THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
MINISTRY OF MINES AND ENERGY
ETHIOPIAN ELECTRICAL LIGHT AND POWER AUTHORITY

GILGEL GIBE HYDROELECTRIC PROJECT
ENVIRONMENTAL IMPACT ASSESSMENT
EXECUTIVE SUMMARY

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1. INTRODUCTION AND BACKGROUND

1.1 Purpose

The purpose of the environmental impact assessment (EIA) is to predict the negative impacts that are likely to occur as a result of the preparation, construction and operation of the Gilgel Gibe Hydroelectric Project. The assessment also identifies the mitigative measures required to minimize the impacts identified. The scope of the EIA also includes the preparation of an environmental management plan. A comprehensive resettlement plan has also been prepared under a separate document.

1.2 Project Background

Ethiopia has an abundance of highland rivers providing the basis for a large potential sustainable energy resource in the form of hydroelectric power. Recent power planning studies have estimated that Ethiopia's hydroelectric potential is in the order of 30,000 MW, a potential that is greatly in excess of foreseeable domestic energy demand. Currently about one percent of this potential is being exploited. Preliminary investigations indicate that the most promising hydroelectric sites could be developed at relatively low cost.

The Gilgel Gibe project is one of the most economically attractive potential hydroelectric developments. Studies of the potential project were initiated in 1963 and ENEL (Ente Nazionale per L'Energia Elettrica, Italy) carried out a feasibility study of the project in 1984. Initial construction activities were carried out in 1988 through a co-operative programme between the Governments of Ethiopia and the Democratic People's Republic of Korea. Subsequent assistance has been provided by the Governments of Italy and Austria.

As a result of initial construction difficulties, changing power demand and finances, a number of major design modifications were made. Due to a lack of progress, the agreement between the Governments of Ethiopia and Korea was interrupted in 1994 and western project management and tendering practices were subsequently adopted.

The ENEL/ELC consortium was retained in June 1995 and given the responsibility of upgrading and completing the project design, the preparation of tender documents, the development of detailed design, and the supervision of construction.

2. PROJECT DESCRIPTION

2.1 Project Location

The project is located in Sekoru Wereda, Jimma Zone of the Oromia Region about 260 km south west of Addis Ababa and about 70 km north-east of Jimma. The project area is indicated in Figure 1.
The project area is situated on a plateau approximately 1650m asl and consists of a series of gentle sloping low hills and broad plains surrounded by hills and mountains. The Gilgel Gibe (Little Gibe) River, crossing the Sekoru Wereda from the south-west to the north-east, is a tributary of the Great Gibe River (known downstream as the Omo River). The river is extremely variable in course and gradient.

In the project area proper, the first stretch of the river between Asendabo and the Deneba waterfall is winding and follows a relatively flat course. The right bank is more or less flat while the left bank has steeper gradients. Approaching the Deneba waterfalls the river banks become much steeper and provide a suitable dam site. A dam located here would provide a reservoir capacity sufficient to regulate most of the river flows and minimise unusable spills.

Downstream of the 20m high Deneba waterfall the river narrows and the gradient increases to about 1.4-1.5 per cent. Straight stretches of the river are interspersed with meandering sections. Within a few kilometres of the dam site the river drops considerably and provides a significant and economic hydroelectric potential.

The project area is well connected by road (Highway 7) and is accessible from Addis Ababa in about five hours.

2.2 Project Scheme

The project is characterized by a rockfill dam with asphalt concrete facing. The resulting reservoir will serve a single underground power plant consisting of three turbines and generators. Water will reach the power plant via a 8.9km concrete lined tunnel. The power plant will generate 180mW of electrical capacity. The main technical and physical features of the scheme are provided in Table 1.1. A complete description of all engineering features is provided in the main report.

During the period from 1986 to 1993 the following various works of the project were undertaken:

- most of the internal access roads including a 40 ton capacity Bailey Bridge across the Gilgel Gibe River near the dam site;
- diversion works including excavation, concrete pouring, and protection embankment construction;
- power waterways including outdoor stripping and excavations, construction adits for the tunnel, and short stretches of the tunnel;
- excavation for the powerhouse platform;
- 230kV transmission line from the old powerhouse to Addis Ababa;
- ECAFCO camp construction;
- main temporary camp;
- offices and warehouses;
- quarry development;
crushing and batching plant;
. power supply feeding camps and work site.

