GIBE III Hydroelectric Project

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT
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0 EXECUTIVE SUMMARY

0.1 Introduction

Ethiopian Electric Power Corporation (EEPCO) is currently focusing on developing the country’s hydroelectric potential and the Gibe III scheme provides generating capacity to meet domestic demand and increase exports of electricity and make the sector a major foreign currency earner for the country. The direct benefits of this project will be 1,870 MW of electrical power and 6,400 GWh of firm energy per year.

The Environmental and Social Impact Assessment (ESIA) has been prepared in compliance with Ethiopian ESIA procedures and in accordance with international standards, as reflected in the policies, safeguard procedures, and guidelines of the African Development Bank and the World Bank.

This executive summary includes information drawn from associated reports prepared within the same study framework, namely:

i) Environmental and social Impact assessment: Dam and Reservoir
ii) Environmental and Social Impact Assessment: Downstream
iii) Environmental and Social Management Plan
iv) Resettlement Action Plan
v) Environmental and Social Impact Assessment: Gibe III-Sodo Transmission Line
vi) Environmental and Social Impact Assessment: Chida-Sodo Road Realignment

CESI of Italy, in association with MDI Consulting Engineers of Ethiopia, was charged with the responsibility of preparing the ESIA and AGRICONSULTING of Italy in association with MDI carried out the additional study on downstream impact assessment. EEPCO’s EMU prepared the ESIA and the RAP for the Transmission line project.

0.2 Project Description

0.2.1 Project Location

The Gibe III scheme is located within the Gibe - Omo River Basin, in the middle reach of the Omo River around 450 km by road south of Addis Ababa. The scheme, from the root of its reservoir to its tailrace outfall, extends over a corridor some 155km long. Administratively, the reservoir stretches over five zones and twelve weredas. The downstream area extends from the dam site upto Lake Turkana. Omo River below the Gibe III dam traverses through the four weredas of South Omo Zone.

The approximate centroid of the project area lies at 757,225 North and 312,293 East. Figure 01 and 02 show the locations of the project area for the dam and reservoir and administration map around the reservoir respectively. The works concerning the construction of the Gibe III scheme (diversion tunnels, cofferdams, main dam, Power House, switchyard, etc.) are concentrated in a small area of about 1.6 km².
0.2.2 Gibe III Hydropower Scheme

The Gibe III Hydropower Project will be the third development in a cascade of water resource schemes (Gilgel Gibe/ Gibe I, in operation and Gibe II under completion) on the main Gibe/Omo River. One further hydropower scheme – known as Gibe IV is foreseen downstream on the Omo River.

Figure 0.1: Location Map of the Project Area
Figure 0.2: Administration Map around the Reservoir Area
Figure 03 shows the overall layout of the Gibe III, Hydropower scheme and comprises a 240m high dam which will create a huge reservoir with a surface area of some 200 km² and a live storage of some 11,750 million m³. It has an underground and inclined penstocks, a surface Power House equipped with ten power generating units and switchyards, with the following characteristics:

- Vertical axis Francis N. 10 turbines, 187 MW, 211 m Hn, 95 m³/s Q
- 0.46 Plant load factor (0.46 Gibe I; 0.44 Gibe II)
- 6,500 GWh Energy produced annually

The electrical power will be available at any time of the day or night to cover both peak and off-peak demand in the Ethiopian interconnected power systems or exported. The so-called specific unit cost of the Gibe III scheme, based on the generation component (excluding the transmission component), is some 2.86 Euro cents per kWh indicative of a very attractive hydropower generation scheme.

### 0.2.3 Transmission Line

The power produced by the 1,870 MW Power House at Gibe III will be delivered to Interconnected System (ICS) through a 65 km long four double circuit 400 kV overhead transmission line that connects the Gibe III to a new substation at Sodo. This line will be 65 km long.

