.

Table 4.3 : Chemical Analysis of Gilgel Gibe River

	Gilgel Gi be	Gilgel Gibe	Wesha*	Tikur-Wuha**	Wendo-Genet** str.1	str.2
Altitude (m)	1640	'640	1900	1680	1680	
Ionic chemicals	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Ca	0.42	8.41	8.1	11.6	8.1	8.3
Mg	0.193	2.35	2.6	2.9	2.6	2.2
Na	0.205	4.73	18.4	30.0	18.4	10.9
K	0.08	3.13	5.6	6.7	5.6	8.3
CO_3	0.73	21.90	105.0	127.0	105.0	79.0
Cl	0.062	2.20	2.5	5.4	2.5	4.9
SO_4	0.079	3.80	1.3	0.8	1.3	3.5
Salinity	1.769	46.52	143.5	157.4	143.5	117.1

* A.D. Harrison 1988
** Tilahun Kibret 1989

Table 4.4: Water Quality Parameter Measurements

Parameter	Measurement
. Temperature	.21^{0}C - 24^{0}C over a 24 hour period
. Total suspended solids	
.dissolved inorganic content	.65 mg/l (1982) and 52 mg/l (1995)
.suspended solid content	.200 mg/l (1982-flow of 25 m^3/s) and 155 mg/l (1995-flow of 18 m^3/s)
.grain analysis	.50% silt and clay; 50% organic matter and colloids (full grain size analysis provided in Table A.2)
	.5.2 - 6.8ppm
. Oxygen content	.N,P,Si solutions
. Nutrients	.46.52 mg/l (concentrations of different salts given in
. Salinity	Table 4.3)

Considering low salinity levels on the usual mineral water scale (Gualtierotti 1978), the Gilgel Gibe River water may be classified as earthy-brackish, alkaline, and with bicarbonate. Due to its high concentration of suspended matter and bacteria, especially faecal coliform type, the water comes into the EEC A2 category of surface water requiring treatment to render it potable for human populations.

Table A.1 (Appendix) gives the results of analyses carried out in 1995 at two points on the Gilgel Gibe River and the Chilelo tributary. If the values of the parameters measured at the beginning (close to the Deneba waterfalls) and end (at the bridge over the Gilgel Gibe near Asendabo) of the section affected by the future reservoir are compared, then the quality of the water in this section remains substantially the same. Statistical analysis indicates that the values recorded are significantly the same. Evidently the tributaries of the Gilgel Gibe River between Asendabo and the Deneba waterfall do not cause quality changes in this section due to their meagre flow rates and similar water quality. The characteristics of the Chilelo River water are similar to those of the Gilgel Gibe River in terms of concentrations of the major nutrients. However, statistically significant differences occur for temperature, suspended solids, total solids and alkalinity which are on average lower, and the dissolved oxygen and concentration of faecal coliform which are higher in the Chilelo River than the Gilgel Gibe River. The chemical-physical differences found can be attributed to the different flow rates of the two rivers. Whereas the Gilgel Gibe River may be considered a slow river, the Chilelo River has typical torrent morphology. The higher presence of faecal coliform is due to the larger number of livestock in a smaller catchment.

The dissolved inorganic content of the total suspended solids is only about 65 mg/l in 1982 and 52 mg/l in 1995. In contrast the suspended solid content revealed by filtration through a 0.2 micron Millipore filter is high but quite similar between the two sampling years: 177-255 mg/I on 1982 and 139-179 mg/l in 1995. On average it is 200 mg/l in a flow of 25 cumecs in 1982 and 155 mg/l in 1995 in a flow of 18 cumecs.

The difference in weight between the different sample years indicates a slight difference in flow conditions at the times of sampling. The results of these laboratory test are shown in the grain size analysis table (Table A. 2). The analysis shows the particles to be about 50% silt and clay, the remaining matter consisting of soluble organic matter (humic acids or other colloidal substances) or colloidal particles measuring less than 10^{-4} mm.

Table A.3 (Appendix) shows partial and cumulative per cent per particle class as well as average sedimentation speeds of quartz spheres of equivalent average diameter in still water at 20°C (Walton 1978).

4.1.5 Soils

The soils of Kefa Province are Alfisol-type which are relatively fertile soils that have been formed in humid areas under deciduous forest cover. Soil color varies from red and brown through to grey and black. Textures range from clay to lime-clay or sandy clay. The pH is generally acid (E. Westphal 1974 and R. Schnell 1971). Soils at the project site are black in the valley bottom (about 1,650 m a.s.l.), grey brown in the hilly strip (1,660-1,760 m a.s.l.) and red at higher levels and elevations. Chemical and physical analysis of three representative soil samples are given in Table 4.5 (Appendix).

Table 4.5: Soil Properties

Soil Type	pH	Texture	Organic Content (%)	Total Nitrogen (%)	Exchangeable Ions
.valley bottom	5.3	sandy clay loam	8.04	0.32	39.7 meq/100g
.medium altitude hill soil	5.9	sandy clay loam	4.6	0.2	30.0 meq/100g
.upper altitude hill soil	6.2	sandy clay	2.0	0.09	39.4 meq/100g

The organic and total nitrogen contents of the valley bottom soils are typical of permanent meadow land. The middle and high altitude soils are less rich in nutrient elements due to the fact that they have been exploited by man and have been subjected to weathering and erosion. The pH factors, organic and nitrogen contents correspond to data collected on the soils between Jimma and Bonga and reported by Dawit Deguefu (1969) and Murphy (1959, 1968).

4.1.6 Climate

Ethiopia has a two-season tropical climate. The dry winter season occurs between October and April and the rainy season (during the summer months) occurs between May and September. In the project area, the average annual air temperature is 19.2 °C. Table 4.6 shows monthly mean values of selected meteorological and climatic parameters, recorded at the Jimma station.

Table 4.6: Mean Values of Meteorological Data Recorded at Jimma Station

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
Temp (min)	8.8	11.3	12.3	14.0	13.9	13.9	13.5	13.3	13.2	11.0	8.8	8.3
Temp (mean)	18.9	19.9	20.9	21.3	20.9	20.1	19.1	19.1	19.5	19.1	18.6	18.5
Temp (max)	29.1	28.5	29.5	28.7	28.0	26.3	24.6	24.9	25.8	27.2	28.4	28.7
H	49.21	51.50	50.21	61.07	64.29	70.14	75.71	74.57	69.64	58.79	51.94	51.46
V	1.20	1.54	1.52	1.17	1.17	1.24	1.15	1.02	1.03	1.06	1.00	1.00
n	7.75	6.94	7.01	6.30	6.28	4.88	3.62	3.73	5.32	7.50	8.07	7.81

The annual rainfall of the Gilgel Gibe catchment area varies from a minimum of 1,300 mm near the confluence with the Great Gibe River, to a maximum of about 1,800 mm in the Utubo and Fego mountains. Rainfall decreases throughout the catchment with a decrease in elevation. The average annual rainfall calculated over the whole Gilgel Gibe basin where it joins the Great Gibe River (5,500 km^2) is 1,527 mm; over the Deneba catchment (4,225 km^2) it is 1,535 mm; over the partial catchment between Asendabo and Deneba (1,295 km^2) it is about 1,479 mm, and over the partial catchment area between Deneba and the Great Gibe River (1,275 km^2) it is 1,429 mm. It appears that 60 per cent of the total amount of annual rainfall occurs between June and September, 30 per cent from February to May, and only 10 per cent between October to January.

The natural evapotranspiration rate is estimated by subtracting the average flow height for unit of surface from the mean annual precipitation. This is calculated as follows:

• the mean yearly precipitation over the catchment between Asendabo and Deneba (S = 1,295 km^2) is about 1,479 mm;

• the annual mean flow for the same basin can be estimated as the difference between the yearly mean flow at Deneba (50.35 m^3/s) and Asendabo (36.83 m^3/s), or 13.52 m^3/s. This discharge corresponds to an average flow height for unit of surface of:

$$\frac{13.52x31.536x10^6}{1.295} = 329.mm / year$$

• the total losses due to evapotranspiration without reservoir are estimated as:

1479 - 329 = 1150 mm/year.

4.2 Natural Environment

4.2.1 Natural vegetation

Moist evergreen mountain forest is the major vegetation cover type of Kefa Province. This cover type grows at an altitude of 1,200 to 2,300 m where annual rainfall is in the range of 1,200 to 2,000 mm. The Gilgel Gibe project area is characterized by evergreen mountain thickets and shrub, a typical vegetation of slopes occurring throughout Ethiopia. Details of plant species contained in the forest, thickets and shrubland are provided in the literature.

No formal botanical surveys have been conducted for the vegetation along the Great Gibe or Gilgel Gibe rivers and there are no previous studies available. Published information on riparian plant life species is only available for the main Ethiopian rivers (Omo, Abbay, Webi Shebele, Awash and Tekkezze rivers). For the EA, a phytosociological survey was conducted on the vegetation of the site of the future reservoir. Information gained could then be used for any future restoration programs that will be implemented for the proposed buffer area.

A list of the species classified is provided in Table 4.7.

The phytosociological study identified the following associations:

a) In shallow water up to about 20-30 cm deep:

Hydrocotyle ranuncoloides	99%
Mariscus hemisphaericus	1%

b) On the riverbank above the water line:

Gramineae	60%
Cyperus sp.	30%
Ageratum conyzoides	9%
Eragrostis teff.	1%

Table 4.7: Species Present in Proposed Reservoir Area

Type and Family	Species
Grasses	
Selaginellaceae	*Selaginella Kalbreyeri Baker*
Davalliaceae(Filicales)	*Athrotropteris monocarpa (Cordem) C. Chr. Commelina sp.*
	Cynodon dactylon (L)
Commelinaceae	*Eragrostis teff (Zucc.) Trotter*
Gramina	*Graminae sp.*
Cyperaceae	*Cyperus sp. o. (perhaps C. Longus L.)*
	Cyperus rigidifolius Stend.
	Scirpus nclinatus(Del.)
	Mariscus aff. M. hemisphaericus (Bök).
	Mariscus cf. richardii Steudal
Ranuncolaceae	*Ranunculus sp.*
Umbelliferae	*Hydrocotyle ranunculoides Linn. F.*
Convolvolaceae	*Ipomea cairica (L.)*
Solanaceae	*Solanum incanum L. sensu lat.*
Verbenaceae	*Verbena officinalis L.*
Compositae	*Ageratum conyzoides L.*
	Gnaphalium luteo-album L.
Bushes and Shrubs	

Palmae	*Phoenix cfr. reclinata Jacquin*
Lauraceae	*Lauraceae*
Leguminosae	*Calpurnia aurea (Ait.) Benth Subsp. aurea*
Rhumnaceae	*Clausena animata (Willd)*
Solanaceae	*cfr. Solanum*
Verbenaceae	*Durata repens L.*
Trees	
Palmae	*Phoenix cfr. reclinata Jacquin*
	Phoenix sp.
Leguminosae	*Acacia cfr. spirocarda*
	Acacia cfr. abyssinica
	Albizzia cfr. Schimperiana Oliv.
	Entada abyssinica (Steud ex)
Tiliaceae	*Tiliaceae*
Sterculiaceae	*Dombeya cfr. quinqueseta*

c) The flat moist ground up to 30 to 40m from the riverbank:

Hydrocotyle ranuncoloides	90%
Cyperaceae	5%
Gramineae	5%

d) In the fairly moist ground 40-60 m from the bank:

Cyperaceae	50%
Cynodon dactylon	40%
Gramineae	5%
Hydrocotyle ranuncoloides	5%

e) Over 60 m from the bank:

Cynodon dactylon	80%
Gramineae	10%
Commelina sp.	10%
Compositae	5%
Cyperaceae	5%

f) Riparian forest

Trees (max ht. of 25 to 30 m)

Albizzia cfr. schimperiana
Phoenix sp., Acacia spirocarpa

Bushes

Entada abyssinica
Phoenix cfr. reclinata
Calpurnia aurea

Suffrutices

Durata repens
Clausena anisata
Solanum sp.

Woodland grasses

Selaginella kalbreyri
Athrtropteris monocarpa
Ranunculus sp.
Gramineae
Ipomea cairica

g) Transitional strip between riparian forest and treed savannah

Trees

Dombea cfr. quinqueseta
Tiliaceae
Acacia cfr. abyssinica

Grasses

Cynodon dactylon
Graminae
Solanum incanum
Gnaphalium luteo album
Verbena officinalis

h) Woody Savannah (1650 m)

Most trees are xerophilous, *Acacia abyssinica* and *Acacia sp.* being the most common. Survey results indicated an average density of approximately 70 trees per hectare.

i) Marshy ground (approx. 1650 m)

Marsh reeds, *Scirpus inclinatus* and *Mariscus cfr. Richardii*, were found in the sunlit marshy ground about one km from the river.

j) Hillside farmland

The cultivated hillside farmland contains scattered *Acacia abyssinica*, *Acacia sp.* and *Adansonia digitata* (Baobab) trees, as well as small clumps of planted *Eucalyptus globulus L.* Near the houses there are small patches of *Coffea arabica, Catha edulis, Citrus medica, Musa sp., Ensete ventricosum, Rhamnus prinoides, Punica granatum, Citrus aurantifolia, Boswellia papyrifera, Psidium guajava, Gossipium spp.* and *Mangifera indica* have been established.

The main features revealed by the phytosociological survey and the literature review include:

- the aquatic vegetation consists of hydrophytes rooted in the riverbed;
- grasses are typical of those found throughout Jimma Province (Fiori 1941);
- *Albizzia schimperiana, Phoenix sp.* and *Glancens anisata* are the typical species found in the moist evergreen mountain forest (Picchi-Sermolli 1957);
- *Dombeya sp.* and *Calpurnia aurea* are the most typical species of the evergreen mountain bush and shrub type;
- *Acacia abyssinica, Entada abyssinica, Acacia sp.* and *Adansonia dìgitata* are typical of the savannah and lower stretches of the mountain savannah (Picchi-Sermolli 1957).

Evidence indicates that the Gilgel Gibe riverbank flora likely represents the residue of the moist evergreen mountain forest which once was predominant in Kefa Province. This riparian forest is several dozen meters deep in some area along the river where soil moisture is adequate (*Hydrocotyle ranuncoloides* is a humidity indicator found up to 50 m from the river).

Back from the riverbank where soil moisture diminishes, typical evergreen mountain bushes and shrub begin to appear and gradually take over on the slope of the "quolla" (600 to 1,800 m) and on the edge of the voina degà (1,800 to 2,500 m). At this point the typical vegetation of the tree-covered savannah is introduced. On untilled hillsides bushes and shrub grade into moist evergreen mountain forest at higher altitudes.

Cultivated hillsides feature isolated *Acacia abyssinica and Adansonia digitata* (Baobab) trees and clumps of *Eucaliptus globulus* planted by the local population, as well as groups of cultivated trees for food and medicine production such as *Coffea arabica, Catha edulis, Musa sp.* and *Ensete ventricosum*.

Figure 4 indicates the vegetation patterns inside the proposed reservoir area (on the basis of aerial photographs 1973-74) and within the project boundary.

4.2.2 Fauna

Aquatic Fauna

A previous study of the stretch of the Gilgel Gibe River in the project area indicated that the river is shallow, slow moving and for the most part fairly turbid and with poorly oxygenated waters. Its banks are occupied with hydrophilic and aquatic vegetation. The river bottom is generally muddy with the occasional rock wing above the surface.

The macro-benthic population consists mainly of oligochaetes, but the abundance of Ephemeroptera and Trichoptera (caddis flies) indicates high water quality, from a biological point of view. Table 4.8 shows the average values of the main groups of macro-invertebrates sampled at the same three stations where fishing operations were conducted.

Table 4.8: Macro-invertebrate Presence

Taxa	Individuals /m^2
Oligochaeta	320
Crustacea	10
Ephemeroptera	170
Coleoptera	20
Trichoptera	170
Diptera	70
Bivalvia	10

Due to its high suspended solids content and low oxygen content, the river is unsuitable for fish species requiring good visibility for foraging and for those requiring high oxygen levels that are normally found in a turbulent environment. The river is ideal for species favouring slow water, tolerant of low oxygen levels and for species with the ability to survive on a varied diet culled from the lower end of the food chain (plants and macro-invertebrates).

Immediately downstream of the dam site, the 20 m Deneba waterfall is an obstacle to fish migrations from downstream to the upper stretches of the river. The dam will have little effect on migration patterns because the falls already blocks such migrations.

Breeding grounds are found within the project area and eggs are presumably laid upstream. Young fish are dispersed along the Gilgel Gibe River from the breeding areas both during the flood periods and while the young fry search for food. However, the migration is probably insufficient to maintain population levels downstream of the waterfall. The mortality rate among the fish dispersed by the waterfall is probably high and the number of survivors negligible relative to the numbers swimming upstream.

Species of the Gilgel Gibe River in the project area include *Barbus duchesnii* (fam. Cyprinidae),
Tilapia nilotica (L) (fam. Cichlidae) and *Labeo sp.* (fam. Cyprinidae).

Barbus sp. is dominant, accounting for about 91 per cent of the fish population, the remaining nine per cent being comprised of the other two species. In a general study of African cyprinids, Matthes (1968) concluded that *Barbus* species are highly adaptable and that the genus probably speciated explosively whenever the environment was suitable. Nagelkerke (1994) asserts, in accordance to this point of view that the African species can be split into several distinct groups based on feeding habits. Competition for food is an important factor in natural selection and thus in the adaptive radiation of species.

Barbus sp. is found throughout Ethiopia. Parenzan (1939) Nagelkerke (1994) and Dgebuadze (1994) reported its occurrence in many rivers and lakes throughout the region, ranging from the Lake Tana-Blue Nile complex in the north to the Omo catchment and the Margherita lakes (Abaya and Ruspoli) in the south. *Barbus sp.* is omnivorous and in the project area feeds mainly on vegetable matter and organic debris found on the riverbed.

The composition of the *Barbus* population appears to be normal with a clear numerical superiority of young over adult fish. The smaller fish (175 mm long, weight less than 75g) are far more numerous than the medium size fish weighing over 500 g. (Figs. 6 and 7). Using the death rate of fish 100-450 mm long as an index, there is approximately a 30 per cent mortality rate in the transfer from one size class to the next. This is considered a low figure. This transfer rate indicates that the biomass turnover within the fish population is not particularly rapid and that the incidence of predation, parasitosis and disease, in general, is relatively low. The transfer rate suggests that the species is permanently and successfully inserted into the local ecosystem. Further evidence is given by the confirmed sex ratio (female:male = 70:30). This sex ratio is common where fish have access to an ample supply of food. The regression between length and weight indicates slightly allometric ($b > 3$) growth and shows that there is no substantial difference in the growth rates of the two sexes.