Table 1.1: Summary Descriptions of Main Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Data/Specifications</th>
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<tr>
<td><strong>Reservoir</strong></td>
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</tr>
<tr>
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<tr>
<td>average water level</td>
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<tr>
<td>total storage</td>
<td>839 million m³</td>
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<td>live storage</td>
<td>711 million m³</td>
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</tr>
<tr>
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<tr>
<td>maximum height</td>
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</tr>
<tr>
<td>crest length</td>
<td>1,600m</td>
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<tr>
<td>embankment volume</td>
<td>2.5 million m³</td>
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<tr>
<td><strong>Tunnel</strong></td>
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<tr>
<td>type</td>
<td>concrete lined</td>
</tr>
<tr>
<td>construction method</td>
<td>drill and blast</td>
</tr>
<tr>
<td>length</td>
<td>8.950m</td>
</tr>
<tr>
<td>diameter</td>
<td>5.5m</td>
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<tr>
<td>invert elevations</td>
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</tr>
<tr>
<td>at intake</td>
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<tr>
<td>at surge tank</td>
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<tr>
<td>slope</td>
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</tr>
</tbody>
</table>

3. LEGAL FRAMEWORK

Since the 1940s Ethiopia has shown a growing concern for the country’s environment. This is reflected in a large number of proclamations and regulations relating to a wide range of environmental components that fall within the responsibility of different government agencies.

The country's constitution contains the basic and comprehensive principles and guidelines for the protection and management of the environment. Two articles of the constitution specifically hold the people of Ethiopia responsible for the preservation of natural resources and maintenance of ecological balance.
In 1995 the Environmental Protection Authority was established by proclamation to prepare environmental protection policy and laws. As well, the authority has been given the responsibility for preparing directives and systems necessary for evaluating the environmental impact of development projects.

The World Bank requires that a comprehensive environmental assessment be conducted as a basis for project loan appraisal.

4. METHODOLOGY

EIA Responsibility

The ENEL/ELC Consortium was charged with the responsibility of preparing the EIA and to "predict the likely environmental consequences of implementing project activities". World Bank guidelines for preparing environmental assessments have been followed. The EIA has also been based on the previous environmental studies including the "Gilgel Gibe Hydroelectric Scheme-Feasibility Study (January 1984)" and "Gilgel Gibe Hydroelectric Project - Public and Environmental Health Implications" by UNDPH/WHO (April 1986).

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 EIA and preparing the draft and final reports.

Bounding and Scoping

The bounds of the environmental assessment 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.

Scoping has included the most important and major environmental components, in particular, water quantity and quality of the Gilgel Gebe 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.

Assessment

Potential impacts in the three stages of the project: preparation, construction and operation, were considered. Impacts were given a subjective value rating determined by members of the assessment team.
Data

Most of the data used as a basis for the assessment were made available from previous studies carried out in the 1980s. These were supplemented with additional data collected by the assessment team in July and December 1995. These data included:

- detailed evaluation of natural vegetation biomass;
- collection of farming and agricultural land data;
- water quality, including measurements of chemical, physical and biological parameters;
- review of diseases amongst workers on site;
- water level evaluations;
- photographic survey;
- highway #7 survey;
- fisheries data;
- public input regarding wildlife presence;
- public participation regarding farming difficulties in new settlement areas;
- sanitary conditions.

Public Participation

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

A comprehensive public participation programme was carried out during the preparation of the resettlement plan. The people to be resettled have been continually represented by their respective Kebele farmers’ associations throughout the planning process. 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 farmers’ 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 programme. Initially four candidate areas for resettlement were identified by a technical committee. The committee selected one particular area and presented it to the people through their farmers’ association representatives. All agreed that the area selected was the most suitable. The associations indicated a number of concerns (some of which are reflected in the identified impacts presented in Table 8.1). The host society was also given the opportunity to provide input, the most important concern being the acceptability of the settlers to the area. The host community accept the newcomers willingly.

Mitigation and Management Plan

In addition to identifying the important impacts that could be expected as a result of the project, the team has suggested possible mitigative measures that should be considered. Finally, the team prepared an environmental management plan detailing the mitigation actions that would be required to address the identified impacts.
5. DESCRIPTION OF THE ENVIRONMENT

5.1 Physical Environment

Geology and Seismology

The project area is situated on the south-western Ethiopian plateau. The area is characterized by a series of basic and subsilicic effusive volcanic rocks that are frequently interlayered with reddish paleosols of Tertiary age. In some locations these are topped with fluvio-lacustrine sediments, particularly in the area of the upper end of the proposed reservoir. The volcanic layers generally dip a few degrees towards the south-west and are crossed by minor faults and fractures.