The transmission line towers will be constructed as self-supporting steel lattice structures. The normal spacing between consecutive towers will be approximately 350m. The footprint of the towers will be approximately 12m by 12m. A right-of-way, 50m in width and approximately in the centre of the wayleave, is to be kept clear of both vegetation and structures. The right-of-way will be used for the footings of the transmission towers and as an access track for construction and maintenance of the transmission line. This land will also remain under the ownership of its present owners. As much as possible the route where practical, has avoided houses or settlements and agricultural areas.

### 0.2.4 Access Roads

The existing bridge across the Omo River (on the Chida-Sodo Road) will be submerged by the future Gibe III reservoir and a new road bridge will be built downstream of the dam. After reservoir impounding, the permanent link between the Omo River left and right banks will be possible utilising Road (on the right bank plateau) to the dam site, passage over the d/s toe of the dam and a new road on the left plateau from the dam site to the existing road (or to Kindo Halale).

The proposed relocation road still lies in Wolayita and Dawro Zones of SNNPRS and serves the same community. Both the existing road and the relocation road are shown in Figure 4. The total length of the road along the selected alignment is approximately 72 km. The EPC contractor has studied a 47 km road alignment on the left bank and a 24.5 km on the right (see Figure 04). The surfacing will be about 7 m wide carriage way gravel road. A new bridge will be constructed across the Omo downstream of the Gibe III dam. The detailed design of the road is illustrated in the relevant report.
Figure 0.3: General Layout of the Site Installations
Figure 0.4: Chida - Sodo Road Realignment Change
In terms of function, the road is classified as a link road. The suggested formation width for the road is 10 m and it includes 1.5 m wide shoulders on either side. The road has a gravel surfacing. Based on the field investigations and the cross profile, requirement for roadside drainage and other protection measures required are identified. Hence, the proposals include roadside drains (furrow and lined), scour checks, retaining walls, etc. Other provisions mainly include sign, markings and road furniture.

### 0.3 Policy, Legal, and Administrative Framework

The ESIA study for the proposed Gibe III Hydroelectric project has been carried out within the framework of local, national and international environmental regulations. The legislative framework applicable to the proposed project is governed by the Federal Democratic Republic of Ethiopia (FDRE), Africa Development Bank (AfDB), World Bank, and European Investment Bank (EIB).

#### 0.3.1 Regulatory Framework of FDRE

The Federal Democratic Republic of Ethiopia adopted its Constitution in 1995, which provides the basic and comprehensive principles and guidelines for environmental protection, and management in the country.

Federal Environmental Protection Authorities (EPA) administers the EIA process in Ethiopia, as set out in its establishment proclamation. EEPCO has complied with the EIA and procedural and documentation requirements of EPA, with submission of the ESIA, ESMP and Resettlement Action Plan reports.

EEPCO and the EPC contractor will be responsible for implementing the recommended environmental mitigation measures and management plans in coordination with the Federal EPA and the Regional Environmental Protection Offices. The environmental performance of the project will be monitored on a regular basis through EEPCO’s own set up and through external/third party audits.

#### 0.3.2 African Development Bank Guidelines

According to AfDB screening criteria, Gibe III project is a category “1” project, for which a full-scale environmental impact assessment is required. This ESIA report was prepared to fulfil the requirements of AfDB involved in financing of the project investment.

The following AfDB policies and guidelines dealing with environmental and social issues related to the project were taken into consideration for preparation of the ESIA and ESMP reports and the Gibe III project is in compliance with the AfDB polices:

- Environment and social assessment procedures and guideline
- Guidelines on Involuntary displacement and resettlement in development project

#### 0.3.3 World Bank

The WB provides detailed guidelines for the EA process. The Gibe III hydropower project falls under Category A as per WB Performance Standards and its procedures for project appraisals. The WB policies and guidelines dealing with environmental and social issues related to the project were taken into consideration for preparation of this ESIA.
0.3.4 International Conventions

The Federal Democratic Republic of Ethiopia has ratified several international conventions and protocols, and some of these have relevance to Gibe III Hydroelectric Project and these include:

- Convention on Biodiversity (Rio convention);
- Framework convention of UN on climate change;
- African convention on the conservation of Nature and natural Resources;
- Convention on Wetlands of International importance Especially as waterfowl Habitat (Ramsar);
- Convention concerning the protection of world cultural and Natural Heritage.