It is not known when *Barbus duchesnii* spawns. However, many of the *Barbus* species in Lake Chad lay their eggs between June and October and ascend the rivers during the flood flow period (Blache, 1964). Since the Gilgel Gibe River is hydrologically similar to the water courses of the Chad catchment, *Barbus sp.* probably follows a similar reproductive timetable, or possibly later due to the lower average temperature.

Only two specimens of *Tilapia nilotica* were found and it is not common according to reports by the local population. The species is not indigenous to the site. Tilapia is widely used for fish farming and to replenish rivers, since it is robust and adaptable, being able to breed and survive new environments. This species was probably introduced. Limited numbers of the species may indicate that the introduction was not successful or, less probably, that its adaptation has not yet been completed.

The third fish species found in the Gilgel Gibe River belongs to the genus *Labeo sp. Labeo sp.* generally inhabit close to the bottom and feed on its benthic material or on plankton. The different species generally breed in the hot season (June-September). Some species prefer a hard river bed (rock or clay) and a fast current while others prefer a soft bottom (sand or chalk) and slow moving water. The Gilgel Gibe River species probably belongs to the second group although it may prefer rocky stretches. Its population size in the project area is similar to that of *Tilapia nilotica*.

Aquatic Reptiles

Crocodiles have been reported by local residents above Deneba Falls and they are more common in the lower reaches of Gilgel Gibe and the Gibe Rivers. No crocodiles were observed during the surveys by the EA team, Department of Wildlife staff and EPA visits. The long stretch of fast flowing river and the falls may present a barrier for crocodiles moving upstream to the reservoir area. It is likely that crocodiles would find a conducive habitat in the reservoir.

Aquatic Mammals

Hippopotamus are present in the river and they would proliferate in the reservoir.

Terrestrial fauna

During the wildlife surveys, very few terrestrial mammals were observed. Human usage of the area for agriculture and the practice of annual burning has reduced the wildlife habitat significantly. The remaining riparian forest has been slowly degraded and has been harmed by the exposure of fire. Most of the land within the proposed reservoir zone is being used for agriculture or is in fallow which does not provide suitable wildlife habitat. However, Black and White Colobus monkeys were observed in riparian areas above and immediately below the Deneba Falls where burning has not been a factor. There is a clear distinction between the proposed reservoir zone and the downstream section of the project area in regards to wildlife habitat. The downstream area has steep banks and is unsuitable for agriculture. The forest cover remains relatively undisturbed and has not been subjected to frequent burning. In the downstream portions of the project area, wildlife is present, but difficult to survey because of steep slopes and limited access. Baboons, monkeys, smaller felines and perhaps leopards are likely to be found.

In the remaining sections of wooded savannah, small populations of Vervet monkeys, Spotted Hyaena, Wart Hog, Common Duiker, Bush Pig, Baboon, Abyssinian Hare, African civet, Genet, mongoose and Silver-backed Jackals were identified by observations, signs or inquiries from local people.

The results of the qualitative survey are indicated in Table A.6. There are three Ethiopian endemics including *T. scriptus* (bushbuck), an elusive species associated with riparian forest and brushwood; *A. buselaphus lewel* (hartebeest), living in open territories including the savannah; and, *F. harwoodi* (Harwood's francolin), a species present in riparian forest, swamp, marsh, and bush and shrub lands. Only the bushbuck is known to occur near the project area. at low population densities.

A wide variety of birds, especially water fowl, both local, and migratory, are found in the area although they have not be quantitatively surveyed. Ethiopian avifauna has not been extensively studied and the project area is not an exception to this lack of research. During the survey, 67 species were identified in the project area and this would represent a very conservative figure of the total number of species. The presence of a reservoir and a wooded buffer zone would result in a major shift in the species composition from one dominated by birds associated with agriculture to one featuring more waterfowl and raptors.

4.3 Socioeconomic Environment

4.3.1 Existing Conditions

Land use

The dominant land use both within the area to be occupied by the reservoir and the general project area is agriculture and grazing. Along the Gilgel Gibe River, the small amount of remaining riverine forest provides some habitat for wildlife and provides a source of fuelwood, building materials and other materials used for meeting a variety of domestic requirements. The agricultural landscape is dominated by small plots cultivated for the production of cereals, primarily maize, teff, sorghum and flax.

The population of the project area is widely scattered and lives in tukul type dwellings. Tukul settlements are found on the slopes and on the vegetation-free heights. Arable fields are small and pasture land is generally treeless. Livestock, consisting mainly of zebu cattle, have access to plenty of water due to the presence of the Gilgel Gibe River, and to reasonable grazing areas. Traditional farming techniques are still used with the land is worked with animal traction scratch ploughs. Bee-keeping is commonly practiced, but at low technical inputs.

The economy of the local population is based almost entirely on agriculture and livestock. Commercial trade takes place primarily in local markets and this local trade exceeds the volume of trade and goods with other regions.

Population

Small scattered settlements are widespread throughout the area with groups of tukuls distributed with varying degrees of regularity. Single tukuls are also scattered over a wide area of land. Concentrations of individual tukuls can be defined as settlement units. The term 'kebele' refers to an area rather than a precise village. The project includes 18 kebeles belonging to 4 different weredas. The population affected by the reservoir, buffer zone and associated construction facilities was 15,351 people belonging to 2,476 households. This number will be smaller in the actual resettlement since the buffer zone has been reduced by more than 1,400 ha.

The average family size in the survey was 6.2 members with little variation amongst kebeles. The range is 5.1 to 6.8 members per family. Table 4.9 summarises the census results. The degree to which the population will be affected by the project will vary, depending on the following:

- .people residing and carrying out agricultural activities on land inside the proposed reservoir area;
- .people residing outside the reservoir area (but within the project area) and conducting agricultural activities within the proposed reservoir area.

Table 4.9 provides a breakdown of people affected by the project.

Table 4.9: Population Distribution in the Project Area

Wereda	Kebele	No. of Families	Population	No. of Students
Kersa	Harena	22	136	0
	Dogosso	43	267	9
Sekoru	Telgo	59	366	3
	Inkure	77	477	19
	Bore	244	1513	3
	Liben	18	112	1
Omo Nada	Osobili	265	1643	139
	Ture Meta-Jebo	399	2474	88
	Seyo	9	56	1
	Wonji	9	56	0
	Goro Sibilo	9	56	0
	Goro Warso	11	68	0
Tiro Afeta	Ino	176	1091	4
	Nono Dimtu	113	700	64
	Koticha Maru	628	3894	10
	Koticha Kesi	290	1798	0
	Budo	48	297	0
	Usmani	56	347	5
Total		2,476	15,351	344

Acting on comments from an earlier draft of this report, EELPA has elected to reduce the size of the buffer area by over 1,400 ha and a new perimeter has been established. The new boundary is set between 500-800 m from the reservoir edge at full supply level. The new perimeter will no longer affect dwellings along an existing block of nearly 1,400 ha at the upstream area of the reservoir near Koticha Kesi. The boundary has been set back from the existing track that passes by the upstream portion of the reservoir so that dwellings along the track will not have to be removed. The change in the buffer zone area was made in July 1997 and the resettlement unit is in the process of evaluating the changes in the number of households which will have to be involuntarily resettled. The people who are affected by the change will have the option to determine if they wish to be relocated or remain on their holdings.

Economy

With the exception of a few traders and tailors living in the Harena and Dimtu areas, and four people registered in Omo-Nada wereda as workers extracting sand from the Nada-Kelo and Nada-Guda rivers, people living within the project area gain their livelihood from farming. Privately owned farm and grazing lands have been registered in the respective names of their owners.

Income

The economy of the area is obviously based on subsistence agriculture and livestock. The registered average annual income considers income gained from the sale of seasonal farm crop produce. Crops produced and local crop prices are provided in Table 4.10.

Table 4.10: Crops and Market Values

Type of crop	Local price by quintal (birr)
Maize (Zea mays)	132
Teff (Eragrostis teff)	222
Sorgum (Sorghum spp.)	132
Flax (Linum usitatissimum)	420

Income derived from permanent plants, livestock, trading activities and other sources is not included in the annual average incomes provided in Table A.10 (Appendix) which indicates average incomes of the families which are primarily farmers. The income analysis is provided for groups of people depending on where they live in relation to the project. That is, i) families who reside in the future reservoir area (RIR); ii) families which reside in the project area but outside the future reservoir area (ROR); and, iii) families which reside outside the project area (ROB). The statistically significant difference between the incomes of families in the different residence conditions, which shows a clear predominance of the RIR and ROR family incomes compared to the ROB families, is due to the fact that the ROB families also farm land outside the project area and gain income from products which have not been considered in the annual income calculation.

The annual net income per family from land located in the area affected by the project appears to be relatively high, particularly when compared to the results of a survey carried out in 1995 using the data reported by Gamachu (1990). This data showed that the average annual gross income from crops for upland plain farms ranged from 330 to 640 birr. In the case of the project area, the annual gross income is extremely variable from family to family with a minimum of 420 birr recorded for a family at Liben and 58,050 birr declared by a family living at Osobili. In 37 per cent of all cases, the income reaches a level of between 1,000 to 5,000 birr/year, and in 34 per cent of the cases between 5,000 and 10,000 birr/year. Table A.11 shows the incidence of families belonging to the different income classes, by kebele. A high average income from agriculture reflects land of high productive capacity, however, the average expanse of land devoted to cultivation in this area is higher, ranging from 2.8 ha per family in Sekoru to 3.4 ha per family in Omo Nada. The average agricultural land holding over the project area is 3.2 ha per family. Gamachu (1990) showed that the average expanse of land devoted to cultivation on upland plain farms was between 0.85 and 1.4 ha per family.

Resources - Agriculture and animal husbandry

Cereals are the most important local crop. The most common cereals sown are teff (*Eragrostis teff*), sorghum and maize (*Zea mays*). Tubers grown include *Colocasia esculenta, Dioscorea sp*. and potatoes (*Solanum tuberosum*). Pulses, garlic, onions, cabbage, peppers and herbs are also grown as well as bananas (*Musa ensete*.) and "Enset" (*Ensete ventricosum*). The latter plant provides a starchy substance which, with cereals, forms the basis of the local diet and a valuable fibre much used by local craftsmen. On higher ground coffee (*Coffea arabica*) is also grown. Table 4.11 lists cultivated trees and their uses.

Table 4.11: Cultivated Trees and Their Uses

Tree	Use
Catha edulis (Enat chat)	Medicinal
Citrus medica (Tiringo)	Food and medicinal use
Rhamnus prinoides (Gesho)	Flavouring
Punica granatum (Roman)	Food
Citrus aurantifolia (Lomi)	Food and medicinal use
Boswellia papyrifera (Mager)	Production of incense
Psidium guajava (Zeituna)	Food, fuel, production of wooden tools
Gossipium spp. (Tit)	Production of cotton fibre
Mangifera indica (Mango)	Food

Farming techniques are still primitive, with animal traction scratch ploughs being used to till the soil. There is no standard crop rotation but some farmers questioned quoted the following sequence:

- Two years of teff, followed by one year of sorghum, followed by one year of *Colocasia esculenta* after which the land is placed into fallow. The practice and duration of fallow is highly variable among the area farmers, ranging from absent to several years of fallow depending on the amount of land used by the household and the inherent fertility of the plot. Legumes are not a part of crop rotation practice.

The fields are usually abandoned for several years when they appear to be worked out and another piece of fallow ground is then brought back into cultivation. Crop productivity is indicated in Table 4.12.

The productivity of the herbaceous crops turns out to be rather low due to the primitive farming techniques, the lack of machinery, poor seed, lack of agrochemicals, and the shortage of capital. The people of the project area normally sow cereals in spring, at the beginning of the rainy season, and harvest them in autumn or winter. The growing conditions (high temperature, little sunlight, high humidity) are not optimal and crop production is generally poor. Sometimes the existing vegetation (either fallow or crop residues and weeds) is burned off before the fallow area is ploughed.

Table 4.12: Crop Productivity

Crop	Productivity (quintal/ha)
Maize (*Zea mays*)	25
Teff (*Eragrostis teff*)	6
Sorgum (*Sorghum spp.*)	15
Flax (*Linum usitatissimum*)	7

Cattle are raised on the hillsides where *Cynodon dactylon* provides good fodder and the Commelinaceae grasses provide excellent grazing. Many herds (20 to 70 head each) of zebu are found in the valley as well as sheep, goats, some donkeys and chickens.

The grazing land, presented in Table A.9 (Appendix) excludes the free and common grazing land. Private grazing lands have not been registered at Osobili kebele farmers association (Omo Nada), since most of the grazing land within the project area is common.

Fuelwood

Fuelwood resources are not in short supply in the project area or in the resettlement area. In addition to natural woodlands, there are many plantations of exotic species, such as eucalyptus. Unlike the plateau between Jimma and Addis Ababa, woody vegetation is still relatively abundant in the province.

Resources - wildlife

There are few data relating to hunting activity in the area, however, according to information gathered during the 1995 survey, it seems to be little practised. Warthogs, wild pigs and birds are occasionally captured. Very little fishing is carried out. There are no full or part time commercial fishermen, local people fish only occasionally and fish is very rarely consumed. Fishing is only by primitive hook and lines and consequently only the larger fish such as older specimens of the *Barbus sp.* are captured. Nets are not used.

Resources - tourism and landscape

The area does not attract tourists in large numbers at the present time. The area has not been developed, nor promoted for tourism. Jimma has begun to develop tourist facilities including new hotels and has sites of cultural interest. However, the area immediately surrounding the project site has little attraction for either international or national tourism. If Highway #7 is improved, it is possible that a small increase in tourism will result.

Cultural features

In the area to be affected by the project, there are four mosques and a primary school but there are no known features of historical or archaeological importance.

Public utilities and roads

Development of the reservoir will necessitate the flooding of approximately 15 km Highway #7 which links Addis Ababa with Jimma, between the towns of Deneba and Asendabo. Apart from this highway there are no other important communication routes in the area. Connections between the various settlements consist of non-vehicular tracks which the population usually traverse on foot. The Gilgel Gibe River is normally crossed using primitive canoes made from hollowed out tree trunks. However, the river crossing points are numerous since the inhabitants of the left bank travel to the weekly markets in Asendabo, Deneba and Sekoru for trade and commerce, and for purposes of socializing.

About 14 km of telephone line and 237 poles along Highway #7 will be removed as a result of the project.

Housing

Houses in the area are basically of two types: cottages (tukuls), and mud houses with corrugated iron roofs. Table A.12 (Appendix) indicates the number of houses in the area by kebele and according to the position of the future reservoir. There are 361 houses in the area which will be flooded, most of which (205) are large cottages. The number of houses in the project area outside the future reservoir is decidedly higher: 839 large cottages, 206 medium-size cottages, 316 small cottages and 36 houses with corrugated iron roofs giving a total of 1,397 houses. These figures are likely to be smaller with the reduction of the buffer zone as some people who will have a choice to stay or move will elect to remain in their present location.

Wooden walled mud houses with corrugated iron roofs but without ceilings cost from 110 to 130 birr per square metre. The cottages have been classified into large, medium-size and small and the cost of rebuilding or replacing these houses would be 900, 600 and 400 birr, respectively.

4.3.2 Public Health

Water supply

Apart from the towns of Deneba, Asendabo and Sekoru, and the construction camp, which have deep wells as a source of drinking water supply, the people of the project area use untreated stream or spring water sources nearby their locations. The physical and chemical analysis of the 22 water samples collected from different sources in 1984 (UNDP/WHO Report 1984) revealed that the major components of cations and anions of the water were within the normal acceptable range. The fluoride and nitrate content of the water from the deep wells and springs was also found to be within normal range (Table A.13, Appendix).

Thus, all water resources in and adjacent to the project area are, from a chemical point of view, of sufficient quality for domestic purposes, but are contaminated with bacteria from human and livestock faecal material. At present, polluting activities such as industries, modern agricultural operations using fertilizers and pesticides, and municipal sewage, are virtually non-existent in the immediate vicinity of the project area. The only source of concern is the faecal contamination of the streams and springs located near densely populated areas.

Sanitation and toilet facilities

There are no health facilities within the project area and the nearest health units to the project are in Deneba and Sekoru towns which do not have adequate facilities and are staffed only by health assistants. Asendabo health centre is located 14 km away from the project area and is better staffed with a nurse, a sanitarian and a laboratory technician. It also has a laboratory for routine analyses. The nearest hospital with adequate facilities for both inpatient and outpatient care is located at Jimma, 70 km away from the project area.

The general sanitary conditions in the towns and villages located in the vicinity of the project area are unsatisfactory. Except for a few pit latrines in the old established towns of Deneba, Asendabo and Sokoru, there are no basic sanitary facilities for excreta and waste disposal. People use the open space around their dwellings for defecation.

Water Related Vector-Borne Diseases

A preliminary survey undertaken by the Ethiopia Water Resources Development Authority in 1986 revealed that malaria, onchocerciasis and helminthic infections (including bilharzia) are the major diseases found in the project area. According to the reports of the Institute of Pathobiology (1982) the incidence of *Schistosoma mansoni*, the vector for intestinal bilharzia (schistosomiasis) in the towns of Deneba and Asendabo is 1 per cent and 2 per cent, respectively which is low considering the presence of a large amount of standing water which could provide suitable snail habitat.

In the Gilgel Gibe River, a malacological survey has shown that out of the 32 habitats surveyed, 10 of them support *B. pfeifferi*, the snail intermediate host for intestinal bilharzia. Three of these ten habitats also supported *B. africanus* which is considered potentially important for the urinary form of the disease. As well, some of the snail vectors were observed shedding human cercariae, indicating the existence of the diseases in the area, albeit in an extremely low level of prevalence. According to the results of recent research (October 1995) carried out among four heath institutions (Asendabo Health Centre, Deneba clinic, Sekoru clinic and Jimma Zone Health Office), the number of schistosomiasis cases is surprisingly low throughout the region.

The Zone Office for Malaria Control at Jimma has indicated that malaria is endemic in the project area. The main transmission season is between September and November. *Plasmodium vivax* is the dominant malaria species and the major mosquito vector is *Anopheles gambiae*. As indicated by earlier results of the seasonal blood surveys and subsequent classification of the area in the 0 round spray category, malaria has been controlled effectively throughout the project area. Nevertheless, this same research indicated that all malaria cases, *Plasmodium vivax* and *P. falciparum*, increased significantly (refer to Tables A.14 and A.15, Appendix) throughout the project and surrounding area between 1989 and 1995.