Most of the epicenters of observed earthquakes in Ethiopia are related to major rift structures. The dam site is at least 96km from the most active seismic centres and any earthquakes originating in these centres 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 0.1g. 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 related to it, the adoption of a design earthquake of 0.1g and a maximum credible earthquake of 0.2g has been considered.

Soils

Soils of the general area are alfisol-type that have been developed under humid and deciduous forest conditions. Soil texture ranges from clay to lime-clay or sandy clay and the soils are generally acidic. The project site is characterized by black soils in the valley bottom, grey brown in the hilly strip and red at higher levels. Organic and total nitrogen content of the valley bottom soils are typical of permanent meadow land. Middle and high altitude soils have lower nutrient levels due to exploitation and intensive erosion.

Climate

The climate is semi-arid with average temperature and rainfall of 19.2°C and 1535mm respectively. Sixty per cent of the total rainfall occurs within the June to September period, 30 per cent in the February to May period, and 10 per cent in the October to January period. The total loss due to evapotranspiration without the reservoir is estimated at 1150mm per year.

Hydrology

The mean annual discharge of the Gilgel Gibe River for the period between 1967 and 1992 is 50.4m³/s which corresponds to an annual runoff of 1,578 million m³ and a total rainfall volume over the corresponding catchment area of 6,485 million m³. The flow of the Gilgel Gibe River at the confluence of the Great Gibe River is 53.1m³/s. At this point the flow of the Great Gibe
River is 177.7m³/s. 28.36 per cent of the Great Gibe River flow is contributed by the Gilgel Gibe River. The Great Gibe River joins the Gojeb River with a flow of 86.2m³/s to form the Omo River with a flow of 531.7m³/s where it enters Lake Turkana. The Great Gibe contributes 32.1 per cent of the flow of the Omo River and the contribution of the Gilgel Gibe River to the Omo River is 9.48 per cent.

. Water Quality

Daily water temperature of the Gilgel Gibe River ranges from 21°C to 24°C. A low oxygen content ranging from 5.2 to 6.8ppm is caused by the high suspended solid content. Low levels of orthophosphates are indicative of low use intensity by man. The low nitrogen levels are typical of natural situations or those that are only slightly altered by minimum organic additions.

Salinity levels are low (46.52mg/l) and considerably lower than salinity levels of many of the country's rivers at similar altitude.

The river's water is classified as earthy-brackish, alkaline, bicarbonate and slightly mineral. The river has high levels of turbidity and bacteria, particularly faecal coliform type. As a result, the river is categorized by WHO as "non-mains water supply" and requires treatment to render it potable.

5.2 Natural Environment

. Vegetation

The natural vegetation of the Oromia Region is characterized by moist evergreen forest which is found at an altitude between 1,200m and 2,300m and where the annual rainfall is in the range of 1,200mm and 2,000mm. The remaining natural vegetation cover of the project area includes remnants of this evergreen forest in the form of thickets and larger isolated patches. This is particularly true along the river itself. The project area contains three main types of natural vegetation cover including riverine, treed savannah and a transitional vegetation zone between these two types.

A well defined riverine forest system, defined by moisture availability, is present along the Gilgel Gibe River. This includes the section to be inundated and the 16km section downstream that will be devoid of most of its annual water flow as a result of the dam and reservoir. The total extent of the riverine forest to be inundated is estimated to be in the order of 300ha. In places the forest shows signs of degradation, probably as a result of areas of easy access by residents of the project area seeking construction materials and fuelwood. However, its overall condition has not been fully assessed. The riverine forest is comprised of five plant associations and the relative abundance of their constituents has been identified on the basis of moisture regimes.
The transitional strip between the riverine system and the savannah system includes three main tree species including *Acacia cfr. abyssinica*, and a number of grasses. The treed savannah is characterised by xerophilous species with *Acacia abyssinica* and *Acacia sp.* being the most common.

**Fauna**

Wildlife abundance and diversity in the project area is low, probably as a result of past and present intensive farming and grazing activities, and the extensive reduction in suitable habitat. Three species of amphibians and reptiles, ten bird species, and 21 species of mammals are thought to be present in the project area as a result of earlier surveys. Input from local people has indicated the presence of large carnivores but to date this has not been verified. The relatively inaccessible gorge between the proposed dam and tailrace probably contains suitable habitat and food supply (e.g. baboons) for leopard.

The macro-benthic population consists mainly of oligoetos, and the abundance of caddis flies confirms high water quality from a biological perspective. The river conditions are ideal for fish species requiring little oxygen and a diet from the lower end of the food chain. Three major fish species were sampled from the river, including *Barbus intermedius* (the dominant species), *Tilapia nilotica* and *Labeo cylindricus*. The dominant *Barbus intermedius* has a population of normal composition. Various other factors suggest that this species is a permanent and well adjusted member of the river ecosystem.