0.4 Description of the Project Environment

Information on existing natural and socio-economic resources is of fundamental importance for evaluation of environmental impacts. The baseline data on the current status of the physical, biological and socio-cultural environments of the project area have been assembled, evaluated and presented.

0.4.1 Dam and Reservoir/upstream

0.4.1.1 Physical Environment

Climate

The amount of rainfall decreases throughout the Omo-Gibe catchments with a decrease in elevation and varies from a minimum of 1,200 mm to a maximum of about 1,900 mm. The average annual rainfall calculated over the whole Gibe III basin where the dam is located is 1,426 mm. 75 to 80% of the annual rainfall occurs during a five months period from May to September. The mean annual temperature is 20.4°C.

Geology

The regional geology of southern Ethiopia consists mostly of metamorphic rocks of green schist, amphibolite and granulite facies that represent the southern margins of the Arabian-Nubian shield.

The dam site area is characterized by a deep gorge with sub-vertical walls. The river alluvium is constituted by fine sands and gravel of variable thickness, with a maximum depth up to about 15 meters. From the river banks start the 30-50 m slopes of a coarse angular colluvium in silty-sandy matrices. The slightly weathered trachyte walls, outcropping are mainly characterized by two sub-vertical joint families, being parallel and orthogonal to the river. The walls are affected also by a relevant transverse fault system with NW-SE orientation.

The left bank is about 200 m high and appears almost intact, while the right bank is affected by a NNW-SSE fault system. The trachyte flow appears in some parts weathered and altered by fractures and hydrothermal fluids. At the top of the right bank a main NNW-SSE fault has caused a vertical displacement and put basalt and trachyte structures into contact. Near the contact with the colluvium, the rock assumes a more plutonic look. The ends of the walls are sometimes characterized by basalt columnar flows (two at least) upset by a structural movement.
Seismology

While the Gibe III dam is located in Ethiopia, in the vicinity (about 70 km) of the eastern branch of the East African rift system the entire area interested by the project, according to the LEVEL 1 DESIGN Geological Report, doesn’t show any evidences of present existing seismic activity.

Hydrogeology

Available data concerning the reservoir were collected from boreholes drilled at the dam site, from documents of the Gibe II project, and from remote sensing. The stratigraphy and structural geology of the reservoir banks were defined on the basis of the interpretation of ASTER scenes and other remote sensing data. Local permeability values were acquired from boreholes drilled at the dam site. According to the geological report no relevant filtration couloirs from the reservoir have been observed along the river basin. Permeability would be of secondary type (i.e. related to fracturing of the rock mass) while primary permeability (i.e. related to porosity) would be limited to the pyroclastic units interbedded in basalt flows.

Hydrology

The Omo River Basin is drained by two major rivers from the highlands, the Gibe River flowing southwards and Gibe River flowing eastwards. Downstream of their confluence only minor tributaries join, as the river continues southwards and enters the deep gorge where the Gibe III dam site has been identified. At the dam site, the catchment area is some 34,150 km² that represents 45% of the total catchment area at Lake Turkana and contributes 80.5% of the basin flow. The Omo River has an average slope of 3.1 m/km. The long term mean flow at Gibe III site is estimated to be 435 m³/s or 13.5 Billion m³ per annum. Seasonal variations are extreme, with monthly mean flow ranging from around 60 m³/s in March to more than 1,500 m³/s in August.

Water quality

In order to describe water chemical characteristics upstream and downstream the dam site, a water sampling campaign has been done to define the abundance of defined chemical parameters in three stations (downstream Gibe II Power House, at Bele Bridge and near the Gibe III dam site). Considering very low salinity levels on the usual mineral water scale, the Omo River water can be classified as earthy-brackish, alkaline, and with bicarbonate.