Onchocerciasis (river blindness) is widespread in south-western Ethiopia including throughout the Kaffa Administrative Region through which the Gilgel Gibe River flows. The microfilarial carriers and the rate of ocular onchocerciasis, with partial and total blindness in Ethiopia, are estimated at a million cases. Oomen (1969) found 29 per cent (Deneba) and 19 per cent (Asendabo) positive incidence for onchocerciasis among males over 15 years old. This is an indication of a low level of endemicity. Oomen also confirmed the presence of *Similium sp.*, the blackfly vector for onchocerciasis in the streams adjacent to the project area. The 1986 surveys showed an incidence of onchocerciasis of 22.2 per cent in Kele village, 15.6 per cent in Enkure village and no cases in the other three areas surveyed. No case of blindness attributable to onchocerciasis has been found among the population examined during the socioeconomic study.

One blind person in the study group was negative for *Onchocerciasis volvulus*. An increase in incidence between the period 1989 and 1995 has been noted.

The project area is located within the tse-tse fly belt of the country. According to Langridge (1976), the Greater Gibe River and its tributaries are mostly infested with *Glossina fuscipes*. To date, no cases of human trypanosomiasis have been reported.

Infectious diseases

A survey amongst the principal health centres in the area for the incidence of infectious diseases has been conducted and the results are indicated in Table A.16 (Appendix). Asendabo Health Center and Jimma Zone Health Office indicate that the number of TBC patients increased 93 per cent from 213 cases in 1989/90 to 412 cases in 1994/95 at the Asendabo Health Center. Cases increased 193 per cent from 248 cases in 1989/90 to 726 cases in 1993/94 at Jimma. The TBC incidence is increasing yearly.

The Asendabo Health Center recorded 28 cases in 1992/93 and 15 cases of infectious hepatitis in 1994/95. In the past six years the total number of infectious hepatitis cases reported was 116. The Jimma Zone Health Office treated only 4 cases in the 1993/94 period.

Asendabo Health Center feedback shows that the incidence of AIDS has increased from 2 cases in 1989/90 to 13 cases in 1994-95. There has been no formal survey carried out to determine the exact number of AIDS cases. There were eight AIDS cases in 1994-95 at Jimma. Out of these, 4 cases were from Omo Nada District (including Asendabo) and 4 cases from Sekoru District .

Other sexually transmitted diseases (STDs) have remained relatively stable between 1989-95 around Asendabo. Typhoid Fever had remained stable until a dramatic increase in 94-95. Meningitis and Relapsing Fever have not increased. A large number of cases of bacillary dysentery and STDs have occurred in the Sekoru area. Jimma also reports an increase of typhoid fever.

Given the rural nature of the area and the rudimentary health services, it is likely that many of the illnesses are not reported or are mis-diagnosed. The data can best illustrate disease potential rather than actual situations. Water-related diseases are the most serious threats to human health, closely followed by the STDs.

5. PROJECT BENEFITS

The main economic benefit to be realized locally is the temporary, but considerable, on-site employment opportunities created for the local population. Approximately 1,000 temporary jobs will be made available for unskilled and semi-skilled employment. The benefit will last only through the construction period, producing approximately 5,000 person years of unskilled and semi-skilled employment. Since most of the wages generated by construction will be spent locally, there will a multiplier effect in the local economy as the money from wages is spent or invested locally. Further, contractors will spend money to purchase food and services locally if the local entrepreneurs can be positioned to take advantage of the potential local economic windfall.

During the construction phase, shops and households along Highway #7 in proximity to the construction site will have access to a much increased market created by the large work force that will be concentrated in the area. However, to a large extent, this potential benefit will be temporary and will last only for the construction period. There will be permanent work force remaining in the area, but it will be much less than the number employed during construction. However, the longer term work force will consist of a much higher percentage of skilled and professional staff who will enjoy higher incomes. Further, this financial contribution will be more stable and will provide a more stable economic foundation for the project area.

Depending on the manufacturing and industrial base in the region, purchases of goods and services will generate income, and contribute to salaries and employment during construction. At present, most of the economic benefits will accrue to Jimma where commercial and entrepreneurial skills are highest in the region and has relative proximity to the project area.

Economic benefits will be spread along Highway #7 owing to the increase in vehicular traffic, especially trucks between Addis Ababa and the project site. Property values along the highway will be inflated, especially near urban centers. To some extent, these benefits can be longer term if the project stimulates long term economic development in Jimma.

Although studies are only at a preliminary stage, it is expected that, productivity could increase by improving agricultural technology, including irrigation. Even modest agricultural interventions, such as small amounts of mechanization, improved seeds, use of agrochemicals and improved extension efforts, will greatly improve the agricultural productivity. In addition, improved access to markets, brought about through project-induced improvements to Highway #7, will provide incentives for increased productivity and a shift to higher value crops. The presence of an expatriate population in the contractors village will encourage a shift towards growing higher value fruits and vegetables as well as providing a much larger and more lucrative market for meat, eggs and dairy products without commensurately increased transportation costs.

The Regional Government of Oromia is approaching the resettlement issue as a development opportunity and must in that context be viewed as a potential benefit. The relocated population will receive better health, education and social infrastructure that they presently enjoy. The opportunity for more employment, better markets, access to agricultural extension services and availability of credit should stimulate economic growth and options for positive changes in standards of living.

Regionally, the project's expenditures will have a positive effect on the regional economy. Transportation companies, hotels, small factories and other outlets providing goods and services will all benefit from business with the project because transportation costs from outside the region are quite high. Investment costs from the realization of the project are conservatively estimated to be in the order of $US 246.5 million (for details, reference should be made to the Design Review Report, Jan 1996). The "boom and bust" syndrome has always been associated with large infrastructure projects, but has not been quantified in the published literature to the point that extrapolations can be made to the GGHP. To a large extent, much of the small entrepreneurs without aspirations of long term economic growth, do pack up and move out after construction, but a large portion of the commercial growth remains because they have been positioned so that they can compete in other markets. The possibility of a regional economic collapse following the completion of construction is well-known and the regional government will plan accordingly.

The construction of the dam will have an indirect positive effect on the downstream area, including:

- the possibility of deforestation and sedimentation will be minimized because the project area will be protected and the interference by human activity will be reduced. The resettlement program will shift the population into a less erosion-prone area and the dam/reservoir complex will become an effective sediment trap for the larger and more destructive materials.
- the calculated maximum flood for 10,000 years return period (3,495 m^3/s) will be controlled and regulated against possible serious flood disaster on the downstream flood plain area of the Gilgel Gibe and Gibe River confluence.

Nationally, the project will contribute to the national grid and assist in meeting the country's demand for electrical energy which is an essential part of economic development. The project relieves the country of some of the burden of spending foreign exchange on fuels and their transport charges for thermal power which is mostly imported. Given the advanced state of construction and site preparation, GGHP can be brought on line more quickly than another "greenfield"hydropower sites on other rivers.

6. IMPACT ASSESSMENT

The following sections describe and expand on the impacts that can be expected from implementing the project and provides an indication of mitigative actions that may be considered. The matrix of Figure 8-10 (Appendix) presents in shorthand form these potential environmental effects corresponding to the various actions foreseen while constructing, and operating the Gilgel Gibe project. In addition to addressing the impacts, some sections highlight potential mitigation measures which will be described in more detail in the environmental management plan which provides a format for the mitigation measures. The repetition should be helpful in allowing readers to become aware of the mitigation as the issues or impacts are defined. More detail of the measures will be given in the section on environmental management along with some cost estimates and schedules for implementation.

6.1 Physical Environment

6.1.1 Seismology

The dam site is 96 km from the most active seismic centres. Energy developed by any earthquake originating in these centres would be of concern in the project area even though the energy developed would be considerably attenuated at the site.

Reservoir induced seismicity (RIS) is always a possibility for any reservoir. The new body of water could increase the fluid pressure in the rock mass which in turn would reduce the frictional strength on the fault planes of the area. This would normally induce a higher number of micro-earthquakes to be released but this in turn would reduce the probabilities of far more disruptive events. The micro-earthquakes would free energy that would be accumulated and released at once during a more relevant phenomenon. The effects of RIS is local and normally not serious unless there is a potential for large land slippage which is not a condition at Gilgel Gibe. The RIS events are restricted to surface events that would not threaten life or dam integrity. The effects are very local, but raise considerable and understandable fears in local populations, but rarely cause loss of life or serious property damage. The danger of RIS is lessened in Gilgel Gibe because people will not be living in the buffer zone, the most likely area to experience any RIS effects.

6.1.2 Hydrology

While the main dam is under construction, temporary diversion tunnels will allow the river to bypass the work site. The river downstream would maintain its natural flows during this phase including the potential for heavy floods. There is an assumption in downstream populations that once construction starts on an upstream dam that flooding is a thing of the past. During and after construction, the potential for downstream flooding still exists although reduced in magnitude and frequency of occurrence. Beyond the confluence with the Gibe River, the controlling effect of Gilgel Gibe Dam is greatly reduced because the Gibe River will remain uncontrolled and it contributes the far greater volume of river discharge.

The filling of the reservoir is designed to occur gradually. Once reservoir filling begins, the diversion channel will still release water, which will be supplemented by the Chilelo tributary flowing into the stretch between the dam wall and the tailrace. The amount of river flow in this 16 km stretch will be greatly reduced, but will not disappear. The amenity flow is programmed into the filling sequence as a mitigation measure.

The reservoir will have a theoretical fluctuating level in any one year between 1651 m a.s.l. and 1671 m a.s.l., but realistically, the reservoir will not be allowed to reach the maximum level before spilling will occur, nor will it reach the absolute minimum before generation is curtailed. The more normal operating range will be between 1653 and 1671 m a.s.l. The predicted drawdown for any one year is 18 m. The reservoir will rarely reach it's full area of 60 km^2 which would occur when the spillway would be spilling water at full capacity. At normal operating schedules and meteorology, the reservoir area would not exceed 50 km^2.

6.1.3 Storage Sedimentation

During the construction phase, substantial effects on the characteristics of the sedimentation regime in the section of the river below the dam are not expected as the environmental management plan will control erosion caused by construction through constant on-site surveillance.

In terms of operation, sedimentation studies and field measurements carried out to date indicate an average annual sediment inflow in the upper reservoir in the order of 4.5 million tons. Granulometric analyses indicated that most of the suspended sediment is represented by very fine particles of silt and clay. Given the granulometric characteristics of the sediments and the limited volume of the reservoir in relation to the annual runoff, the reservoir trap efficiency is expected to be in the range of 80 to 90 per cent which corresponds to a total of 50 years deposition of approximately 180 to 200 million tons, or 140 to 160 million m^3 which is slightly more than the

128 million m^3 of dead storage in the reservoir. The implementation of a naturally vegetated buffer zone should reduce the amount of sediments entering the reservoir, thereby extending the useful life of the reservoir.

Sediment content of the water inflowing to the reservoir averages 0.255 mg/l. The minimum volume of sediment content is 2.8 million m^3/year and the maximum is 3.4 million m^3/yr. The finest particles deposited in the reservoir by the river will eventually pass through the spillway or the turbines. Given the very small size of such particles and the limited head, no special abrasion problems are expected. Taking also into account the low level outlet incorporated into the diversion tunnel, which, if properly operated, will assure a certain flushing effect, a dead storage of 128 million m^3 is considered sufficient to ensure the proper operation of the upper plant for an economic life period of 50 years.

The maximum drawdown area (the difference betwwen the theoretical reservoir largest surface area and the area occupied when resevoir surface elevation is at offtake level) is estimated to be 27 km^2 at the end of an extreme dry period. The more likely drawdown area will range between 0 at full service level and 20 km^2 at minimum operating level. This area will be tempting to use as dry season pasture but if it is used serious erosion could occur, exacerbating sediment loading in the reservoir. As part of the mitigation plan this area will be closed to grazing and agriculture and will be within the buffer zone.

6.1.4 Water Quality

Contamination of the future reservoir water from faecal matter and domestic wastes will not be a serious problem since all villages and individual houses in the project area will be relocated and no dwellings or livestock grazing will not be permitted in the protective buffer zone. However, water quality downstream could be altered by the construction activities and workers. Erosion, chemical pollution from construction activities, and pollution from human and domestic waste from the camps and offices could occur. To the extent possible, pollution will be controlled by on-site environmental management activities carried out by EELPA and the construction contractors.

The quality of the reservoir water is partially dependent on upstream conditions and activities as well as on the retention time within the reservoir. The non-point pollution potential from the watershed is low since agricultural practices in the watershed are relatively primitive and do not involve the use of chemical fertilizers or pesticides. Predicted annual drawdown levels of 18 m should ensure that riparian macrophytes will not flourish in the new impoundment. The major contributor to adverse water quality in the reservoir will be the operating schedule of the reservoir and the possibility of a proliferation of aquatic vegetation over time.

Floating macrophytes such as water hyacinth (*Eichhornia crassipes*), the presence of which is well known in all regions of Central and East Africa and is likely to be the invader to expect. It is particularly prolific in Ethiopia and within the basin which provides water for the Awash hydroelectric plant and has caused significant problems. The probability of reservoir colonization by water hyacinth will be decidedly higher in the first years following the filling of the reservoir due to the high concentrations of nutrients from decaying vegetation. The environmental management plan includes an aggressive approach to monitoring and controlling water hyacinth by the on-site environmental management unit.

The chemical and physical characteristics of the Gilgel Gibe and Zambezi rivers are similar. It is therefore possible to calculate likely future changes in the catchment water. Salinity is estimated to be 1.2 to 1.4 times higher following the construction of the dam. Water turbidity, which reduces light penetration and thus limits the production of algae, the reservoir will probably be much clearer than the water of the Gilgel Gibe River. This effect will follow the settling of suspended fine particles. It is estimated that water will remain in the reservoir for a period of 120 to 150 days and this would result in levels of fine suspended material downstream of the hydroelectric plant being about 40 to 50 per cent lower than current levels without a project.

Increased productivity of the reservoir system will occur as a result of nutrient richness from the presence of large quantities of decomposing biomass in a slow-changing, low-oxygen body of water with a low level of turbulence. These conditions could provoke the phenomena of anoxia, and an initial increase in CO_2 in the water would be followed. If anoxic conditions occur at the bottom of the reservoir, anaerobic decomposition would produce H_2S and an increase in acidity will take place. The anaerobic conditions would have an immediate (although temporary) repercussion on the aquatic invertebrates at the bottom of the reservoir while the increase in the waters' acidity could cause damage to the power station plant. However, aerobic conditions will prevail at the intake level unless water hyacinth mats block out sunlight penetration into the reservoir. Releases from the bottom outlet would be anoxic and would have to be mixed with surface waters in order to prevent downstream fish kills. Since the Chilelo tributary enters the Gilgel Gibe river one kilometer downstream of the dam, the anoxic conditions from bottom releases would disappear quickly.

Removal of woody vegetation from the reservoir prior to flooding will partially mitigate the adverse quality that could be expected. Reservoir clearing of woody vegetation will be a part of the civil works contract. However, herbaceous material will remain during reservoir filling and the decomposition of this material will produce an initial flush of nutrients for several years in the reservoir. Algae and plankton will proliferate and fish growth will be more rapid. As the reservoir matures, the nutrient levels will decrease as will total reservoir productivity of biomass.

Proper storage, handling and disposal of construction materials, particularly chemicals, fuels and lubricants, and the provision of proper treatment facilities for human and domestic wastes will reduce the threats of water pollution. Proper construction techniques will minimize erosion at the site and downstream sedimentation. Construction contracts will require each contractor to define an environmental management component that would be implemented during the construction period. Runoff from blasting operations in the tunnel and at quarry sites will be properly controlled and contained (e.g. sediment ponds) to ensure that contaminated runoff does not reach the Gilgel Gibe River. Maintenance facilities and fuel handling areas are located well away from the river's edge.

6.1.5 Climate

The area to be occupied by the reservoir will vary during the year as flows from the reservoir are regulated according to the expected cycle of drawn-down level and flooding. As well, the volume of losses will also vary from month to month in response to changes in the weather.

Evaporation from the surface of the reservoir will replace the present evapotranspiration from the soil of the area to be covered by the reservoir. In certain months evapotranspiration from the soil would exceed the evaporation from the reservoir as a result of heavy rainfall periods when the soil becomes saturated. In addition, vegetation and topographical depressions in the soil create a much greater contact surface with the air, allowing a greater opportunity for water release than that provided by the surface of the reservoir. The presence of the reservoir will expand the floodplain microclimate within the buffer zone. Microclimate changes beyond the buffer zone are not expected to be significant or noticeable except for a slight increase in fog. The estimation of the additional evaporation rate, induced by the presence of the reservoir, has been calculated on the basis of meteorological data from Jimma during the periods of 1972 to 1975 and 1984 to 1993. The area under investigation appears to be sufficiently homogenous from a morphoclimatic point of view, such that measurements carried out at the Jimma station can be extended to the Deneba site where the dam will be located.

The monthly total evaporation and daily mean evaporation rates are provided in Table 6.1 and 6.2. The method used in this report to evaluate the evaporation from a water surface is based on a simplified energy balance, details of which are provided in Hydrological Report 05/1/1996.

Table 6.1: Daily Mean Evaporation Rate Ep [mm/day] for Each Month at the Dam Site

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
EP	5.39	5.72	6.17	5.46	5.18	3.83	3.97	4.60	4.60	5.32	5.30	5.05

Table 6.2: Monthly Evaporation at the Dam Site

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Ep/ Month	167	160	191	164	161	133	119	123	138	165	159	157

The total annual evaporation is 1,837 mm per unit of surface. The additional water losses that will be induced by the presence of the reservoir can be estimated by comparing the evaporation rate prior to construction, from the ground and vegetation, with the rate to be expected from the reservoir. Since the annual mean evaporation from the reservoir will be 1,837 mm, it is possible to deduce that the liquid surface causes an evaporation rate of:

De = 1837 - 1150 = 687 mm/year

• if S is the liquid surface area of the reservoir in km^2, then the increment of the losses, DQ, can be estimated in m^3/s with the relation:

$$DQ = \frac{DexS}{31.536x10^6}$$

with :	$S = 20\ km^2$	$DQ = 0.44\ m^3/s$
	$S = 30\ km^2$	$DQ = 0.66\ m^3/s$
	$S = 40\ km^2$	$DQ = 0.88\ m^3/s$
	$S = 50\ km^2$	$DQ = 1.10\ m^3/s$

These values represent 0.9, 1.3, 1.7, 2.1 per cent of the long-period mean annual flow rate respectively, and for this reason it is possible to consider the evaporation losses negligible.