5.3 Socio-economic Environment

**Population and Livelihood**

The population of the project area is found in villages and small scattered settlements with groups of tukuls and single tukuls. There are no towns in the project area. Sekoru is 17km distant, Denabe 5km distant and Asendabo 14km distant. Jimma is the nearest city situated 70km away.

The area to be affected by the project includes 18 kebele farmer associations located within four Wereda administrations. At the time of registration, for purposes of resettlement, the total number of households was 2,476 representing a total population of 15,351. This population is expected to grow by 2.5 per cent to yield a total population of 16,886 by the year 2000.

The project area is characterised by an agrarian economy, primarily subsistence in nature. Cereal production, particularly teff, sorghum and maize, provides the basis of agriculture although tubers, vegetables and fruit (primarily bananas) are also grown. Coffee is cultivated along with other cash crops including citrus. A variety of other food and non-food trees are also cultivated. Agricultural practices are primitive.
Culture

The dominant religion in the project area is Moslem and is the exclusive religion in Sekoru and Omo-nada Weredas. Christians comprise 35 per cent and 15 per cent of the population in Tiroafeta and Kersa Weredas, respectively. Oromita is spoken exclusively in all Weredas except Kersa where it represents 80 per cent of the spoken language (18 per cent Amharic and 2 per cent others). Ethnic affiliation is exclusively Oromo in all but Kersa Wereda where it is 80 per cent Oromo, 18 per cent Amhara and 2 per cent others.

Resource Use

The land resources of the project area are used primarily for grazing and agriculture. Forest cover, both dry land and along the river, is accessed for local products including timber for house construction, fuelwood, and probably for charcoal making and the provision of a variety of plants for medicinal and food purposes. Some wildlife including warthog, wild pig and birds are reportedly captured, but generally hunting is minimal.

Fishing is carried out but there are no full time fishers. Only hooks are used to catch the larger specimens of Barbus intermedius. Fish consumption in Ethiopia is generally low.

Infrastructure

The project area is serviced by the main centers of Deneba, Sekoru, Asendabo and Jimma (70km distant) and national highway #7 connects Addis Ababa to these centers. Connection between various settlements within the project area is by footpath. A number of Gilgel Gibe River crossings by canoe are made by local farmers for access to markets.

Public Health

Malaria, onchocerciasis and helminthic infections are the major diseases found in the project area. Malaria is endemic with the main transmission season between September and November. Within the project area ten of 32 habitats surveyed contained the immediate snail host for intestinal bilharzia. These ten habitats also showed the presence of the host for the urinary tract form of the disease. Although tse-tse fly is present in the area, no cases of human trypanosomiasis has been reported. Lower tract infections and diarrhoeal diseases are found in 11 per cent and 7 per cent of the population respectively.

Pulmonary TBC has been steadily increasing in the area since 1989 with 1,538 cases being reported in 1994-95 through the Asendabo Health Centre and the Jimma Zone Health Office. Hepatitis has been reported in 116 cases over the past six years and, to date, 36 cases of AIDS have been reported. Other STDs, typhoid fever, relapsing fever and meningitis are on the increase.
There is one health centre within the project area. Other health units are located at Deneba, Sekoru and Dimtu towns but these are managed only by health assistants. The Asendabo health centre offers the best facilities including the services of a doctor, nurse, sanitarian and a laboratory technician. The nearest hospital is located in Jimma, 70km distant.

With the exception of well water supplies for the major towns in the area, and the wells located at the construction camp and near the dam site, all domestic water is obtained from surface water and springs. The only source of contamination in these supplies is faecal contamination which occurs mainly in water supplies in proximity to densely populated areas.

Apart from a few pit latrines located in the older towns (Asendabo, Deneba and Sokoru), there are no basic toilet facilities. Generally, people of the area use the open space adjacent to their dwellings and villages for defecation.

6. PROJECT BENEFITS

The Gilgel Gibe project will provide a number of benefits at the national, regional and local levels. These benefits are briefly described in the following.

A total of 5,000 person years of jobs will be created with many being made available to local people. It is estimated that the total increased input into the local economy of the area as a result of these jobs will be approximately 18.6M birr. Additional money will enter the economy as a result of direct project spending for local goods and services. This increased spending will have spin-off effects including entrepreneurial development and the support of a number of secondary and tertiary activities. Local people will also be given the opportunity for training and learning new on-the-job skills which can be transferred elsewhere upon termination of the project.