0.4.1.2 Biological Environment

Land Use and Land Cover

Land cover assessment was carried out for the Gibe III reservoir area and it was based on satellite images interpretation, field observations, field data collection and analysis. The classification resulted into the following four classes: The riparian vegetation in the reservoir area was observed along the river sides and it occupied 1,839 ha of land (8.8 %), and deciduous woodland covers about 17,158 ha (82.2%) and it is characterized by approximately 2% tree cover and 98% grass at the time when the field survey was carried out. The exposed surface and silt/gravel land covers 4.7% of the reservoir area and it mainly occurs along the lower parts of the river, on steep sides of rivers and degraded hillsides and rock outcrops. River/ water body covers 4.3% of the reservoir area. Farming practices and settlement are concentrated in areas (outside the valley on the highland) which are not affected by the future reservoir.
Natural Vegetation and Forest Resources

The vegetation on the hill slopes of the valley is characterized by deciduous phenology of the woodland species which shed their leaves during the dry season and regain them during the wet season as an adaptive mechanism for the prolonged dry season. The plant species of the Omo Valley have over time developed adaptive mechanisms and traits that allow them either to survive fire, germinating after the heat shock or to regenerate after a fire episode. In general, the vegetation which has evolved (around the reservoir area) as response to the frequent fires is poor in species composition. There is a narrow band of riparian vegetation of almost similar species composition as the woodland on the hill slopes. Due to ample moisture, trees found at the edge of the riverbank are not affected by fire as the rest of trees in the upper parts of the study area.

The altitudinal ranges, temperature, humidity and the floristic and physiognomy composition of the vegetation in the Omo river basin and Gibe Basin provide ideal conditions for Tsetse fly infestation.

Wildlife Resources

Based on the assessment, the number of wildlife species in the project area is low and does not rate well with areas in downstream of Gibe III dam (the Mago and Omo National Parks) and harbours only limited number of wildlife. However, the local residents and professionals from the offices of Agriculture interviewed during the field studies reported the presence of wildlife within the project area. The wildlife that have been recorded for the reservoir area are very common in many parts of the country and none of these species are endangered or threatened.

The vegetations provide good habitat to support diverse wildlife species. However, the wildlife habitats have always been under threat due to wildfires that are practiced during the dry season and it is greatly affecting the overall ecology and resource base. The woodlands, in particular are under high threat from fire.

Fishery Resources

The Omo-Gibe river basin is known to contain high diversity of fish species with over 70 species listed. The fishery in the study area includes: the riverine fishery along the mainstream Omo River, flood plain fishery (and Dipa Hayk), and the lacustrine fishery at Lake Turkana (Bubua and Toltale).

Studies on the biology of the different fish species have shown that they have different seasonal and spatial distribution for optimal growth – feeding, reproduction and survival. The large variety of species found in the river system is distributed in all sorts of habitat like in the deep open river channel or in pools (*Heterobranchus longifilis*), in the floodplains, in rocky habitats like *Labeo cylindricus*, demersal areas (*Hyperpisus bebe*), etc. Similarly their feeding habit varies enormously among the species covering all available niches. Some species undergo seasonal migration from the lake feeding grounds to spawn in the River Omo – like *Distichodus niloticus*, *Labeo horie*. Others prepare their own spawning sites (nests) close to the vegetated shore areas in the lake and complete the life cycle (*Oreochromis niloticus*). There are also fish species that spawn in the lake and also some of the population in the river systems (*Hydrocynus forskalii*).

There are few species which are endemic to the Lake Turkana and lower delta of the Omo River. However, none of the reports referred in the studies indicate the occurrence of endangered or threatened fish species in the Omo-Turkana system. The endemic fish species breed in different locations in or close to the lake - like
in the estuarine, littoral and pelagic habitats of the lake. These fish species have apparently evolved in the lake from the riverine ancestors to fill up the niche created in the lacustrine system.