The construction of a reservoir with a surface area of approximately 60 km^2 can cause hydrological, hydrogeological and microclimatic changes over an average area of 0.3 to 1.5 km from the edge of the reservoir (Avakyan, 1975). In some cases minor climatic changes can occur up to a distances 20 to 30 km away. At the edge of the reservoir daily temperature ranges could fall by 2 to 4°C; relative humidity could increase by 10 to 15 per cent; wind speed could increase; and, there could be reduced soil evapotranspiration. With protection of the buffer zone and a small amount of management, the area of riparian forest would be greater after the reservoir fills than under the present conditions.

6.1.6 Downstream Effects

Evaporation from the surface of the reservoir would cause a minor loss in the flow into the Great Gibe River, and thus in the flow of the Omo River, and consequently, on the inflow of Lake Turkana.

The reservoir area would normally fluctuate within the range of 29.12 to 49.45 km^2. With an average surface area of the reservoir being 40.11 km^2, the annual reduction in flow of the Gilgel Gibe River by evaporation due to the creation of the reservoir will be 0.87 m^3/s. This flow corresponds to an annual volume of 27.55 million m^3 which is considered insignificant (0.17 per cent) as compared with the annual flow of the Omo River which contributes an average annual flow of 16,600 million m^3 to Lake Turkana.

Once the reservoir has completely filled, and operation of the plant has started, 44.65 m^3/s flow will be discharged through the turbines, 1 m^3/s will be allowed as compensation flow and 5.28 m^3/s on average will be spilled monthly over the spillway. This will provide a balanced flow for the downstream users. Annual flooding of the Gilgel Gibe River would be reduced, but the flood reduction might not be noticed by people living in the Gibe River floodplain except at the confluence of the rivers.

6.1.7 Landscape

During the dry periods, the reduction of the flow of the Gilgel-Gibe will have a significant impact on the appearance of the Deneba Falls which is an attractive landscape element. At present, the falls are not an important touristic feature because tourists do not visit the area.

6.2 Natural Environment

6.2.1 Natural Vegetation

Project construction activities will entail the removal of natural vegetation and the dumping and stockpiling of earth on areas occupied by natural vegetation. Riparian areas, transitional vegetation between riparian forest and the woody savannah will all be affected through the loss of natural vegetation. Hillside farmland which consists of isolated *Acacia abyssinica, Acacia sp.* and *Adansonia digitata* (Baobab) trees as well as small clumps of *Eucalyptus globulus L.* will also be affected by during the construction phase. However, the total loss of land and vegetation during the construction phase will be limited to the areas needed for construction and access. Since most of the construction sites have already been developed and are in place, incremental losses of natural vegetation will be minimal except for the area to be inundated.

The reservoir will be a permanent feature and will directly affect a land area of nearly 60 km^2 when filled to it's maximum area. Clearing of all large forms of vegetation will occur and all vegetation on this area of land will be lost. The proposed reservoir area includes 300 ha of partially degraded riparian forest that provide habitat for several desirable wildlife species. The remaining area consists of cultivated and grazing lands with remnants of the transitional zone and savannah woodland.

The loss of riparian vegetation and its wildlife habitat will be compensated by the creation of a buffer zone of over 2,000 ha which will encircle the reservoir and extend on both sides of the river down to the powerhouse site. This buffer zone will have natural vegetation and will not be used for dwellings, agriculture or grazing. Access to the reservoir for fishing will be permitted by EELPA which is consistent with company policy at other hydroelectric sites in Ethiopia.

These changes will produce a suitable microclimate for the restoration of natural vegetation of the reservoir edge (about 78 km long) using species listed in the phytosociological survey. *Albizzia schimperiana* and *Morus mesogriza* which grow rapidly would be suitable replacements for the existing riparian flora and are also ideal for the poor lateritic soil on the slopes surrounding the proposed reservoir. The environmental management plan includes the collection of plant propagules prior to and during reservoir clearing that will be used to restore natural vegetation in the buffer zone. The moister air masses created by eastern and southeastern winds (Griffiths, 1972) would be blown onto the hills and mountains to the west and north-west. It is predicted that the revegetation of the buffer area will in time convert the evergreen mountain shrub into woodland and subsequently this will succeed to a moist evergreen mountain forest, providing all of the advantages of a forest including a rich biodiversity.

The plant life that will naturally be established along the edge of the reservoir and in partially flooded areas will include those species currently found in the area and probably, as well, other species which inhabit the banks and water edges of the rift valley lakes and Lake Turkana (FAO, 1961). These will include those listed below.

<u>bank vegetation</u> - *Typha sp,.*Phragmites, *Juncus sp. and Scirpus sp.*

floating and emerging plants - *Nymphaea sp.,*Leersia and Panicum

underwater species - *Potamogeton sp and.Ceratophyllum sp.*

Part of the flooded pasture land will be retrievable when reservoir levels recede, particularly in the December to April period. These areas are likely to produce the kind of grasses currently found in the riverside meadows and could be made available for controlled grazing in the dry season in emergency situations. Current plans do not include grazing within the buffer zone, but manual harvest of the vegetation for fodder would be considered during periods of drought. It is possible that EELPA may consider allowing local people to cut the drawndown vegetation for housing materials. A determination of how buffer zone vegetation will have to wait until the reservoir has been in operation for a few years in order to evaluate the productivity and utility of species that will grow in the drawdown zone and the effects of limited access.

The riparian vegetation along the section of the Gilgel Gibe River between the dam and the tailrace could be modified to an evergreen mountain vegetation type as a result of a decrease in air and soil humidity due to the loss of river flow. Since the topography of this 16 km section of the river is very steep, there is little floodplain vegetation so any conversion to a different vegetation type would be slow. The most noticeable effect would be a reduction in the epiphytic plants growing on the evergreen trees.

6.2.2 Fauna

Fish population

No significant adverse impacts on fish populations or on fish habitat in the Gilgel-Gibe River are anticipated during the construction phase, but there should be dramatic changes following dam closure.

The fish population in the section of the river above the proposed dam site is naturally isolated from downstream populations by the Deneba waterfall. The population is ecologically adapted to this position of isolation. As well, the fast current around the waterfall largely discourages this population from swimming downstream. The presence of the dam will have little influence on the current population and its movement in this regard. However, the change from a river environment to a lake environment will affect fish population, its composition and dynamics.

The reservoir will provide an enriched food supply in the form of submerged plant life which will nourish the invertebrate food chain for several years. This will likely increase biological productivity and overall fish yield. However, once this food supply is exhausted, production will decline and an equilibrium at a lower level will be established. This decline will be more pronounced in deeper sections of the reservoir as these are deprived of the riparian environment favouring the main biological functions of the ecosystem. In shallower waters production levels will be kept fairly high because of periodically raising or lowering the water level that accelerates oxidation and thus recycling the organic matter accumulated on the reservoir bed.

The morphoedaphic index (MEI) can be used to estimate the maximum sustainable yield (MSY) in the reservoir once it has achieved a level of production stability. MSY is the surplus fish population that can be captured without damage to the core population. This sustainable capture is thought to be in the order of 30 to 50 per cent of the total population (Gulland, 1970).

Based on the formula developed by Ryder (1965), production, once the reservoir has stabilised, should range between 15 and 25 kg/ha/annum, given that total dissolved solids (TDS) are 64 parts/million (ppm), as measured in the Gilgel Gibe River, and the average depth of the reservoir is 16 m .Since the maximum surface of the reservoir will be about 60 km^2, the Ryder formula gives an absolute MSY for the entire reservoir of 75 to 125 tonnes/annum.

MSY estimates from similar surfaces of several large African lakes are higher which may be due to the altitude of the project area which contributes to a more temperate climate. The calculated yield per unit area of the proposed reservoir is similar to the yield of the Nasser/Nubia reservoir (21 kg/ha/year) and is much higher than the yield for the Kariba reservoir (7.6 kg/ha/year).According to Welcome (1978), the estimated sustainable yield of the Gilgel Gibe River is probably in the order of 40 to 60 kg/ha/year.

Species composition in the reservoir will probably reflect species currently found in the Gilgel Gibe River since the catchment upstream of the reservoir contains the same species found in the portion of the river to be flooded. Of the three fish species found in the Gilgel Gibe River, two (*Barbus intermedius* and *Tilapia nilotica)* are well adapted to a lake environment. The third species, *Labeo sp.*, will probably be able to tolerate the lake environment. Proportions of the three species are not expected to change. At present, *Barbus sp.* accounts for 90 per cent of the population and there is little reason to believe that it will lose its dominance in the reservoir.

Tilapia nilotica, which prefers tropical water courses, may obtain some advantage from the increased temperature of the reservoir (the hydroelectric plant will remove some of the colder water from the lower depths) but the advantage will not likely lead to a significant increase in its population. It is expected that *Labeo sp.* will maintain its marginal presence among the fish population. The data resulting from this analysis indicate that the local fishery will be aided by the creation of the reservoir, particularly in the early years. The introduction of improved fishing methods and equipment such as bow-nets and fish traps would increase the importance of fish in the local diet and contribute to the local economy if a small local commercial fishery is established. At this time, there is no indication of interest from the local population for an expanded local fishery.

Downstream aquatic life

The Gilgel Gibe Dam will reduce the aquatic life in that portion of the river between the dam and the tailrace, roughly 16 km of the 70 km to the confluence with the Gibe River. The reduction in the fish production downstream will be more or less compensated for by the net increased production in the reservoir, as has been the case in many of the larger African (Chari, Niger, Senegal), American (Missouri, Colorado) and European (Volga) rivers (Wellcome 1978) and their associated reservoirs.

As an extreme example, even if the length of river downstream to be affected is 100 km (but only 16 km between the dam and the tailrace would have significantly reduced flow) this would represent a total water area (assuming 0.03 km average river width) of 3 km^2, and the loss of MSY would be 16.5 t/annum. This amount would be easily compensated through the production of the reservoir.

Other vertebrates

Habitats will be lost as a result of buildings and access roads, as well as general construction activities. Of particular importance during the clearing of the riparian forest are the loss of habitats for a variety of wildlife. The loss of habitat provided by the riparian forest will be partly compensated for by the establishment of vegetation in the buffer area.

General noise levels on the construction sites will cause wildlife to temporarily move away from the area. Most wildlife populations will become established once again in the area, once construction has been completed.

The removal of existing natural habitat, in particular, the riparian forest, will result in wildlife migration both upstream and downstream to other relatively undisturbed and suitable riverine habitats. However, the assumption has to be made that ecological niches in these areas will already be occupied and these habitats will be at the extent of their carrying capacities. In addition, many of the wild animals are strongly territorial and will defend their territories against invaders As a result, many of the wild mammals from the riverine habitat to be removed are likely to perish. The effects on other vertebrates (birds, reptiles and amphibians) are likely to be less harsh as they are less constrained by carrying capacity and territorial behavior than mammals.

Only partial mitigation will be achieved through revegetating the reservoir shoreline and the buffer area. Riverine vegetation can not always be duplicated due to different soils, microclimate, and moisture regimes. Newly vegetated areas will attract some wildlife but the riverine faunal community, as it is currently structured, could be lost for a long time. It is not possible to predict to what extent riparian forest will be established along the new reservoir and how long it would take to reach maturity and some degree of ecological equilibrium.

Predator populations, notably crocodiles, may increase in response to diminished turbidity of the reservoir and an increase in fish productivity. At present, there are no plans to control or prevent predators in the reservoir. Since the buffer zone will keep most people away from the reservoir, the expected increase in cocodiles will not pose a serious threat to humans. The EMU would become aware of any serious threats during the course of water sampling and waterweed control. Bird predators, waterfowl and raptors, will increase which provide a small atraction to tourists.

6.3 Socioeconomic Environment

6.3.1 Dislocation of People

Three different groups of people within the project area will be directly affected by the project and will be required to move from the area. Figure A.1 shows the area occupied by the reservoir together with the project area limits These groups will include:

- . Families living and cultivating in the area of the reservoir.
- . Families living outside the reservoir zone area but cultivating within the reservoir.
- . Families living and cultivating outside the reservoir area but within the project area.

An area of approximately 60 km^2 will be inundated at maximum supply level and will affect 18 kebeles belonging to 4 weredes. The area includes 2,476 families representing 15,351 people who will be obliged to move from the area. Those who live and work within the area (273 families representing 1,715 people) of the proposed reservoir will have to abandon their homes as well as the land they use for agriculture and grazing. In this area 1,196 ha of land is used for agriculture and 114 ha of land is used for grazing.

The land within the area of the future reservoir that is used by families living outside the area includes 1,545 ha for agricultural uses and 164 ha for grazing.

The third group of people, those who live and work outside reservoir area but within project area, is the largest, with 1,946 families and 12,516 people. These families use 6,282 ha for farming and 199 ha for grazing.

As noted previously, the figures for the latter two groups will change owing to the reduction of the buffer zone. Some of the people who will not longer have holdings in the buffer zone due to the change will elect to stay on their present holdings. Since, the reservoir perimeter is unchanged, the first group will not have any options to stay as their holdings will be inundated. The new area of the buffer zone and reservoir will be approximately 9,200 ha instead of 10, 650 ha.

The above groups of people to be affected by the reservoir will have to be relocated. Experience with involuntary resettlement in other development projects has not been good. Relocation can occur over a period of several years and unless resettlement is planned and implemented carefully it can create psychological and socio-cultural stress and tension amongst those displaced and those in the receiving areas, especially if the two areas are different culturally, ethnically and linguistically.

Usually people are reluctant to move from familiar surroundings and be disrupted from their socio-cultural groups. Most are particularly upset that they are forced to do so in order to produce benefits for others i.e. hydroelectric power generated in rural areas and transmitted to urban areas).

The high stress level is generally expressed in very conservative attitudes among those displaced, who in the first few years after relocation (at least 3 years) tend to insist on their former production techniques and seek out social groups that are familiar to them. Experience in other resettlement efforts has shown that the majority of people who are forced *to relocate prefer to be* relocated to areas close by and wish to maintain the cohesiveness of their social groups as much as possible.

The impact can be extreme and could last for a long time. Even after resettlement it is unrealistic to expect that displaced people are able to quickly adapt to new production systems under different climatic and soil conditions, and perhaps even being required to change occupations.

The resettlement program required for Gilgel Gibe Hydroelectric Project is designed to avoid many of the risks stated above. The people have been aware of the possibility of involuntary resettlement since the early 1980s and are more prepared psychologically to move. A Resettlement Planning Unit has been established in the Oromia Regional Government to design and implement the resettlement plan as a development opportunity. A resettlement site has been selected. . The resettlement site is large enough to accommodate the entire relocation populations so that existing communities do not have to be fragmented. The selected site is also very close to the project area and environmental conditions are similar. Further, the receiving communities are similar ethnically, culturally and linguistically. These advantages do not completely eliminate the potential for psychological or economic stresses for the people to be relocated, therefore the resettlement program will contain counselling and advisory services plus make financial credits available to the resettlers if necessary. To the extent possible, the relocating population will be able to retain or improve their current life style as they choose.

The new site will be provided with access roads, drainage systems, an elementary school, health unit, offices for the Farmers Associations, Mosques, Churches, a veterinary health post, and a flour mill. Money has been budgeted to provide agricultural extension services, vocational training and credit for the people to be resettled. The cost for the resettlement infrastructure is approximately US$ 750,000.

The resettlement study indicated that 38.9 per cent of the total number to be resettled prefer to arrange their own resettlement affairs, 45.5 per cent prefer to settle in government prepared resettlement sites and 15.6 per cent were undecided. After further discussions regarding the modality of providing housing, the GOE has decided that the settlers would be provided with prepared sites at the resettlement area. The settlers would be paid compensation for the dwellings to be left behind and they would make personal arrangements for house construction. The Resettlement Unit would provide assistance with materials and technical advice.

6.3.2 Loss of Livelihood

If the resettlement plans are implemented successfully, there should be no loss of livelihood for the population to be relocated. The government has provided a resettlement site that is equal in size and quality to the land that they currently use. All people will be able to continue with their means of livelihood, mostly agriculture if they prefer. In addition, many will gain employment and new job skills as project laborers. New means of earning a living will become available through supplying goods and services to the construction labor force. A new temporary market at the construction camp and contractor's village will be opened for the sale of their agricultural and livestock production.

6.3.3 Loss of Agricultural Resources and Food Production

The removal of about 8,600 ha of cultivable land may result in a temporary reduction in local agricultural production and possibly a consequent increase in pressure on the surrounding land. Loss of production will be mitigated through the resettlement program whereby new lands will be brought under production with improved agricultural techniques. As well, a fisheries development and management programme for the reservoir may result in a net food production gain and additional jobs for the area. Effective agricultural extension, planned in the resettlement program, promoting good land husbandry practices, will minimize soil erosion and increase agricultural production.

Preliminary calculations show a loss of about 6,138 metric tons of food and grain per annum if the resettlement site is not ready for agricultural production in time. Paddy, wheat and maize alone account for 5,400 metric tons or 12 per cent of the total production of the entire two districts (45,000 metric tons). The district food balance could be disturbed, thus the successful implementation of the resettlement plan is envisioned as critical to the local area by the Resettlement Planning Unit..

6.3.4 Loss of Infrastructure

A total of 130 houses, 2,605 large cottages and 1,857 small cottages will be expropriated as a result of the project. In addition, 6,311 barns will be expropriated.

Approximately 14 km of telephone line and 237 poles will be lost as a result of the project. As well, four mosques and one primary school will be lost. There are no registered historical or archaeological features within the project area.

All infrastructure losses and the services that the infrastructure represents will be replaced or compensation will be provided.

6.3.5 Health

Dust and Noise

General construction activity, including blasting, dumping of waste (e.g. tunnel spoil), construction and traffic, will lead to an increase in dust and noise in the general area. This will have an effect on people's health. Dust can cause respiratory problems and noise, if sufficiently loud and frequent, can cause hearing problems amongst both workers and local residents, and it can cause stress.

These impacts can be mitigated through the provision and use of proper hearing equipment for workers and warnings provided well in advance in order that local people will be prepared. The impact on local people of heavy construction noise will be minimal since all local people within the proposed project area will be relocated. Dust can be controlled through the watering of roads, the controlled speed of road traffic, and various other control techniques to be applied during drilling and blasting operations. The contractors will be required to address these issues in their environmental management plan when they submit their contract proposals. In addition, the EELPA on-site environmental unit will monitor contractor's compliance with environmental protection standards in the contracts.

Public Safety

Public safety will not be a significant problem since residents within and close to the proposed project area will be relocated. Heavy vehicle movement between Addis Ababa and the project area will provide the potential for road accidents, particularly with local residents who are not accustomed to heavy traffic and heavy vehicles.