Project jobs made available to women will allow them to gain a degree of economic independence and as a result, the family socio-economic position will improve.

In the area to be resettled, infrastructure and social conditions will improve. Health centres will be expanded and better supplied, new schools will be built and existing ones expanded. Water supplies, sanitation, roads and general access will be improved.

A fishery developed in the reservoir will benefit local entrepreneurs, earning money to be further invested in the community. The fishery would create permanent jobs.

Providing the buffer zone around the reservoir will reduce erosion in the watershed, a multi-faceted benefit for energy managers and downstream users and ecosystems.

Regionally, the project will provide the source for developing the rural electrification programme which will contribute to improved socio-economic conditions.
At the national level, the project contributes to the national grid and helps the country to meet its electrical energy demands. Economic expansion will occur as a result of increased electricity supply. Harnessing hydropower will allow the country to reduce its dependence on diesel generation for energy and thus allow it to shift its foreign exchange expenditures to other important development needs. The foreign exchange savings would be in the order of USS 8M per year.

The project provides a contribution to the national grid, which will eventually produce a surplus that can be exported to neighbouring countries such as Sudan, Egypt, Djibouti and Somalia, thus earning foreign exchange for Ethiopia.

7. PROJECT IMPACTS

7.1 Major Impacts

Six major environmental impacts have been identified and assessed. These have been identified on the basis of their intensity, area covered and/or the size of human population affected. They are described briefly here in terms of their nature and mitigative considerations. Residual impacts are described in Section 10.

Dislocation of People

The proposed reservoir will occupy an area of approximately $60km^2$. This will necessitate the removal of 2,476 households representing a total population of 15,351. The stress on people who know that they will have to move from the area, in many cases abandoning ancestral homes, familiar surroundings, social relationships, and knowing that they will be moving to a new and relatively unfamiliar environment, can be severe. Two distinct groups of people will be required to move from the area. The first group of 361 households resides and farms within the reservoir boundary. This group will be losing homes, 3,169ha of agricultural land, and 295ha of grazing land. The second group includes those who live outside of the area to be flooded and who rely on lands within and outside of the reservoir area. The second group, represents 2,115 households and will lose 7,483ha of agricultural land and 49ha of grazing land.

The loss of homes, land and livelihood can be fully mitigated through the preparation and implementation of a comprehensive resettlement plan.

Health

The reservoir will cover an area of $60km^2$ and will create an environment suitable for the diffusion of three main types of infections, all three of the parasitic type: malaria, onchocerciasis and schistosomiasis. The transmission vectors of these infections involve a stage linked to the presence of water. The major factor for the spread of malaria and during construction will be the thousand labourers who will be deployed on the project. People coming into the area from other water related vector-borne disease endemic areas will establish transmission foci and
intensify disease dissemination. It is possible that the density of *S. ethiopense*, one of the vectors of onchocerciasis, will be enhanced as a result of the creation of the reservoir.

Although it is expected that many of the labourers will be recruited locally, a number of single men from distant areas will be hired as well. Experience has shown that construction camps attract women who are willing to deal in commercial sex. There is no reason to believe that the situation at the project site will be different. It can be expected that the incidence of STDs will increase and of particular concern will be an increase in the number of HIV positive cases.

A buffer area around the reservoir would mitigate the impact of water borne related infectious diseases. As well, the margins of the reservoir should be deepened to remove favourable habitat for mosquitoes and snails. Health education, the prevention of shanty town development near the construction camps, the provision of separate dwelling sites within the camp for men and women, health education, and the free distribution of condoms would all contribute to the prevention of STDs.

**Gender Issues**

Often a development project that affects people, particularly if relocation is required, places an extra burden on women. Issues relating to women and resettlement are presented in Table 8.1. Women can be affected in several ways as a result of the project. They are often used on construction sites as unskilled labour in strenuous jobs. Although this provides them with some economic independence, they still often have to return home daily to attend to many of their usual chores including water collection, wood gathering, meal preparation and child rearing. Overwork can lead to stress and physical illnesses. Although in many countries women are often paid a lower wage than men for carrying out similar tasks on the construction site, this will not be the case on the Gilgel Gibe project. By taking on work at the construction site, a lifestyle is lost, community social interactions change and a culture is affected.

Alcohol abuse by men, as a result of extra money available from construction jobs, can affect women and children at home through the loss of finances for household maintenance and through physical abuse.

The effects on women can be minimized through careful planning and consideration for their welfare. Women should have full access to all project jobs for which they are qualified, including supervisory positions. They should also be eligible for any training opportunities provided through the project.