Riverine fishery is not developed partly due to lack of access to suitable fishing grounds and also the food habit or culture of most of the rural community does not favour fish consumption. Fishing is done mainly with hooks and some gill net. Commercial fishing is mainly reported in the lower course of the river far below the proposed dam site, at Omorate and at the Lake Turkana.

Protected Areas

Ethiopia issued a number of regulations aimed to conserve and protect the remaining natural ecosystems of the country in National Parks, Wildlife Sanctuaries, National Priority Forest Areas and Controlled Hunting Areas. However, the reservoir area is neither contiguous with nor in close proximity with any of these nationally protected areas.

0.4.1.3 Socio-Economic Environment

The socio-economic assessment has been carried out with the objective to provide a comprehensive analysis of the existing socio-economic conditions of the population in the future reservoir area.

Population and Settlement

In 2006, an estimated 253,412 people were living in the 67 Peasant Associations located around the Gibe III reservoir area of which 49.9% were males and 50.1% were females. This population represents 10.8% of the Wereda population. However, as a result of steep slope and Tsetse fly infestation, there is no settlement in the future reservoir area and settlements are concentrated on the highland in areas outside the valley. Settlement around the project area is also fully rural, and the residents are organized into small villages. The average population density within the Peasant Associations located around the reservoir area is 127.8 persons/km².

More than 13 different ethnic groups live around the future reservoir area and the major ethnic groups are - Hadiya (25.3%), Wolayita (23.0%), Oromo (20.4%), Dawro (6.9%), Kembata (6.7%), Tembaro (5.0%), and less than one percent of Amhara, Keffa and Sodo Gurage, Silte and Sebatbet gurage. The rest of the ethnic groups constitute less than 3.3 in total.

Major religions practiced in the project Wereda are Christianity (67.7%) and Muslims (24.6%). Traditional religions are practiced by about 5.3% of the population.

Agriculture and livestock populations

The main areas of farming are confined to the middle or upper slopes of the hills where the settlements are situated. The farmers in the project area (mainly on the high land) produce small quantities of a wide range of crops (15-20 different crops), including cereals, roots, tubers, pulses, spices, coffee and fruits. Such use of the land is very sound, allowing the land to be converted with vegetation throughout most of the year, which helps to reduce the erosion effects of the heavy rain occurring in July and August.

As the result of the less favourable rainfall, Tsetse fly infestation and the consequent occurrence of cattle disease, trypanosomiasis, there is very little farming activity around the Omo valley bottom lands only near the dam site. The steepness of the slope on either side of the valley appears to be another important factor which has discouraged the use of the valley for agricultural purposes.
The main livestock populations in the project area are cattle, sheep, goats, poultry and equines. Few farmers own oxen, although this varies throughout the project area.

**Public Health**

The major health problems of the project area are reported to be infectious diseases and malnutrition. Most illnesses are communicable and are related, either directly or indirectly, to lack of adequate and safe drinking water supplies and sanitation, low living standards and poor nutrition. Waterborne and vector borne diseases are also prevalent in the area. The project areas are highly endemic for malaria with continuous transmission and malaria is by far the most important of the diseases. The presence of several rivers (tributaries to Omo River) provides ideal breeding habitats for mosquitoes. The health coverage in the affected Weredas ranges from 34.6% to 83.6% (that is the population living within 10km radius of a health station).

**Cultural, Religious, Historical and Archaeological Sites**

The importance of the Gibe III reservoir area and the immediate surrounding has been investigated in terms of religious and cultural site relics and archaeological importance. Based on this investigation the historical sites known as King Ijajo Kella and King Halala Walls were found on both sides of the Omo River. An additional archaeological impact assessment as well as the elongated stone ramparts in Wolayita and Dawro has been initiated with the Authority for the Research and Conservation of Cultural Heritage (ARCCH).