Project related vehicles will be required to abide by good driving conduct, obey speed limits and generally follow the rules of safe driving. All vehicles will be equipped with properly maintained lights and audio warning systems. Night driving will be minimal and strictly controlled. All local residents will be made aware of the traffic increases to be expected as a result of the project and safety lectures, probably in conjunction with public health lectures, will be provided to community groups.

Water Borne Diseases

The reservoir will lead to an increased potential for water borne diseases. The Gilgel Gibe reservoir will suitable for the transmission of three main types of parasitic infections: malaria, onchocerciasis (river blindness) and bilharzia (schistosomiasis). The transmission vectors of these to humans involve a vector or intermediate host linked to the presence of water.

The entomological and malacological studies, and the reports of the health authorities of the area, confirm the endemic nature of malaria and the presence of bilharzia and river blindness in the area. If suitable measures are not taken, the creation of a very large body of water with a gently sloped perimeter covered with vegetation will provide ideal conditions for the growth of the vectors responsible for the transmission of malaria and bilharzia. The reservoir conditions will reduce habitat for river blindness vectors except at the spillway and tailrace. Anopheline mosquitos (responsible for transmitting malaria) will find conditions that are particularly favourable for their larval development in the areas of the sun exposed flat banks which contain aquatic vegetation Such habitats are also suitable for the growth and development of *Bulinus sp.* and *Biomphalaria sp.*, snail hosts of the parasite which causes bilharzia.

A major factor for the spread of bilharzia is human population movements. During the construction phase of the project, it is expected that over one thousand labourers, some from different parts of the country, will be employed. As a result, it is probable that some of these will be people from malaria and bilharzia endemic areas. They will increase the existing transmission foci and intensify disease dissemination. It is also likely that laborers and truck drivers from bilharzia and malaria free areas will contract the diseases while working in the project area and then take the diseases back to their home areas. Of the sixteen employees that are currently at the project site, one is currently infected with *S. mansoni*, which is the parasite that causes intestinal bilharzia, which is more serious than urinary bilharzia.

Reservoirs generally decrease the prevalence of onchocerciasis as a result of a decrease in the density of the vector. This is seen in areas where *Simulium damnosum* is the sole vector of the disease. In the Gilgel Gibe area it has been observed that both *S. damnosum* and *S. ethiopense* are vectors. The breeding habitat of *S. ethiopense* is quite different from *S. damnosum* in that the former species breed on crabs and requires a relatively slow moving river in contrast to the latter which prefers fast well-oxygenated water, such as the spillway and tailrace. Although the construction of the dam may adversely affect affect *S. damnosum* due to the creation of a slow moving river, it is expected that this may not be so for *S. ethiopense*. In fact, the density of the latter species may be enhanced and will probably become a vector of primary importance.

Possibilities for increasing the seriousness of the malaria vectors and the disease are high due to the introduction of vectors from adjoining areas, the creation of suitable habitats and the introduction of new strains of malaria through migrant labourers.

The uninhabited buffer zone will decrease the project-induced exposure to bilharzia and malaria for the general population. However, the threat of contracting the diseases will remain high in the region because of the ubiquitous presence of standing water throughout the region during the rainy season. There will be considerably increased exposure to the diseases to the large work force who will be working and living in conditions ideal for transmission of malaria and bilharzia. Construction camp clinics must be well supplied with a variety of medicines to treat the diseases. Chloroquine resistant strains of malaria can be expected and prophylaxsis must be provided for anyone working for the project. Living and eating quarters must be protected from mosquitoes and sleeping nets should also be provided to workers.

In addition to bilharzia and malaria, increases in other mosquito borne diseases such as encephalitis and Rift Valley fever can occur. Clinics must be staffed by personnel experienced in the diagnosis and treatment of these and other tropical diseases.

Sexually Transmitted Diseases (STDs)

Experience from other similar construction sites indicates that a large work force dominated by single men will attract women to the area for purposes of commercial sex. This can lead to an increase of sexually transmitted diseases (STDs). Of particular concern is an increase in the incidence of HIV/AIDS. AIDS has already been reported to be increasing in the region, but at relatively low rates. These rates will increase as laborers and truck drivers from urban areas where AIDS prevalence is much higher come into the region as a result of the project.

The mitigation plan will take an aggressive approach to control the spread of STDs. The plan will feature public health education programs (including sex education), control of informal sector activities near the project site, and the distribution of condoms. Even with the most vigorous campaign and safeguards, an increase in STDs resulting from the project is inevitable. Systematic blood testing at the camp clinic is absolutely necessary, if the increase in AIDS is to be kept at a minimum. The blood testing must be used for information purposes and not be used to dismiss infected employees. Contractors should address employee health issues in their contract proposals.

Other Infectious Diseases

Intestinal diseases, hepatitis, respiratory diseases (including tuberculosis) and plague are diseases that can occur in situations where a large work force is not provided with the proper sanitary and work place facilities.

Contractor work camps will be maintained in a clean and healthy condition as proscribed by international worker health standards. Human waste will be treated properly and disposed of by the existing camp sewerage system which will be maintained in good working order. A clean and protected water supply is already in use. Kitchen wastes will be burned, buried or taken off site, to prevent a large rodent population and the breeding of disease carrying flies and other insects. Health education will include the proper handling and storage of food stuffs, and all living quarters and work places will be adequately ventilated to prevent respiratory diseases. Workers would be screened for tuberculosis.

Substance Abuse

A large construction labour force comprised primarily of young men living away from families, relatively stable wages and idle time with few recreational pursuits and no domestic responsibilities can often lead to the overindulgence with alcohol. This can lead to abuse, fighting and injury, particularly if women are involved. Men who live in the area but who work on the site may abuse the use of alcohol, return home in an inebriated state and abuse and injure family members, and generally cause a good deal of domestic upheaval.

The problems of alcohol abuse must be explained to workers as a part of the health education program. Recreational areas are available at the camp and additional activities should be a normal part of camp living. Severe penalties for drunkenness and disorderly behaviour must be given out along with the provision of counselling services for substance abuse.

6.3.6 Communication Facilities

The loss of a section of Highway #7 will occur as a result of the reservoir. No other major roadways will be affected. The creation of the reservoir will eliminate the boat routes across the river which local people use for access to markets, family and friends.

Highway #7 will be re-routed and new pathways established to make sure that no human populations are cut off from access to the new road. The Ethiopian Road Authority is planning to upgrade Highway #7 and will assume all the responsibilities for the necessary construction for the new road sections. The authority is in the process of preparing new environmental standards and requirements for road work and these will be employed for the work on Highway #7.

6.3.7 Social Services

An increase of workers to the area will place additional pressure on social and cultural facilities. Of particular concern will be the pressure placed on health and medical facilities. The construction camp will provide health services for the work force community.

6.3.8 Economic Development

The upgrading of Highway #7 will add to the economic development of Jimma and Asendabo. The increased movement of goods to the project site through the cities and towns along the route will spur secondary economic development since vehicles will require service, parts and fuel en route.

6.3.9 Gender Issues

Little information is available in the project area on specific women's issues. A number of impacts are anticipated, based on experiences from other similar development projects in the world. The following are some of the potential impacts, many of which relate to the resettlement programme, but these should be evaluated specifically for the Gilgel Gibe project.

- relocation disrupts the family unit as men often migrate to areas of large infrastructure projects to seek employment and forcing women to assume additional domestic responsibilities at home;
- cash compensation often does not benefit women since they have little or no control over it;
- relocation can mean the loss of an existing job or a means of gaining an income;
- relocation can mean the loss of certain types of food to the diet;
- formal and informal social networks often have to be reconstructed;
- women are often used on construction sites as unskilled labour and often without health precautions or insurance which are available to men;
- women are usually paid less than men for the same work;
- stable disbursements of unaccustomed amounts of money to newly employed husbands sometimes leads the men to prostitution and associated health problems, substance abuse which can lead to physical harm to women and children;
- when women join the labour force a lifestyle can be lost;
- if women work they are vulnerable to a number of health problems as a result of overwork and stress.

To mitigate some of these potential problems, program planning must take into account consideration for women. Employment programs should promote the equal treatment of women. Educational and skills training programmes should be made available equally to both men and women. While the resettlement plan sets aside funds to address individual family hardships, a similar program should be made available to women who are not part of the resettlement program but are employed by the project or are married to a construction worker.

6.4 Institutional Environment

People being resettled originate from four weredas (Kersa, Sekoru, Omonada and Tiro Afeta). Two weredas will be losing population and land while two will gain. The loss of people will affect the economy of the weredas and to some degree it will probably also affect the social and institutional network of the weredas.

7. ENVIRONMENTAL MANAGEMENT PLAN

The purpose of the environmental management plan is to describe in the detail possible the actions that have been taken or will be taken to ensure that the impacts which have been identified are mitigated to the extent feasible. Where impacts cannot be mitigated, compensation programs will be designed, as well as any environmental enhancement activities that will be required to offset, where possible, those impacts that cannot be mitigated. This plan will also provide estimated costs where feasible and a schedule for implementation. For the most part, responsibility for implementing the plan will rest with EELPA or EELPA's contracted representatives unless noted otherwise. To a considerable degree, construction contractors will be responsible for implementing mitigation measures but the ultimate responsibility for ensuring that environmental and social protection elements are being carried out properly rests with EELPA or their legally constituted agents. Thus the schedule for some of the mitigation is linked to the allocation of construction contracts. EELPA is currently taking actions to increase their capacity to implement and monitor the environmental and social protection parts of this plan. EPA will collaborate with EELPA by providing review, advice and policy guidance. Financing for the mitigation plan, including resettlement, will be guaranteed by EELPA and the Government of Ethiopia.

Most of the impacts which occur during the construction phase can be reduced or avoided through the application of sound construction management guidelines. Construction contracts will require all qualified bidders to include environmental management plans as a part of their submitted bids. The additional costs of these plans can not be predicted at this time, but they are considered an integral part of total project costs.

Some impacts will be permanent and cannot be mitigated. Many of the impacts that will occur as a result of the reservoir fall into this group. In some cases, these impacts will be compensated, or enhancement activities will be put into place that will offset their effects. Enhancement is an important part of the overall management plan as it is used to improve existing environmental conditions, restrict any likely environmental degradation (which is not directly related to the project) in the future, and it can form a part of compensatory measures.

The management plan, outlined below, takes into account the impacts identified and described in the previous section and where some mitigation measures have been defined. There are two key elements, one physical and the other institutional, of the management plan which cut across many of the identified environmental and social issues. The project includes a relatively large buffer zone to be established at the reservoir perimeter. This zone will be uninhabited and basically free of intensive human use. This buffer zone will greatly reduce the impacts in erosion, sedimentation, environmental health, and wildlife habitat. The buffer zone will not be fenced so that wildlife can move freely in and out of the area. Only certain areas of the project area will be fenced for security or to protect the public from harm. These areas would include the dam site, powerhouse, tailrace and electrical equiment. In terms of schedule, action on the buffer zone will be coincident with with the first movement of the people to the resettlement area. The cost for the expropriation of dwellings, barns, crops and improvements is approximately US$ 950,000. These costs have been programmed into the resettlement budget and have been partially disbursed.

The second major element is the creation of an environmental management unit within EELPA which will be posted at the project site and will report to project management and to EELPA headquarters. This unit will be staffed prior to release of bid documents and will be charged with implementing the environmental management plan and ensuring contractor compliance with their proposed environmental management proposals. The unit will be empowered to advise financial sanctions for contractor non-compliance through project management. The unit will be staffed to handle both environmental and social issues. This unit has been created in July, 1997 as a part of the GGHP project management. Capital costs to establish offices and equipment at the construction site will be approximately US$ 50,000 and the recurrent costs of operation will be approximately US$ 10,000 per year.

The general terms of reference for the Environmental Management Unit are as follows:

The Environmental Management Unit (EMU) will be initially staffed by three people. One person will handle the biophysical aspects of the project. This person should have a technical degree in environmental or natural resource sciences. Experience with hydropower construction is desirable. Tasks for this person will include *inter alia*:

- Monitor Contractor Compliance with environment protection issues with systematic inspections during construction;
- Monitor effectiveness of erosion control measures;
- Monitor water quality through a systematic sampling program using portable field kits;
- Monitor for presence of waterweeds, mainly water hyacinth, in a weekly program of reservoir inspection after dam closure;
- Monitor impacts on wildlife in the buffer zone above and below the dam;
- Submit weekly reports to project management regarding environmental conditions of the construction site and subsequently the reservoir and buffer zone area;
- Determine with EPA which threshold values in the water quality monitoring program should be reported to EPA for further action.

A second EMU member will be primarily concerned with social issues relating to the project. This person should have a degree in social sciences, preferably sociology or anthropology. Experience in agricultural extension would be an acceptable subsitute.Tasks for this person will include, *inter alia*:

- Provide liaison with local communities near the project site;
- Supervise or conduct environmental health education program and public safety program;
- Monitor resettlement community working with the Resettlement Planning Unit of the Oromia Regional Government;
- Conduct periodic surveys through interviews or questionnaires of the resettled population and the host community;
- Monitor Contractor compliance with health and safety standards at the project site;
- Work with local NGOs;
- Submit weekly reports to project management with copies to the Resettlement Planning Unit.

The third EMU staff member is not seen as a long-term member of the team, at least at this point. This person will be concern with botanical (primarily forestry issues). It is envisioned that this person will be seconded to the EMU from the Ministry of Agriculture or Ministry of Environment. It is expected that this person would have a degree in forestry or botany. The tasks for this person will include, *inter alia*;

- Monitor clearing of the reservoir zone by the clearing subcontractor;
- Establish a small nursery at the construction area;
- Collect and maintain plant propagules from natural vegetation for subsequent planting;
- Evaluate natural vegetation in the downstream buffer area
- Assist the environmental person in monitoring contractor compliance and erosion control;
- Prepare weekly reports for project management during the clearing period and monthly reports after the clearing has been completed.

The EMU has been created as a unit of EELPA and will be assigned to the Gilgel Gibe Hydroelectric Project. At present, only the environmental scientist has been appointed and EELPA will recruit the social scientist as soon as possible to work with the Resettlement Planning Unit. The unit will report directly to GGHP project management and to EELPA management if requested.

In terms of scheduling for the mitigation plan, the buffer area has been defined and will become active as soon as the affected population is relocated. The EMU unit has been created. The remainder of the mitigation measures will be controlled by the implementation schedule of the construction contracts.

Specific components and guiding standards of the management plan are discussed below in the same categories used for describing the likely or potential impacts. The overall estimated costs are provided at the end of the section.

7.1 Physical Environment Impacts

7.1.1 Climate

Any change in climate is likely to be insignificant except at the microclimate level near the reservoir. Most of the microclimate changes are considered to be positive. The buffer zone will keep these microclimate changes from affecting human populations. No mitigation costs have been assigned to this category.

7.1.2 Hydrology

The operation of the reservoir will affect natural flows downstream with the most significant effects felt in the first 16 km of the river. Without compensation flows, the river reach downstream would remain dry for 4-6 months each year when the dam would not be spilling water. A compensation flow is part of the mitigation plan. This flow released from the dam will be at least equal to the low flow of the river (0.128 m^3/s). This release will be augmented by the uncontrolled flow of the Chilelo tributary approximately one km below the dam. The effects of the reduced flow will be evaluated by the EMU with technical assistance from EPA. Any change recommended in the amenity flow would be subjected to a cost/benefit analysis. No human population would be affected in this first stretch of the river as it is uninhabited and will remain that way because of the buffer zone.

Considering the low water levels of the river during the long season, a increased release of 1.0 m^3/s may be considered for maintaining the downstream ecosystem. EELPA, as operator of the power station and dam will be responsible for the maintenance of the compensatory flow. A dry season channel must be present, so that the released water is not immediately lost after being discharged, but can flow freely downstream section of the river. The channel configuration will be evaluated at the same time the ecological effects are studied.

The dam will have a pronounced effect on the appearance of Deneba Falls. A compensation flow of 1 m^3/s will produce a noticeable flow but the visual attraction of the falls will be severely compromised. The river works must involve the dry season channel section near the drop as well as the upper overflow edge. The mist from the falls provides a distinct microclimate and this is reflected by the vegetation which grows near the falls. The evergreen trees are profusely covered by epiphytic plants which will not grow as abundantly when the flow over the falls is reduced.

7.1.3 Geology and Geomorphology

During the construction phase, the following mitigative measures should be implemented to minimize erosion problems that may occur at the different construction sites.

- Removal of vegetation above the reservoir FSL must be kept to a minimum and any removal should be carried out manually to prevent erosion caused by machinery and the reservoir perimeter must be clearly marked prior to clearing to prevent any accidental removal of vegetation;

- Where necessary, reservoir banks should be graded to reduce erosion and slumping potential;
- Construction equipment used outside the reservoir zone should be of a type that will cause minimum damage to soils with low bearing capacity;
- Topsoils should be stripped and stockpiled for rehabilitation once the construction in an area has been completed ;
- Removal of vegetation in areas sensitive to erosion should be carried out manually;
- Clearing of vegetation should be limited to rights-of-way and reservoir zone;
- Disturbed banks should be graded and stabilised and, if possible, vegetation should be restored;
- Once a borrow area is no longer required, its slopes should be reduced and rehabilitated with stockpiled topsoil; stabilising structures should be installed to provide effective drainage into natural watercourses.

These requirements will be stated in the contractor's environmental management plan and the costs of implementing these protective measures will be included in the contract costs.

7.1.4 Sedimentation

Sediments that will be generated during the construction phase will be insignificant and normal construction practices will be sufficient to mitigate any threat of sedimentation. After dam closure, the sediment load of the river will be greatly reduced owing to the efficiency of the reservoir as a sediment trap. The modification of the sedimentary regime of the Gilgel Gibe River downstream of the dam site after dam closure is an inherent part of the project that can not be mitigated.

The sedimentation of the reservoir itself can only be mitigated through integrated watershed management. This is difficult to achieve and impractical on a catchment area of more than 4,225 km^2. A co-ordinated plan for the protection of the Gilgel Gibe watershed should be considered as a co-operative effort between the Ministry of Agriculture, EELPA and non-government organisations.

7.1.5 Water Quality

During the construction phase, water quality will be effected to a small degree from construction generated erosion and pollution.

With the objective of mitigating the effects resulting from the preparation of the area and its subsequent flooding, appropriate interventions will have to be made with the aim of avoiding negative effects on the waters of the planned reservoir due to submersion of the vegetation of the savannah areas and the riparian formations (about 50 km^2 at full service level).

A high level of nutrients will be produced in the reservoir as a result of the presence of large quantities of decomposing vegetation in an environment that is slow to change, has a low oxygen content and a low level of turbulence. This could provide the phenomena of anoxia near the bottom with subsequent production of H_2S, together with a significant increase in acidity. The phenomena of anoxia in the basin would have an immediate (although temporary) effect on the invertebrates present, while the increase in acidity could cause damage to the turbines.