**Loss of Food Production**

The reservoir and buffer area will eliminate a total of 10,652ha of agricultural land, thus permanently removing future agricultural production represented by this land. As well, 344ha
of grazing land will be permanently lost, an area that represents a specific number of animal production units.

There is no mitigation for the permanent loss of land that has the capacity to produce crops or to rear livestock. More intensive agriculture and improved livestock management may compensate for overall lost food production for the area and maintain area levels of food security. As well, bringing fallow land into production as will be the case in the resettlement area, will compensate for lost food production.

In terms of lost food production potential, the reservoir, which will represent 3,169ha of agricultural land, will provide an area of 6,000ha that can be managed for fisheries production. This would offset lost agricultural capacity and production.

. Loss of Area Biodiversity

The reservoir will eliminate approximately 300ha of riverine forest and along with it the habitat for a variety of fauna. These represent a significant and important component of the area’s overall biodiversity. As well, the loss of normal river flows downstream of the dam for a distance of 16km may have some effect on the riverine forest in this stretch of river, and on the fauna that rely on the forest and water flows for at least part of its habitat. The plant community below and within the vicinity of the falls immediately downstream of the dam will be modified as a result of lower river flows.

There is no mitigation for the loss of biodiversity, for either the loss of riverine forest or the faunal communities that rely on the forest. Although establishing forest elsewhere such as in the dryer buffer zone above the edge of the reservoir will replace total biomass loss, it will not replicate the plant and animal communities of the current riverine forest. It can be assumed that the reservoir will develop its own ecological system over time and this will offset some of the biodiversity loss.

Formal protection of the forested valley between the dam and the tailrace will ensure that the riverine forest in this area is protected. Such protection could be extended further downstream below the tailrace where the topographic conditions and other natural features are similar and warrant protection.

. Loss of Downstream Aquatic Habitat

The Gilgel Gibe River downstream of the dam for a distance of 16km will have its water flows altered permanently as a result of the reservoir and the operating regimes for the reservoir. The loss of normal water flows will affect the aquatic communities in this stretch of river. Without compensation flows, the loss will be complete and permanent.
Partial mitigation can be accomplished through the provision of a compensation flow. However, the cost of such a flow in terms of lost hydropower should be carefully weighed against the value of riverine and aquatic habitats that will be lost.

The downstream effect will not extend much beyond the confluence with the first major inflow below the tailrace. Total loss of water to Lake Turkana will only be 0.17 per cent as a result of evaporation from the reservoir. This loss will have a negligible effect on the aquatic communities in the Omo River and on the total flow into Lake Turkana. However, regulated flows from the reservoir could affect downstream aquatic communities, at least to the confluence of the first major inflow.

7.2 Existing Environmental Impacts from Earlier Activities

The Gilgel Gibe Project was initiated in the early 1980s but subsequently halted. Prior to abandonment much of the construction work had been initiated. Impacts of these past construction activities are much in evidence. Road building at the powerhouse site has left heavy scarring on the valley walls and has probably led to some degree of soil erosion. The 230kV transmission line in place did not take into account aesthetics or social impacts and in several places the line passes close to and overhead of individual houses.

The construction compound contains a large quantity of physical plant, much of which will never be used again. One particular potential hazard is the stacking of old vehicle batteries alongside one of the camp buildings. These should have been properly disposed of a long time ago to ensure that battery acids do not leach into the ground. It is likely that a number of situations at the compound have led to the leaching away of petrochemicals. It is the intention to have the campsite cleared of unnecessary materials at the beginning of the construction phase of the current project.

7.3 Other Impacts

A large number of other potential and less disruptive impacts are envisioned. These are presented in Table 7.1. The table indicates the impacts to be expected, the causes of the impacts and their effects, and the mitigative measures to be considered.
Table 7.1: Other Impacts

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>CAUSE</th>
<th>EFFECT</th>
<th>POSSIBLE MITIGATION MEASURES</th>
<th>REMARKS</th>
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<tbody>
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<td>Physical Environment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humidity rise</td>
<td>Creation of reservoir</td>
<td>Moderation of shoreline and other nearby vegetation, discomfort</td>
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<td>Likely not to be significant</td>
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<tr>
<td>Water quality in reservoir</td>
<td>Water Impoundment</td>
<td>Could affect potential biological production in reservoir</td>
<td>Water management through release programme</td>
<td>Reservoir ecosystem will be developed within parameter of existing water quality</td>
</tr>
<tr>
<td>Water quality downstream</td>
<td>Water Impoundment</td>
<td>Negative effect on aquatic ecosystem of 16km stretch immediately downstream of dam, damage to aquatic communities</td>
<td>Operating schedule to take quality of released water into account</td>
<td>Poor quality water will be released; effect downstream on aquatic communities is unknown</td>
</tr>
<tr>
<td>Shoreline slumping</td>
<td>Reservoir wave action</td>
<td>Loss of shoreline and vegetation</td>
<td>Stabilization with suitable species</td>
<td>Vegetation can only be established at edge of full supply level</td>
</tr>
</tbody>
</table>
### Natural Environment