The UNESCO designated heritage site is not in close proximity to the proposed Gibe III dam and reservoir areas. The lower valley of the Omo River which is designated as a UNESCO World Heritage site is located far downstream and will not be affected by this scheme.

No visible archaeological remains, which have scientific, cultural, public, economic, ethnic and historic significances, have been observed in the area and dam sites. The sites have no archaeological importance. However, a Chance Find protocol has nevertheless been prepared to cover any unexpected finds.

**0.4.2 Baseline Information: Downstream Area**

**Population and Settlement**

The Lower Omo stretches over Salamago, Hamer, Nyangatom and Dasenech weredas and is well endowed with both cultural diversity and natural resources. The population within these four weredas of the lower Omo is estimated to be about 131,831 of which 50.3% were males and 49.7% were females in the year 2007. There are 28,713 households with an average of 4.6 people per household. Of the total population, an estimated 50% are economically active (age 14-64), 45% are youth (ages 0-14) and 2% are elders. The population is predominantly rural based with nearly 94.8% living in rural areas. The urban population is estimated to be only about 5.2%.

**Agriculture**

There are different farming systems in the Lower Omo, which are influenced by agro-climatic and socioeconomic constraint, and these include cereal-based mixed farming system and retreat flood cultivation. Rainfed agriculture: Rainfed crops are cultivated in three out of the four weredas where flood recession cropping is also important; Hamer, Salamago and Nyangatom, at higher altitudes towards the west and eastern margins of the Omo valley. Rainfall at lower altitudes (e.g. in Dasenech Wereda) is insufficient to support any rainfed cropping. Labour for hoe cultivation and weeding is the main input, and is generally said
to be in short supply due to the demand of livestock herding, low population levels and poor general health. Oxen are very rarely used, partly due to cultural objections and also because of losses to disease.

Flood recession agriculture: The Omo River rises during the rainy season and overflows its banks to flood the land on the plains bordering the river, permitting crops to be grown on the residual soil moisture after the floods recede. Further upstream where the valley slopes are too steep to allow large scale flooding, areas of recession crops are grown on the river banks, especially where silt has been deposited at bends in the river. Flood recession cropping is important in the four weredas: Hamer, Salamago, Nyangatom and Dasenech, from the Omo River. Flood recession cropping starts as the topography levels out around latitude 5.15°N, some 70km north of Lake Turkana, around Karakorocho in Hamer wereda. The fringes of the ox-bow Lake Dipa (Dipa Hayk) in the Kara area of Hamer Wereda are also planted as the lake level drops. Peak flooding normally occurs between August and September and the water recedes 2-4 weeks later to allow planting from August to October.

The Wereda officials reported that for most people, the grain produced from recession cultivation was only sufficient for 3-6 months. Thereafter, they depend on food aid from the government and NGOs. The food insecurity in the lower Omo River is associated with the natural factors and the socio-economic base of the population. Uneven distribution and erratic rainfall, floods, landslides, pest infestation, epidemic diseases of human and livestock are all considered natural factors. On the other hand small land holding (for flood recession) lack of drought oxen, less infrastructure and inadequate farm inputs are conceived under the second factor.

Irrigated Agriculture: Irrigation farms and schemes are found mainly in the lower reaches of the Omo River, because the banks of the river upstream are generally too high to permit efficient pumping. Most are small farms growing high value crops like vegetables and fruits, particularly bananas, using either diesel pumps or windmills to extract water from the river. Overall, the present level of irrigation development is really quite minimal and damage caused by annual flooding, low river levels in the dry season (too low for pumping), and limited market development are probably some of the reasons.

Livestock and Grazing Resources

The livestock population of the study area is estimated to be 1.2 million, poultry 71,880 and 132,500 bee colonies. Livestock provide the pastoralists of the Southern Omo Lowlands a number of benefits. The major ones that relate to their livelihood include milk, meat and live animals.