It is be necessary to remove the large woody vegetation (> 3m in height) that grows below the full supply level of the reservoir (1,671 m.a.s.l.). The cost of this mitigation would partially be offset by the sale of the timber to be removed. Since the clearing will be part of the civil works contract, it is not possible to predict the amount of the bid.

7.2 Natural Environment Impacts

7.2.1 Vegetation

The following measures will be implemented during construction to minimize impacts on vegetation:

- Inform construction workers of the importance of protection of the environment including vegetation and wildlife habitat;

- Take all necessary precautions to prevent fires; construction contracts will include normal provisions for fire prevention;

- EELPA will exert control to prevent encroachment into nearby forests by workers in search of timber and fuel wood.

The riparian forest lost due to the project is approximately 300 ha. Forestry and other extension activities (e.g. community forestry, pasture land development, on-farm fodder tree plantation establishment) in the watershed would yield important benefits for both the project and the region. Such a program would not only compensate for lost resources but it would also enhance the local environment. It would provide and protect wildlife habitats, protect watersheds, provide a sustainable supply of forest resources for local uses, and contribute to the fight against global warming. Revegetation will be carried out using local varieties that develop rapidly on poor soils, such as those present on the borders of the planned reservoir (e.g. *Albizzia schimperiana* and *Morus mezogrisa*). At present, the Oromia Region does not experience acute fuelwood shortages throughout the region, but such an approach could help to maintain the regions relative prosperity in fuelwood sources.

7.2.2 Fish

The loss of fish habitat downstream will be partially mitigated through the provision of compensation flows. The overall loss of fish production will be mitigated through the reservoir fishery. Such a fishery would require a research component to determine the most suitable species and management regime for the newly created environment. At present, there is no clear demand from local people for management of a reservoir fishery. EELPA reservoir use policies permit artisanal fishing on their reservoirs.

7.2.3 Wildlife (Birds and Mammals)

The creation of the reservoir will remove 60 km^2 of agricultural land and terrestrial wildlife habitat. This loss can be replaced with a vegetated buffer area around the reservoir. To facilitate the re-establishment of fauna in the buffer area, the clearance of the vegetation from the area to be occupied by the reservoir should be carried out gradually, and in a planned way. The deforestation operations should begin from the banks of the river, extend towards the margins of the proposed reservoir, and move in an upstream direction.

The EMU will be delegated to enforce measures to protect wildlife and wildlife habitat. Construction activities such as drilling, blasting, siting and operation of batching plants, disposal of spoils and mucks, and the construction of quarries and access roads, will be well planned and will be monitored by the EMU to ensure protection of wildlife.

There are not known to be any rare or endangered wildlife species that will be jeopardized by the project. Although there may be a variety of wildlife species in the small area of riverine forest, the more open areas are relatively void of wildlife.

In order to compensate for lost wildlife habitats, the forest adjoining the proposed reservoir will be enhanced and, if necessary, some of the existing areas of forest would be designated as special areas for wildlife protection.

Costs for revegetating the buffer zone to enhance wildlife benefits will be part of the recurrent operating budget of the EMU. These costs are expected to be minimal since machinery will be available to prepare nursery areas and to transport seedlings to selected sites within the buffer zone.

7.3 Socioeconomic Impacts

7.3.1 Resettlement

Over the years, world experience with involuntary relocation programs associated with dam construction has produced a number of basic criteria that have been tested. The following are satisfied by the resettlement program:

- Quality of life of the population being resettled and those who will be the hosts of the newcomers will not be compromised;

- The resettlement program is being adequately financed by the Government of Ethiopia through the Oromia Regional Government to ensure that local commitment and that the newly occupied resettlement land will be as productive as the land being vacated;

- Support is being provided to ensure that settlers arrive in an inhabited area that does not provoke a negative impact on the standard of living of the host population;

- Both those to be resettled and the host community are actively participating in detailed resettlement planning;

- The transition period will not be longer than necessary, and during this period adequate and suitable economic and social support will be provided;

- The area selected for resettlement is as close as possible to the areas being left;

- Resettlement planning has ensured that communities and social/cultural groups are kept intact.
- The resettlement site was evaluated for environmental suitability during the site selection process. A separate EA report for the site was not deemed necessary.

- A schedule for resettlement has been established.

Homes and infrastructure

Homes will be reconstructed by the affected people with financing sufficient to achieve a standard equivalent to or higher than the homes being abandoned;

Adequate infrastructure, including roads, bridges, clinics, schools and religious buildings will be provided to ensure that the affected people have a higher level of services that are currently available in the area to be abandoned. Infrastructure improvements to the resettlement area have already commenced.

There was open dialogue with the affected population regarding the reconstruction of dwellings and barns. The population is being presented with two options. One option is to have the Resettlement Unit contract construction of homes for each household after offering the people with several design alternatives. The second option is to compensate the people and have them arrange for their own construction on their site. The latter option was selected by GOE.

Host area

Impacts of resettlement in the host area have been considered. Erosion and deforestation in the host area are two of the major potential impacts that have been addressed. Construction activities for roads and other infrastructure, and fuel gathering by the settlers, will not lead to deforestation and further soil erosion.

The Resettlement Unit is preparing plans for drainage and the contract for this work will be let soon. Financing for this work has been placed in the resettlement budget and funds have been dispersed for preliminary work at the site.

7.3.2 Resettlement Plan - An Outline

The area to be claimed by the project is part of 18 Kebele farmers associations and these associations are located in four wereda administrations of the Jimma Zone. The weredas affected are Tiro Afeta, Sokoru, Omonada and Kersa. The resettlement area is within the latter two weredas and the area is similar to the area being left.

The population represented by the households to be displaced will be resettled and compensated under the Constitution of Ethiopia and by Civil Code.

For the population to be displaced a comprehensive inventory of economic status, social and cultural background, and ethnicity has been carried out and is being up-dated. The immovable property of each household has been assessed and registered. Compensation for lost property has been determined by committee and each property for which compensation will be provided has been valued at replacement cost. Another survey will be necessary to evaluate the changes caused by the reduction of the buffer zone area. The number of people to be relocated will not increase as a result of the change, but it may also not decrease as much as expected because some of the people may still elect to be relocated.

Zone, wereda administration and peasant association members, community leaders, women and youth have all taken part in the population and property assessment as well as in the selection of the resettlement site.

Taking into account the needs of the people to be relocated, a group comprised of the Jimma Zone Administration identified three suitable sites for resettlement and decided upon one site which was subsequently accepted by the population being resettled. The site selected is within Omonada and Kersa weredas. The other sites were rejected due to either distance of relocation or previous occurrence of rinderpest in the areas.

The area to be resettled is 8,109 ha in size and is agriculturally and socially suitable. The area is sufficient in size to accommodate the new population and the host community is of similar socio-economic, ethnic (Oromo), linguistic and religious background.

The resettlement area has good access to Jimma, Asendabo, Serbo, Sorkoru and Nada. Public services are already available in the vicinity but additional facilities such as health centres, potable water facilities, veterinary centre, mosques and a church are budgeted for in the resettlement plan. The host population, as well as the population being resettled, will benefit from these additional facilities.

A separate resettlement implementation project office has been organised under the Oromia Government and will be accountable to a supervising committee chaired by the vice president of the Oromia Government. The project office will be responsible for carrying out the following:

- disbursement and utilisation of funds
- preparation of arrival site and construction of infrastructure
- operation and maintenance of project infrastructure
- provision of agricultural advice and assistance
- provision of counciling to resettlers
- preparation of programmes and timetable for expropriation of immovable properties
- compensation payments
- transportation of population to new area
- preparation of progress reports

The resettlement implementation office will ensure that the relocated population is properly re-established and has attained the required level of production and living standards.

Transmission Line Resettlement

The Resettlement Planning Unit will begin preparing a resettlement plan for the people who have encroached on the transmission line. Since the transmission line is within the Oromia Region, it is a natural province of the planning unit. The planning unit will follow the same format as taken for the project area affected population, beginning with a census and socioeconomic survey of the people within the transmission line right-of-way.

Production System

An agricultural suitability analysis was conducted by the zonal committee. A soil survey of the area will be conducted to provide the basis for determining optimum land use and best agricultural practices, including the use of fertilizers. A vocational training programme will be developed in association with the agricultural development program. Farmer associations will be formed and an agricultural investment analysis will be conducted to provided a basis for sound agricultural planning and production. Currently, through the Government of Ethiopia, a credit facility is available for the purchase of fertilizers and seed.

Monitoring

The resettlement plan includes a unit for monitoring income restoration and the social impacts that may occur as a result of resettlement. The work of this unit will be monitored by EELPA's EMU.

Resettlement Costs

The estimated cost of the resettlement plan is $US 10,060,906.00 including costs for relocating the road and the telephone line. . Costs for specific programs are given in Tables A20, A21 and A22 in the appendix. A brief summary of the costs specifically for relocating people are as follows:

Resettlement Costs (rounded in US$)

Planning	11,000
Resettlement	733,550
Expropriation	3,687,800
Monitoring and Counseling	8,000
Additional Mitigation	152,000
Total	4,592,350

7.3.3 Health

Infectious Water-borne Diseases

Mitigation for increase of infectious diseases are as follows:

- Direct control of the proliferation of vectors will be carried out by the EMU;
- Sanitary control of the resident and transitory population (workforce at the site and the population gathering around them);
- Careful management of human waste;
- Snail populations, will be partially controlled through the removal of the macrophytic riparian habitat by the EMU;
- In order to limit new sources of infection, the following steps will be taken:

.Use of local workers as much as possible;
.Medical screening of the work force
.Basic camp health service to provide continuous information regarding prevention of the main infectious diseases;
.During both the construction and operational phases, periodic surveys of the vectors responsible for infections will be conducted by the EMU over the entire area, involving local health services;
.Periodic screening at the health clinic will be carried out on samples of the resident population to evaluate any cases of infection.

* Buffer area around the reservoir will be established.

STDs

STDs can not be totally prevented. To minimize their incidence, informal sector development in proximity to the construction site will be regulated. Workers will be provided with health education lectures and free condoms will be made available.

Other Infectious Diseases and Other Diseases

Sanitary conditions of the camp will be developed and maintained to international standards for construction camps. Human waste will be managed using proper disposal and treatment facilities that will be located in such a way as to ensure that seepage does not occur. Kitchen wastes will be disposed of in a proper manner (incineration, burial or taken off site and disposed of in sanitary landfill sites) to prevent the proliferation of rodents, flies and other disease carrying insects.

Proper facilities for washing and bathing are provided for the work force. All work and living areas will be properly ventilated to prevent respiratory diseases including tuberculosis. All workers will be tested for tuberculosis.

Substance Abuse

Educational sessions for the workers regarding alcohol abuse will be conducted. Penalties for over use will be set, advertised to the workers and will be enforced.

Occupational Health

Comprehensive occupational health standards established by the Government of Ethiopia will be followed and the contractor will be held responsible for full implementation.

Public Safety

All construction sites will be well sign posted, warning both workers and the general public of danger to their safety. All vehicles will be equipped with audio and visual safety warning systems. Suitable speed limits will be posted and enforced and all vehicles will be in top mechanical condition. The local communities will be given safety lectures. All construction sites, and project sites following construction (e.g. dam, tunnel) will be protected from public access. A buffer area around the dam will be off limits to the general public.

7.3.4 Access

The reservoir will cause the flooding of a number of sections of the road which links Addis Ababa with Jimma. Two alternative proposals for a new road have been suggested. However, an environmental assessment for the alignment and construction of a new road will be conducted by the Ethiopian Road Authority. There appears to be little to choose, environmentally, between the two alternatives.

The socioeconomic importance of the regional centre of Asendabo will not be compromised. The isolation to which the town would be subjected if the road is diverted around it would have considerable effect on the social aspects of the surrounding territory, particularly the role that Asendabo plays as a regional market centre.

The presence of the reservoir will create a barrier for those who regularly move from the left bank to the opposite side weekly for marketing purposes in Asendabo, Deneba and Sekoru. Alternate means of access will be provided to the populations not relocated. The access planning will depend on the final selection of the realignment of Highway #7.

7.3.5 Gender Issues

There are a number of potential gender issues as listed in section 6.3.9 and these will have to be examined specifically as they relate to the project and will have to be addressed accordingly. The awareness of the gender issues is the necessary first step in correcting the serious problems. The Oromia Regional Government will assume responsibility of addressing gender issues. Hiring practices of the contractor are subject to Ethiopian Law which promotes complete equality. There is little experience in dealing proactively with gender issues, especially with large infrastructure projects. The GOE will look to international donors for guidance in this area.

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Water quality of the Gilgel Gibe river

DATE		18/05/82	19/05/82	07/10/95	08/10/95	09/10/95	WHO*
TEMP.	°C	23.3	22.5	22.4	22.6	22.8	-
pH		7.20	7.15	7.57	7.69	7.56	6.8/8.5
CO-.	mmmhos/cm 25°c	0.08	0.08	0.08	0.08	0.08	-
O2 (DISS.)	ppm	5.43	5.35	6.80	6.80	6.75	-
O2 SATURATION	%	79.30	76.90	97.50	97.90	97.60	-
ALCALINITA'	ppm CaCO3	35.60	35.60	34.50	36.20	37.30	-
TURB.	NTU	-	-	136.14	138.14	121.75	5
SUSP. SOL.	mg/l	64.00	65.00	57.40	53.90	44.90	-
TOT. SOL.	mg/l	255.30	176.60	179.00	149.00	139.00	1000
N-NH4	mg/l	0.5	0.5	0.03	0.015	0.05	-
N-NO2	mg/l	0.06	0.06	<0.001	<0.001	<0.001	-
N-NO3	mg/l	0.5	0.5	0.37	0.29	0.38	10.16
P TOT	mg P/l	0.125	-	0.2	0.112	0.089	-
P SOL.	mg P/l	0.034	0.034	0.008	0.012	0.006	-
TOT. COLI	col./100 cc	25000	-	3100	2400	3000	10 **
FECAL COLI	col./100 cc	100	-	425	500	300	0 **
Tot. Hardness	ppm CaCO3	30.09	31.4	-	-	-	500
Ca	mg/l	8.28	8.61	-	-	-	-
Mg	mg/l	2.29	2.41	-	-	-	-
Na	mg/l	4.49	4.97	-	-	-	-
K	mg/l	3.48	2.79	-	-	-	-
Sulphate	mg/l	3.8	3.8	-	-	-	400
Cloride	mg/l	2.3	2.2	-	-	-	250
Fe soluble	mg/l	0.17	-	-	-	-	0.3
Cu soluble	mg/l	0.015	-	-	-	-	1
Mn soluble	mg/l	<0.01	-	-	-	-	0.1
Ni soluble	mg/l	<0.01	-	-	-	-	-
Zn soluble	mg/l	0.026	-	-	-	-	5
Cr soluble	mg/l	0.0125	28	-	-	-	0.05
SiO2	mg/l	30	-	-	-	-	-
N total	mg/l	1.57	-	-	-	-	-

* WHO recommendations for drinking water quality

** Non-mains river supply

Tab. 1

Grain size analysis
(pipette analysis)

DIAMETER mm	TOTAL WEIGTH g/l 1982	TOTAL WEIGTH g/l 1995	FINER % 1982	FINER % 1995	LARGER % 1982	LARGER % 1995	
0.06250	0.2420	0.1930	95.0	100.0	5.0	0.0	SAND
0.04420	-	0.1360	-	70.5	-	29.5	SILT
0.03120	-	0.1300	-	67.4	-	32.6	SILT
0.02120	0.2300	0.1290	90.2	66.7	9.8	33.3	SILT
0.01560	-	0.1030	-	52.3	-	47.7	SILT
0.00780	0.2155	0.1005	84.5	51.9	15.5	48.1	SILT
0.00390	0.1845	0.0925	72.3	47.8	27.7	52.2	SILT
0.00195	-	0.0830	-	42.9	-	57.1	CLAY
0.00098	0.1500	-	58.8	-	41.2	-	CLAY
0.00049	0.1325	-	51.6	-	48.1	-	CLAY
0.00029	0.1270	-	49.8	-	50.2	-	CLAY

Tab. 2

Mean settling of quarz spheres in water at 20°C (cm/sec)

PARTICLE CLASS	PARTIAL SETTLING %	CUMULATIVE SETTLING %	MEAN SPEED AT 20°C	SETTLING TIME (DAYS) H=14
62.5 - 62.5 SAND	5	5	0.8 cm/sec	0.02
62.5 - 21.2 SILT	4.8	9.8	0.09 cm/sec	0.18
21.2 - 7.8 SILT	5.7	15.5	0.03 cm/sec	0.54
7.8 - 3.9 SILT	12.2	27.7	0.005 cm/sec	3.2
3.9 - 0.98 CLAY	13.5	41.2	0.0005 cm/sec	32.4
0.98 - 0.49 CLAY	6.9	48.1	0.00007 cm/sec	231.0
0.49 - 0.29 CLAY	2.1	50.2	0.00004 cm/sec	405.0

Tab.3

Spatial water quality

Parameters	Unit	CHILELO	GIBE (near falls)	GIBE (near Asendabo)	Significativity
		Station 1	Station 2	Station 3	95%
TEMP.	°C	19.77	22.60	22.43	1<2,3
pH		7.54	7.61	7.68	NS
COND.	µmhos/cm 25°C	0.06	0.08	0.09	NS
O2 (DISS.)	ppm	7.72	6.78	6.19	2,3<1
ALKALINITY	ppm CaCO3	27.80	36.00	36.80	1<2,3
TURB.	NTU	85.61	132.01	138.55	1<2,3
SUSP. SOL.	mg/l	40.33	52.07	61.10	1<2,3
TOT. SOL.	mg/l	115.21	155.67	159.67	NS
N-NH4	mg/l	0.007	0.032	0.033	NS
N-NO2	mg/l	0.000	0.000	0.000	NS
N-NO3	mg/l	0.520	0.347	0.335	NS
TOT. P	mg/l	0.195	0.134	0.160	NS
SOL. P	mg/l	0.015	0.009	0.009	NS
TOT. COLI	n/100 cc	3108	2833	2992	NS
FECAL COLI	n/100 cc	1042	408	600	2,3<1