<table>
<thead>
<tr>
<th>Reservoir sedimentation and flushing</th>
<th>Soil erosion</th>
<th>Irregular heavy sedimentation deposition downstream</th>
<th>Reduce soil erosion with watershed management practices upstream</th>
<th>Pattern of sedimentation deposition unknown without modelling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eutrophication</td>
<td>Nutrient overloading</td>
<td>Loss of dissolved oxygen and low fish productivity</td>
<td>Removal of large vegetation before reservoir filling</td>
<td>Environmental guidelines should be incorporated into contracts</td>
</tr>
</tbody>
</table>

### Socio-economic Environment

<table>
<thead>
<tr>
<th>Access</th>
<th>Highway 7 rerouted and communities cut off</th>
<th>Reservoir</th>
<th>Reservoir</th>
<th>Reroute highway through Asendabo</th>
<th>Provision of ferry service or access road</th>
<th>Currently under consideration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td>Traffic movement</td>
<td>Respiratory problems; aesthetics</td>
<td>Watering of roads; blasting techniques used that will minimize dust</td>
<td>Impacts only during construction phase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>Traffic movement</td>
<td>Stress</td>
<td>Hearing damage</td>
<td>Proper handling of vehicles</td>
<td>Impact only during construction phase</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blasting and drilling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Category</td>
<td>Issues</td>
<td>Impacts</td>
<td>Solutions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>------------------------------------------------------------------------</td>
<td>--------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.aesthetics</td>
<td>road and quarry scars after construction completion</td>
<td>unsightly</td>
<td>sides of disused quarries should be graded, where feasible, and vegetated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>equipment and camp remains</td>
<td>loss of local attraction</td>
<td>re-vegetate abandoned access roads</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>waterfall below dam virtually eliminated due to low water releases</td>
<td></td>
<td>dismantle, breakup and rehabilitate sites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.safety</td>
<td>traffic</td>
<td>injuries and deaths</td>
<td>public awareness and safety operational procedures enforced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>blasting</td>
<td>injuries and deaths</td>
<td>public awareness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>unsafe quarry faces</td>
<td>injuries and deaths</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>deep water</td>
<td>drowning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.social conflict</td>
<td>migrant workers mingling with local population</td>
<td>cultural values eroded</td>
<td>worker education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>settlers placing pressure on existing services of Asendabo</td>
<td>stress between the two</td>
<td>control of camp movements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>groups</td>
<td>additional services provided and upgrading of existing services</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>.drug abuse</td>
<td>high wages, free time and access to drugs, particularly alcohol</td>
<td>fights, injuries;</td>
<td>worker education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>spousal abuse</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
8. RESETTLEMENT IMPACTS

Dislocation of a population in excess of 15,000 people is the most significant impact of the Gilgel Gibe project. To address the impact a comprehensive resettlement plan, a brief summary of which is presented in Section 9.2, has been prepared. However, a resettlement programme itself presents a number of potential impacts and these are presented in Table 8.1, along with mitigative actions that will be taken to ensure that the impacts are effectively addressed. For further details of the resettlement plan the reader is referred to the full resettlement plan and its implementation plan.

9. MANAGEMENT PLANS

9.1 Environmental Management Plan

An environmental management plan has been prepared and outlines the mitigation that will be taken for each of the impacts that have been identified in the impact assessment. Some costs (e.g. reforestation and fishery programmes) have been detailed. The management plan also provides a summary of the resettlement plan.

9.2 Resettlement Plan

The project will displace a population of 15,351 people in 2,476 subsistence farming households. The purpose of the resettlement plan, along with its accompanying implementation plan, is to ensure that those being displaced are resettled to a suitable area, that they are fully compensated for their losses in terms of immovable property, and that their income generating opportunities are fully restored.

A full inventory of private and public property has been conducted and compensation values have been determined. A resettlement site has been chosen from an original selection of four candidate areas. The site selected has been based on its suitability for meeting the social and agricultural needs of those being resettled.