Tab. 4

Icthyological survey - Total catch

DATE	WATER T (°C)	FISHING -GEAR	SPECIES	TOTAL NUMBER	TOTAL WEIGTH (g)
19/05/82	23.3	Seine net	Barbus intermedius	3	30
		Fike net	Barbus intermedius	1	20
		Trammel net	Barbus intermedius	29	3083
		Trammel net	Tilapia nilotica	2	184
		Trammel net	Labeo cylindricus	2	125
09/10/95	22.6	Trammel net	Barbus intermedius	298	56545
		Trammel net	Tilapia nilotica	2	249
		Trammel net	Labeo cylindricus	42	6006
10/10/95	22.3	Trammel net	Barbus intermedius	360	60675
		Trammel net	Tilapia nilotica	0	0
		Trammel net	Labeo cylindricus	27	3025
11/10/95	22.4	Trammel net	Barbus intermedius	219	39154
		Trammel net	Tilapia nilotica	0	0
		Trammel net	Labeo cylindricus	15	1827

Tab. 5

LIST OF WILD ANIMALS AVAILABLE AT THE PROJECT AREA

AMPHIBIANS AND REPTILES

English Name	Scientific Name
Snake	*Python sp.*
Crocodile	*Crocodylus niloticus*
Frog	

BIRDS

Guinea fowl	*Numida sp.*
Harwood's francolin	*Francolimus harwoodi* *
Dove	*Streptopelia sp.*
Egyptian goose	*Alopochen aegyptiacus*
Pied crow	*Corvus albus*
Black kite	*Milvus migrans*
Africa fish eagle	*Haliaëtus vocifer*
Stork	*Leptoptilos sp.*
Common genet	*Genetta genetta*
Abyssinian ground hornbill	*Bycanistes sp.*

* Endemic

MAMMALS

Hyena	*Crocuta crocuta*
Leopard	*Panthera pardus*
Jackal	*Canis mesomelas*
Bushbuck	*Tragelaphus scriptus* *
Bush duiker	*Sylvicapra grimmia*
Lelwel hartebeest	*Alcelaphus buselaphus lelwel* *
Giant forest hog	*Hylochoerus meinertzhageni*
Wart hog	*Phocochoerus aethiopicus*
Porcupine	*Hystrix sp*
Baboon	*Papio sp.*
Blue monkey	*Cercopithecus mitos*
Colobus monkey	*Colobus abyssinicus*
Hippopotamus	*Hippopotamus amphibius*
Hyrax	*Procavia capensis*
Lion	*Panthera leo*
Mole	*Bathyergidae*
Hare	*Lepus sp.*
Civet	*Viverra sp.*
Aardvark	*Orycteropus afer*
Reedbuck	*Redunca sp.*
Honey badger	*Mellivora capensis*

* Endemic

TAB. 6

Families residing and farming within the project area

Families residing and farming within the reservoir area			
WOREDA	N° Families	Land (ha)	
		Farming	Grazing
Kersa	0	0	0
Sekoru	80	294	0
Omo Nada	268	1057	114
Tiro Afeta	13	45	0
Total	361	1396	114

Families farming within and residing outside reservoir area			
WOREDA	N° Families	Land (ha)	
		Farming	Grazing
Kersa	49	0	0
Sekoru	233	764	117
Omo Nada	284	774	64
Tiro Afeta	1019	235	0
Total	1585	.1773	181

Families residing and farming outside reservoir area but within project area			
WOREDA	N° Families	Land (ha)	
		Farming	Grazing
Kersa	28	403	0
Sekoru	157	482	0
Omo Nada	145	1603	49
Tiro Afeta	200	4995	0
Total	530	7483	49

Total of the families residing/farming within project area			
WOREDA	N° Families	Land (ha)	
		Farming	Grazing
Kersa	77	403	0
Sekoru	470	1540	117
Omo Nada	697	3434	227
Tiro Afeta	1232	5275	0
Total	2476	10652	344

Tab. 8

Arable and grazing land claimed

WOREDA	KEBELE	Outside of lake		Inside of lake	
		Agriculture (ha)	Meadow (ha)	Agriculture (ha)	Meadow (ha)
Kersa	Harena	59	0	0	0
	Dogosso	344	0	0	0
Sekoru	Telgo	69	0	205	0
	Inkure	2	0	49	0
	Bore	411	0	708	117
	Liben	0	0	72	0
Omo Nada	Osobili	524	0	1238	0
	Ture Meta-Jebo	633	0	594	0
	Seyo	158	0	0	0
	Wonji	78	0	0	0
	Goro Sibilo	65	0	0	0
	Goro Warso	115	0	0	0
Tiro Afeta	Ino	745	0	58	0
	Nono Dimtu	444	0	180	0
	Koticha Maru	1796	0	4	0
	Koticha Kesi	1127	0	0	0
	Budo	601	0	0	0
	Usmani	222	0	26	0
	Total	7393	0	3133	117

Tab. 9

Average income (Birr)

	KEBELE		RIR	ROR	ROB	SIGN
Kersa	Harena	mean minimun maximum	ND	ND	ND	-
	Dogosso	mean minimun maximum	ND	ND	ND	-
Sekoru	Telgo	mean minimun maximum	12605 7570 17235	7164 875 29440	4385 1110 16050	ROB, ROR<RIR
	Inkure	mean minimun maximum	ND	5848 3735 7890	3040 2085 4440	ROB<ROR
	Bore	mean minimun maximum	11344 1750 37350	12226 2085 41950	6393 875 19700	ROB<RIR,ROR
	Liben	mean minimun maximum	ND	3676 420 10800	10263 3500 27910	ROR<ROB
Omo Nada	Osobili	mean minimun maximum	14424 1723 87324	9522 888 58050	6121 1660 44730	RIR<ROR<ROB
	Ture Meta-Jebo	mean minimun maximum	9425 1980 21221	9768 2530 57540	5300 1776 15282	ROB<RIR, ROR
	Seyo	mean minimun maximum	ND	6717 2664 9492	2938 888 7104	ROB<ROR
	Wonji	mean minimun maximum	ND	14053 7614 22338	4445 888 20032	ROB<ROR
	Goro Sibilo	mean minimun maximum	ND	5910 4632 7614	2721 1332 7614	ROB<ROR
	Goro Warso	mean minimun maximum	ND	8701 5202 17133	3101 444 11835	ROB<ROR
Tiro Afeta	Ino	mean minimun maximum	ND	11256 2154 31570	8417 1302 31570	ROB<ROR
	Nono Dimtu	mean minimun maximum	9784 5178 17498	9788 1680 33708	7800 2640 18482	NS
	Koticha Maru	mean minimun maximum	ND	11811 2530 45636	10591 1650 22290	NS
	Koticha Kesi	mean minimun maximum	ND	12568 1650 82872	ND	-
	Budo	mean minimun maximum	ND	14463 6066 888	9412 30990 30990	ROB<ROR
	Usmani	mean minimun maximum	ND	10352 2538 32010	4927 888 19974	ROB<ROR

Tab.10

INCOME (FREQUENCIES)

Birr / KEBELE	> 1000	1000÷5000	5000÷10000	10000÷15000	15000÷20000	20000÷25000	25000÷30000	30000÷35000	35000÷40000	40000÷45000	45000÷50000	50000÷55000	55000÷60000	< 60000
BORE	0.6	29.9	36.1	19.8	7.7	3.0	1.2	0.3	0.9	0.6	0.0	0.0	0.0	0.0
BUDO	0.7	19.6	23.9	36.2	10.9	5.8	2.2	0.7	0.0	0.0	0.0	0.0	0.0	0.0
NONO	0.0	12.8	53.6	22.4	8.8	1.6	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
GORO	0.0	75.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IKURE	0.0	61.5	38.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
INO	0.0	14.1	42.7	26.6	8.3	5.2	2.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0
KOTICHA	0.0	5.8	34.1	33.6	17.3	3.1	3.5	2.2	0.0	0.0	0.0	0.0	0.0	0.4
LIBEN	3.7	37.0	37.0	14.8	3.7	0.0	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
KOTICHA	0.0	5.7	38.8	32.4	12.9	6.9	2.6	0.0	0.3	0.3	0.3	0.0	0.0	0.0
OSOBILI	0.9	27.6	30.3	15.6	10.3	9.7	2.1	1.2	0.9	0.6	0.0	0.3	0.3	0.3
SEYO	2.2	86.0	11.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TELGO	0.8	59.5	29.4	6.3	3.2	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TURE META	0.0	11.1	55.3	24.6	6.9	0.9	0.6	0.0	0.3	0.0	0.0	0.0	0.3	0.0
USMANI	2.2	34.4	39.8	15.1	6.5	0.0	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0.0
GORO	4.4	72.1	20.6	1.5	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WONJ	10.7	39.3	35.7	0.0	7.1	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	1.6	37.0	34.5	15.6	6.6	2.7	1.2	0.5	0.1	0.0	0.0	0.0	0.0	0.0

Tab. 11

Private houses, cottages and barnes expropriated

WOREDA	KEBELE	Tin Roofed House		Cottage		Barn
		Qtv.	Area (Sq. m)	Big (Qtv.)	Small(Qtv.)	(Gotera)
Kersa	Harena	3	153	30	51	106
	Dogosso	5	255	54	58	195
Sekoru	Telgo	0	0	71	57	193
	Inkure	2	102	50	61	91
	Bore	47	1807	209	138	
	Liben	5	261	43	28	115
Omo Nada	Osobili	28	2199	276	155	659
	Ture Meta-Jebo	4	56	406	276	926
	Seyo	0	0	33	29	84
	Wonji	3	153	35	35	81
	Goro Sibilo	0	0	35	25	81
	Goro Warso	4	204	38	29	91
Tiro Afeta	Ino	1	30	197	95	437
	Nono Dimtu	12	407	117	85	266
	Koticha Maru	8	556	604	455	1500
	Koticha Kesi	2	120	266	189	791
	Budo	4	204	73	43	177
	Usmani	2	154	68	48	185
	Total	130	6661	2605	1857	5978

Tab.12

Tab. 13

					[illegible]	NO_2	SO_4	Fe^{2+}	Cl	Ca^{2+}	Mg^{2+}	HCO_3^-	CO_3^{2-}	F^-	D.O.
	°C	µmhos			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Sekoru Town water supply (well)	23	200	7	40	4.84	nil	nil	0	6	11.36	13.33	122	nil	0	0
Deneba Town water supply (well)	22	332	7.4	55	8.8	0.019	nil	0.38	5.6	43.29	15.95	200.1	nil	0.45	0
Asendabo Town water supply (well)	21	323	6.9	15	5.28	0.013	nil	0.35	6	19.4	10.15	200	nil	0.65	0
Artisian well T-10	25	405	7.3	13	9.24	0.02	nil	0.1	6.2	36.9	20.54	229.36	nil	0.63	0
Naya Gugums spring water	24	98	6.8	80	12.76	0.009	2.5	0	5	2.94	0.76	24.4	nil	0	0
Inkure Village water supply (spring)	26	75	7	80	11	0.059	nil	0.09	5	3.21	2.28	29.28	nil	0	0
Bebeta Village water supply (spring)	29	110	6.7	825	0	0		0	6	8.02	3.65	44.41	nil	0.36	0
Lebadima stream near EELP	27	318	7.5	120	7.92	0.056	2	0.08	11	34.47	15.39	175.68	nil	0.28	0
Bedru stream near Sekoru	18	150	7.3	890	5.28	0.017	nil	0	7	4.81	0.85	30.5	nil	0	6
Endicha stream	20	113	7	120	7.92	0.046	nil	0.13	10	14.43	4.78	88.33	nil	0	0
Er.ssa stream	17	135	7.4	195	4.4	0.04	nil	0.18	9.8	12.83	10.37	68.32	nil	0	6.2
Goshu stream	17.5	164	7.25	148	4.4	0.06	2.5	0.16	10	16.03	5.81	117.12	nil	0	0
Chilelo stream	19	120	7.5	650	5.28	0.165	nil	0.2	6.4	9.6	9.7	56.12	nil	0	0
Urjbo stream	20.4	148	7.3	130	6.6	nil	nil	0.1	7	10.42	2.96	72.71	nil	0	0
Kalo	19	115	7	175	6.6	0.026	nil	0.17	6	9.46	3.53	67.83	nil	0	0
Omonada river at bridge	21	185	7	370	4.4	0.007	nil	0	8	4.97	2.17	42.7	nil	0	0
Biba river	18	95	7.2	1150	8.8	nil	nil	0.3	4.2	6.4	2.16	43.92	nil	0	6.62
Great Nada river	18	84	7	690	3.52	0.0013	nil	0.34	6	6.413	2.28	34.16	4.8	0	6.2

Physical and Chemical Characteristics of Water in Gilgel Gibe Project Area

Malaria cases in Deneba Clinic according to places of origin 1989 - 1995

PLACES OF ORIGIN	N° OF CASES
Dereba town	4,671
Bore	5,032
Enkore	1,201
Telgo	480
Liben	653
Boro	98
Chopa	136
Welmera	67
Odo	8
Ayino (from other district)	59

Tab. 14

Malaria cases in Deneba Clinic during the years 1982-87 Rth. Cad.
(1989 ÷ 1995)

	1982 (89-90)	1983(90-91)	1984(91-92)	1985(92-93)	1986(93-94)	1987(94-95)
September	–	12	35	29	–	548
October	17	12	191	68	28	6.389
November	—	23	55	136	58	–
December	–	35	10	66	62	985
January	–	7	13	–	25	–
February	22	21	15	15	15	20
March	27	7	10	22	20	120
April	15	–	18	27	10	40
May	13	–	17	–	170	455
June	12	-	16	10	759	1.066
July	6	8	–	–	32	38
August	–	–	22	22	470	55
TOTAL	112	131	402	395	1.649	9.716

Tab. 15

Diseases in Asendabo Health Center during the years 1982 - 1987 Rth. Cad. (1989 ÷ 1995)

Years

ype of diseases	1982(89-90)	1983(90-91)	1984(91-92)	1985(92-93)	1986(93-94)	1987(94-95)
ll Malaria	2.468	2.796	3.621	2.149	3.943	3.248
histosomiasis	2	1	3	2	5	1
patitis	18	21	17	28	17	15
ichocerciasis	21	26	43	11	12	8
ds	2	1	2	1	9	13
her STDs	465	219	463	425	393	411
poid fever	501	241	511	413	513	712
apsing fever	4	6	1	13	1	-
ningitis	21	1	-	-	-	-
tuberclosis	213	318	321	351	411	412

Tab.16

Reservoir Characteristics

Calendar Month	Elevation (m)	Area (km²)	Volume (Mm³)	Loss due to Evaporation (Mm³)	Loss due to Evaporation (m³/s)
1	1667.03	43.92	654.69	30.17	0.96
2	1665.10	40.57	573.16	27.87	0.88
3	1663.02	37.55	491.92	25.80	0.82
4	1660.68	34.18	407.99	23.48	0.74
5	1658.34	30.94	331.80	21.26	0.67
6	1657.00	29.12	291.56	20.01	0.63
7	1659.02	31.87	353.16	21.89	0.69
8	1664.91	40.27	565.45	26.67	0.88
9	1669.21	47.69	754.55	32.76	1.04
10	1670.19	49.45	802.13	33.97	1.08
11	1669.88	48.85	786.89	33.56	10.6
12	1668.73	46.86	731.85	32.19	10.2
Average		40.11		27.55	0.87

Tab. 17

BUDGET FOR A HEALTH CENTER WITH IN-BUILT-TRAINING FACILITIES ONLY

Description	Cost (Birr)
Capital budget	
Forniture	139,500
Medical equipment	260,762
Office equipment	22,875
Teaching &Demostration equipment	20,602
Other equipment	79,717
4wd car & spare parts	115,719
Motorcycle & spare parts	7,906
Sub-total Capital	**647,081**
Recurrent Budget	
Salary	83,400
Perdiem	10,000
Drugs & Medical supplies	150,000
Office supplies	3,000
Cloth/Uniforms	8,036
Training/Seminar/Workshops	27,200
Maintenance & Repair	150,464
Fuel & Lubrificant	17,237
Utilities	3,000
Sanitation	5,300
Printing	3,000
Operational researches	1,000
Subtotal Recurrent Budget	**461,637**
Contingency 15% of recurrent Budget	**69,246**
Total Recurrent Budget	**530,883**
Total	**1,177,964**

GRAND TOTAL

(Above Total + cost of different kind of building with an area = 620 m^2)

Description	Cost/m^2 (Birr)	Total cost *	**Grand total**
Hollow Block	800	503,200	**1,681,164**
Brick	1,200	751,200	**1,929,164**
Mud	400	255,200	**1,433,164**
Stone	1,500	937,200	**2,115,164**
Prefabricated Material	1,500	937,200	**2,115,164**

* Garage cost Birr 7,200 is included in each case

Tab. 18

Tab 19

		C	D	E	F	G
Total lenght		18,060	22,520	18,510	22,970	26,408
New road lenght		13,750	18,710	17,410	22,130	25,888
Bridges Lenght		1,390	890	1,100	600	280
Bridges		3	2	3	2	1
Box culverts 1,00X1,00		35	47	46	57	65
Box culverts >1,50X1,50		6	11	6	11	16

Description	U.M.	U.Q	C	D	E	F	G	U.P. Birr	U.P US$	C	D	E	F	G
Roadworks														
Earthworks	m3	20	275,000	374,200	348,200	442,600	517,760		6.5	1,787,500	2,432,300	2,263,300	2,876,900	3,365,440
Base (20 cm)	m	1	13,750	18,710	17,410	22,130	25,888	83	*13.0*	178,750	243,230	226,330	287,690	336,544
Double surface treatment	m	1	13,750	18,710	17,410	22,130	25,888	1,143	*180.0*	2,475,000	3,367,800	3,133,800	3,983,400	4,659,840
Sub-total 1										*4,441,250*	*6,043,330*	*5,623,430*	*7,147,990*	*8,361,824*
Culverts 1,00X1,00														
cls	m3		833	1,119	1,095	1,357	1,547	1,554	*247.0*	205,751	276,294	270,416	335,080	382,109
Fe	kg		62,755	84,271	82,478	102,201	116,545	9	*1.4*	87,857	117,979	115,469	143,081	163,163
Culverts > 1,50X1,50														
cls	m3		327	600	327	600	872	1,554	*247.0*	80,764	148,104	80,764	148,104	215,424
Fe	kg		19,668	36,058	19,668	36,058	52,448	9	*1.4*	27,535	50,481	27,535	50,481	73,427
Sub-total 2										*401,927*	*592,858*	*494,204*	*676,746*	*834,123*
Bridges														
Abutments														
excavation	m3		210	140	210	140	70	47	*7.5*	1,575	1,050	1,575	1,050	525
cls	m3		360	240	360	240	120	1,554	*247.0*	88,920	59,280	88,920	59,280	29,640
Steel	t		13	9	13	9	4	9,050	*1,440.0*	18,576	12,384	18,576	12,384	6,192
Piers														
excavation	m3		1,946	1,246	1,540	840	392	47	*7.5*	14,595	9,345	11,550	6,300	2,940
cls	m3		8,896	5,696	7,040	3,840	1,792	1,554	*247.0*	2,197,312	1,406,912	1,738,880	948,480	442,624
Steel	t		556	356	440	240	112	9,050	*1,440.0*	800,640	512,640	633,600	345,600	161,280
Beams and slab														
cls	m3		4,087	2,617	3,234	1,764	823	1,554	*247.0*	1,009,390	646,300	798,798	435,708	203,330
Prestressed cocncrete	m3		2,669	1,709	2,112	1,152	538	2,015	*320.0*	854,016	546,816	675,840	368,640	172,032
Prestressing steel	t		31	20	24	13	6		*5,000.0*	152,900	97,900	121,000	66,000	30,800
Steel	t		578	370	458	250	116	9,050	*1,440.0*	832,666	533,148	658,944	359,424	167,731
Guardrail	m		2,780	1,780	2,200	1,200	560		40.0	111,200	71,200	88,000	48,000	22,400
Sub-total 3										*6,081,790*	*3,896,973*	*4,835,683*	*2,650,866*	*1,239,495*
									TOTAL AMOUNT	**10,924,967**	**10,533,161**	**10,953,317**	**10,475,602**	**10,435,441**
									Cost per m	***722***	***637***	***592***	***461***	***399***