The site includes an adequate area of 8,109ha of potential agricultural land, similar to the area being left by the resettlers, and it will meet all of the needs of the resettlers. The host population has the same socioeconomic, ethnic, linguistic and religious profile of the resettler group.

The resettlement plan describes resettlement procedures to be followed, compensation methods, candidate qualifications, infrastructure to be developed, and total costs of the programme which has been calculated at $US 10,060,906.00. A separate resettlement implementation project office has been organised under the regional government of Oromia and will be supervised by the head of the agricultural bureau. The office will be responsible for implementing the plan which identifies anticipated impacts, mitigative measures to be taken, and the costs for carrying out these measures. The plan also has provision for feeder roads, public facilities including health.
## Table 8.1: Potential Impacts of Resettlement Programme

<table>
<thead>
<tr>
<th>POTENTIAL IMPACT</th>
<th>MITIGATIVE MEASURES CONSIDERED</th>
<th>RESPONSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of livelihood</td>
<td>Settlers will be provided with equivalent farmland with necessary machinery and fertilizers</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Loss of houses, cemeteries and other immovable property</td>
<td>New houses will be constructed and full financial compensation for loss of other immovables will be provided; cemeteries will be preserved</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Loss of social structure</td>
<td>Settlers will be resettled all together in one area</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Loss of social services and infrastructure</td>
<td>Health unit and veterinary post will be established in new area; school and peasant association office will be established; flour mill will be built; mosque and church will be built</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Lack of potable water</td>
<td>Wells will be established at the new site</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Lack of access to nearby towns and market places</td>
<td>Access roads and bridges will be established</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Poor drainage at new site</td>
<td>Land with poor drainage will be drained</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Applications for resettlement from non-legitimate candidates</td>
<td>Strict registration procedures will be undertaken</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>Inability of some resettlers to adapt</td>
<td>Monitoring, counselling and training facilities will be provided</td>
<td>Oromia Regional Government</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>---------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Erosion of settlement areas</td>
<td>Soil conservation including soil management practices will be introduced</td>
<td></td>
</tr>
<tr>
<td>Pressure on existing forest and other natural areas</td>
<td>A public awareness programme will be planned and initiated</td>
<td>EELPA and Oromia Regional Government</td>
</tr>
<tr>
<td>Disadvantages to women</td>
<td>.relocation often leads to men migrating and women taking on a double burden .cash compensation often goes to the male household head and women have no control .possible loss of existing jobs</td>
<td>.no mitigation .educational and skills training programs will be provided for women; .entrepreneurial training for women will be provided</td>
</tr>
</tbody>
</table>
centres, a veterinary centre, mosques and churches. It also outlines activities for land use planning, forest protection, erosion control, health problem solving and other actions that will be undertaken.

10. RESIDUAL IMPACTS

Not all environmental impacts will be mitigated and as is always the case in a development project such as the Gilgel Gibe project, permanent impacts will remain. These represent the sacrifices and costs of gaining the benefits to be derived from the project. The major residual impacts include:

. Loss of Food Production Capacity

The loss of 10,652ha of agricultural land and 427ha of grazing land will be permanent. This will be offset partially by a managed fishery in the reservoir, similar to other natural and created fisheries in the country.

. Health

With restricted access as result of the buffer zone around the reservoir, transmission of water related diseases from the reservoir will be minimal.

Inspite of efforts to prevent the spread of STDs, STD incidence will increase. As well, some drug (e.g. alcohol) abuse is expected.

. Dust and Noise

Dust and noise will be controlled but will still be present. It will occur only during the construction phase and thus will represent a temporary residual impact.

. Riverine Forest Loss and Weakening of Area Biodiversity

The loss of riverine forest as a result of the reservoir will be a permanent loss and cannot be mitigated. Biodiversity of the area is weakened and inspite of reforestation of the buffer area, and the development of a reservoir aquatic ecosystem, biodiversity of the area will be weakened.

. Loss of Aquatic Habitat

River aquatic habitat will be permanently lost upstream of the dam for a distance of the length of the reservoir. Downstream for a distance of 16km between the dam and the tailrace the aquatic habitat will likely be permanently altered as a result of a compensation flow equivalent only to low season flows. Below the tailrace the aquatic habitat is likely to be permanently
altered, at least to the point of confluence with the first major inflow, as a result of regulated flows and altered water quality.

. Loss of Fauna

Inspite of all mitigative actions, some loss of fauna and its habitat is inevitable during the construction phase of the project. The greatest permanent loss of fauna and habitat will result in the removal of vegetation from the proposed reservoir.