COST OF EXPROPRIATION AND REPLACEMENT

Item	Cost	
	Birr	USD
Private properties		
• Houses	779,263.00	123,692.54
• Cottages	6,851,104.00	1,087,476.83
• Barns	189,330.00	30,052.38
Plantations		
• Trees	3,895,029.00	618,258,.57
• Fruit trees	2,039,894.00	323,792.70
• Others	9,478,530.00	1,504,528.57
Infrastructures replacement		
• Higway (Addis-Jimma) 28 km access road	28,000,000,.00	4,444,444,.44
• Telecommunication line	112,000.00	17,777.78
Preservation of cemeteries	10,000.00	1,587.30
TOTAL	51,355,150.00	8,151,611.11

Tab 20

UNIT COST OF EXPROPRIATED ITEMS

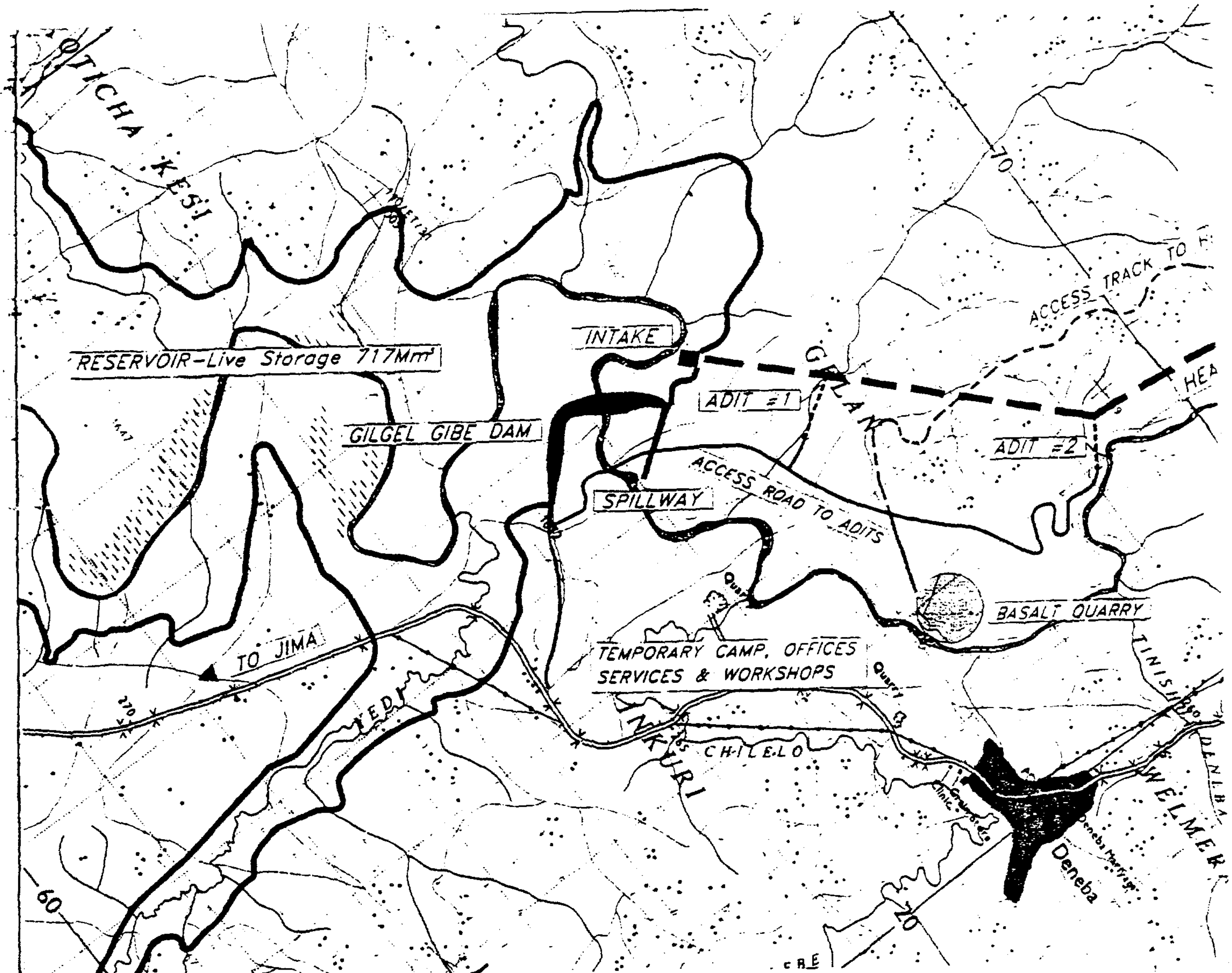
Item n°	Item	Unit	Unit cost (Birr)
1	C.I. sheet roofed house	Sq. m	117.00
2	Big cottage	each	1889.00
3	Small cottage	"	1040.00
4	Barn (gotera)	"	30.00
5	Big Chat	"	48.00
6	Small Chat	"	3.00
8	Small Coffee	"	4.00
7	Big Coffee	"	31.00
9	Big Banana	"	16.50
10	Small Banana	"	3.00
11	Big Enset	"	10.00
12	Small Enset	"	3.00
13	Small Eucalyptus	"	0.55
14	Purlin Eucalyptus	"	1.35
15	Rafter Eucalyptus	"	2.70
16	Post Eucalyptus	"	9.60
17	Other Eucalyptus	"	44.20
18	Big Orange	"	80.00
19	Small Orange	"	5.00
20	Big Mango	"	80.00
21	Small Mango	"	5.00
22	Big Papaya	"	7.50
23	Small Papaya	"	2.00
24	Big Lemon	"	30.00
25	Small Lemon	"	5.00
26	Zeituna	"	20.00
27	Small Gishta	"	4.00
28	Big Gishta	"	28.00
29	Gesho	"	9.00
30	Roman	"	10.00
31	Tiringo	"	40.00
32	Cotton	"	2.00
33	Ananas	"	3.00

Tab. 21

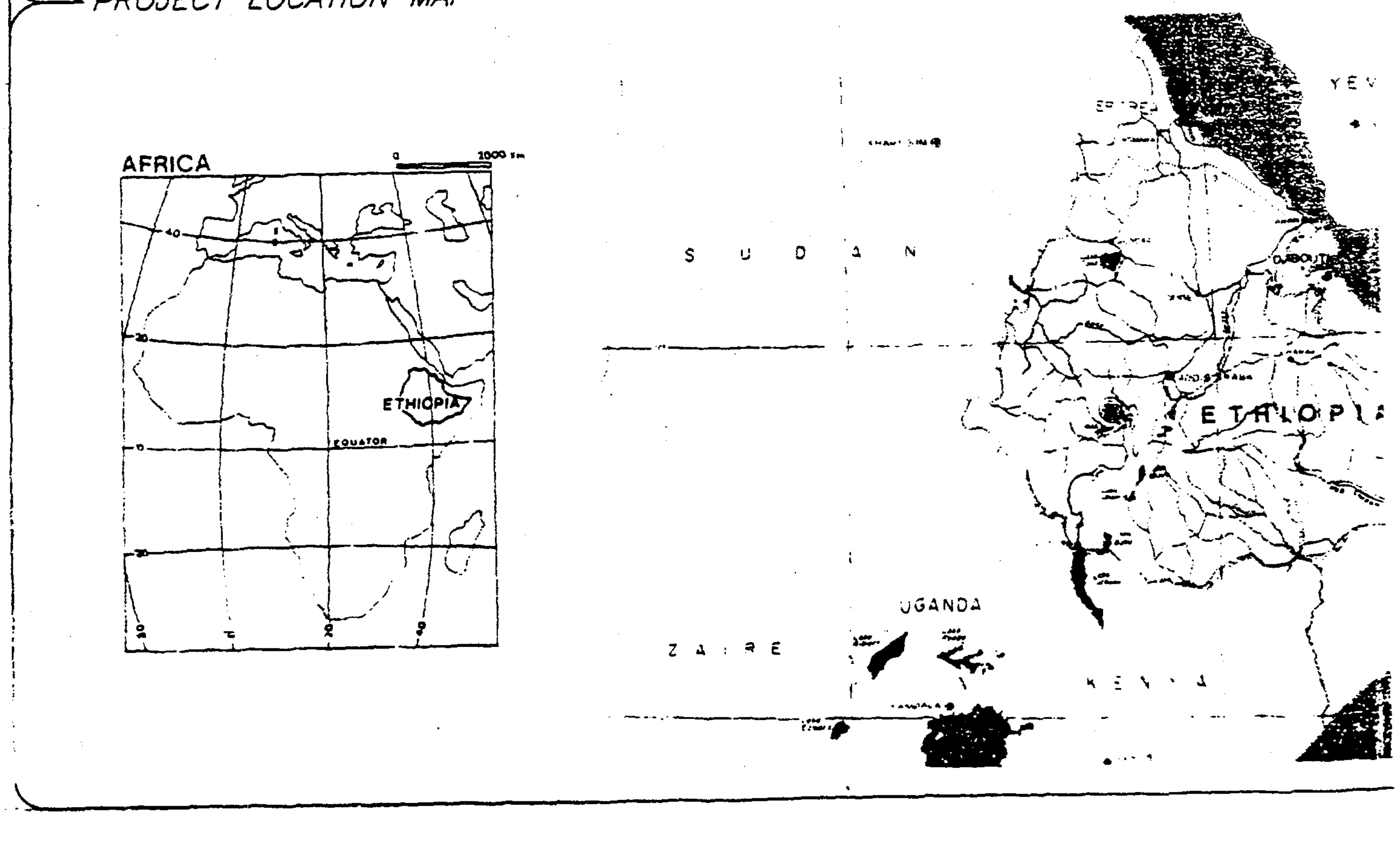
RESETTLEMENT COST SUMMARY

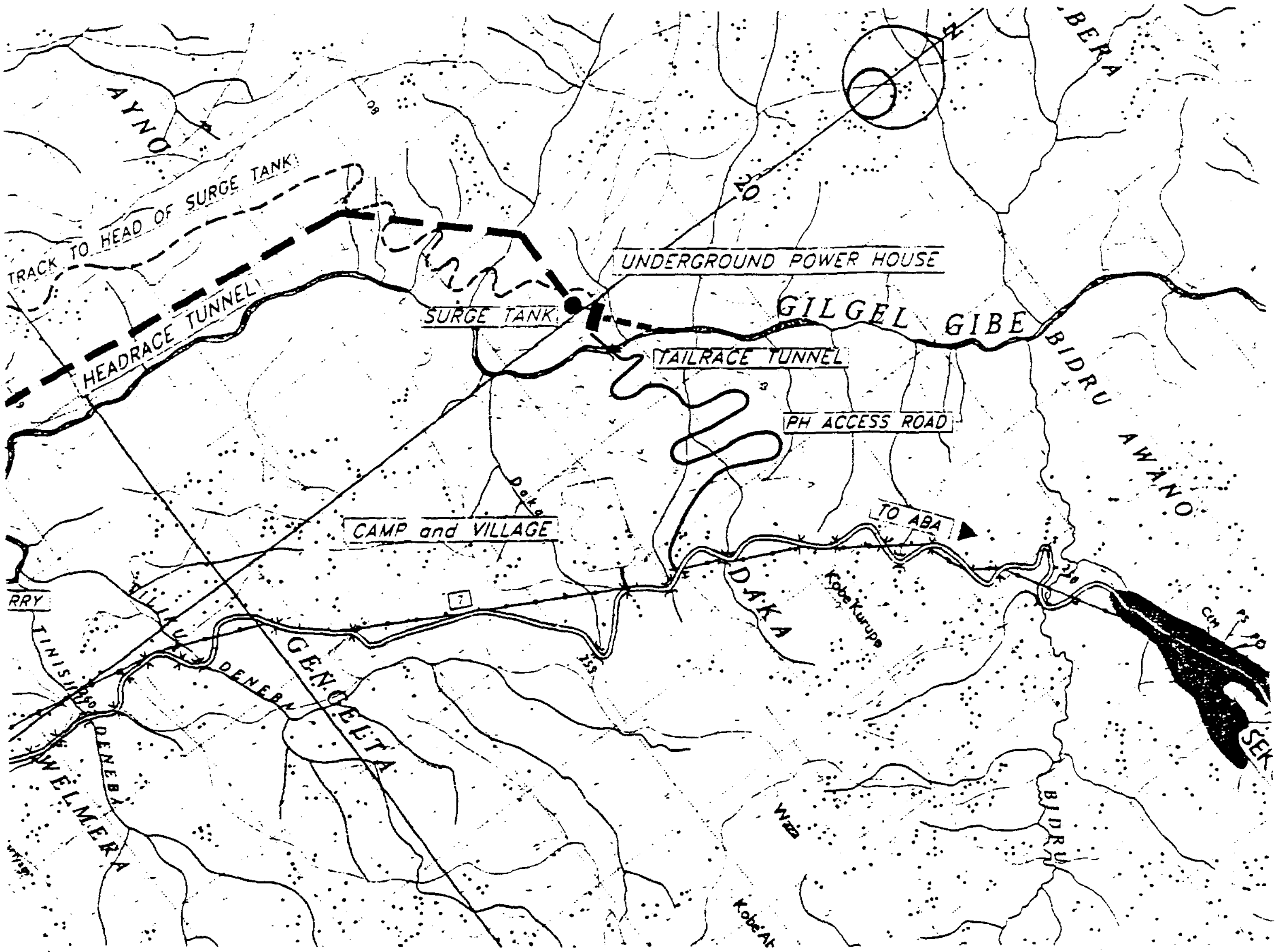
DESCRIPTION	BIRR	USD
1. PLANNING ACTIVITIES	68,840.00	10,927.98
2. RESETTLEMENT		
2.1 Transport	43,564.00	6,914.92
2.2 Infrastructures		
2.2.1 Access Road	4,571,495.00	725,634.13
2.2.2 Drainage	88, 000.00	14,047.62
2.2.3 Elementary School	468,107.00	74,302.70
2.2.4 Health Unit	337,260.00	53,533.30
2.2.5 Farmers Associations Offices	6,480.00	1,028.57
2.2.6 Mosques	28,800.00	4,571.43
2.2.7 Churches	11,309.00	1,795.08
2.2.8 Wells (water)	348.000.00	55,238.09
2.2.9 Flour mill	46,320.00	7,352.38
2.2.10 Vet. Health Post	107,515.00	17,065,.7
2.2.3 Agricultural redevelopment package	4,181,000.00	663,650.79
2.2.4 Vocational training	20,905.00	3,318.25
2.2.5 Credit Facilities	692,736.00	109,958.00
3. EXPROPRIATION		
3.1 Houses and Plantation (RIR)	3,447,941.00	547,292.16
3.2 Houses and Plantation (ROR)	15,138,465.00	2,402.931.00
3.3 Houses and Plantation (ROB)	4,646,743.00	737,578.29
3.4 Preservation of Cemeteries	10,000.00	1,587.30
3.5 Highway No. 7	28,000,000.00	4,444,444.40
3.6 Telecommunication Line	112,000.00	17,777.78
4. MONITORING AND COUNSELING	50,000.00	7,936.51
5. ADDITIONAL MITIGATIVE MEASURE FOR NEW APPLICANTS	957,727.00	152,020.52
TOTAL	63,383,707.00	10,060,906.00

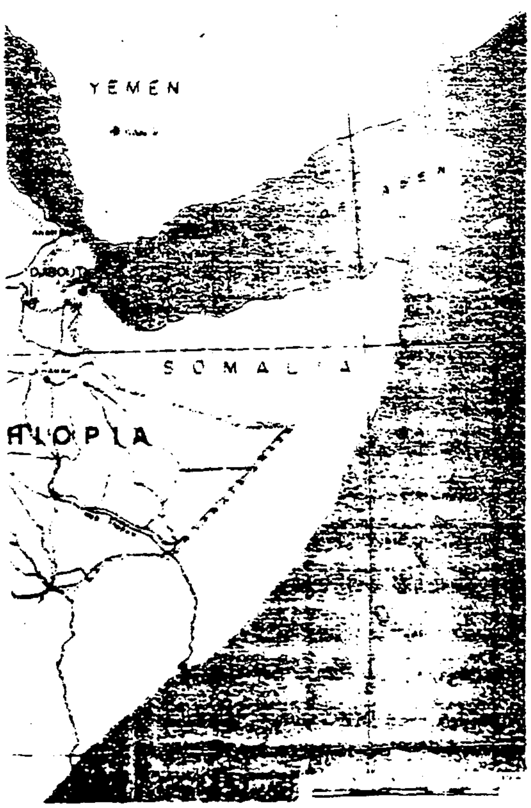
Tab. 22



PROJECT LOCATION MAP







LEGEND

FIGURE 1.

REV	DATE	DRAWN	CH'K'D	COLL	REVISIONS	AP
00	05/03/97	FRABETTI	PALLAVICINI		FIRST ISSUE	PALL

ISSUING OFFICE — SP studio pietrangeli

ETHIOPIAN ELECTRIC LIGHT & POWER AUTHORITY
GILGEL GIBE HYDROELECTRIC PROJECT OFFICE

ENEL Società per azioni
DIREZIONE COSTRUZIONI

ELC

GILGEL GIBE HYDROELECTRIC PROJEC

PROJECT GENERAL LAYOUT

SECT 380 DWG N 111G100027