The major sources of feed for livestock in the Lower Omo area are natural pastures, aftermath grazing and crop residues. Natural pastures contributed greater proportion followed by crop residues. An important feature in all the four Weredas is that feed is also obtained because of the recession of the flood from the Omo River.

A wide range of livestock diseases affect animal in the Lower Omo. Existing veterinary services in the study area are limited and severely handicapped by lack of resources.

The Lower Omo River Basin is under-developed and remote. Access and other infrastructure (road, market, etc) are very poor. The types of livestock markets in the area are mainly bush markets, in some Weredas primary type of markets exist.
National Parks and other Protected Areas

The Omo, Mago, Mazie and Chabara Chorchora National Parks and Murele Controlled Hinting Area are found downstream of the Gibe III scheme. Of which, Omo and Mago NPs are gazetted. It is recommended to strengthen these parks as they all harbour at least some or all species of the animals and birds of the project area and these sites are eventually potential refuge for some of these animals in the project area. According to the information obtained from Park Wardens, reduction in the flood flow of the Omo downstream will have no effect on the wildanimals found in the Parks.

Tourism

Tourism in the South Omo Zone is limited and based in small groups interested essentially in natural resources (parks, natural reserves, animals, the Omo River) and ethnic attractions. In particular Mago and Omo National Parks are the main tourist destinations.

According to the information obtained from both Omo and Mago National Park officials, currently there is an effort to start community tourism by using boat transport from Lake Turkana via Omo gorge to the upstream National parks (Omo and Mago National Parks). Community tourism is expected to help encourage the tourist to visit the different ethnic groups along the Omo River.

0.4.3 Baseline Information: Gibe III-Sodo Transmission Line

**Natural Environment:** The observed land uses along the transmission line route include farmland, grazing land, eucalyptus plantation and settlements. It is also observed that a proportion of the land is unused, especially on the hillsides. Eucalyptus plantations are becoming common in many parts of the project area especially around the compounds.

Human intervention in the area, consisting of expansion for agriculture and grazing practices and encroachment for fuelwood and construction has significantly affected the vegetation cover in the area. Hence, it couldn’t provide a good habitat to support diverse wildlife species.

The transmission corridor is neither contiguous with, nor in close proximity with any of the nationally protected areas like National Parks, Wildlife Reserves or Controlled Hunting Areas.

**Settlement pattern and housing:** Settlement along the proposed Transmission Line (TL) is predominantly rural organized into small villages. The villages are clustered on hilltops and valley slopes. The people along the TL have traditional tukuls as dwelling unites and all dwelling units are one-room structures. The tukuls are built from local materials with wood plastered with mud and have thatched roofs build mostly out of grass.

**Agriculture:** The population and economy of the region traversed by the transmission line project is almost totally dependent upon agriculture and livestock. The farming system in the project area is well known for its complexity and variety of crops that are grown. High human population density, with extreme levels of land pressure and consequently small average farm size, characterized the area. The major crops cultivated in the area include, teff, wheat, barley and ginger. The major perennial crops produced in the three project affected weredas are coffee, enset, mango, avocado, gishta, koke and banana. Coffee, enset and banana are the dominant source of cash income contributors.
**Historical or archaeological significance:** Enquiries to residents along the transmission line route have indicated that there are no known sites of historical or archaeological significance in the vicinity of the selected route.

### 0.5 Project Alternatives

**General**

Five alternatives to the base-case described above have been considered and the implications of each are described in the sections which follow.

**Alternative I: “Do-nothing”**: With the “do-nothing” alternative, the potential social and socio-economic benefits to the nation would be foregone, and quality of life would remain at a low level for many of those who live in the country. Long-term development plans for the country would be compromised and slowed down, since a reliable power supply and the improved service associated with it are fundamental to achieving the full benefits of other development initiatives and meeting the Millennium Development Goal (MDG). Therefore, from an environmental viewpoint, the “do-nothing” alternative is not preferable to project implementation.

**Alternative II: Alternative dam types and layouts**: For the general layout of Gibe III hydropower project two main dam alternative solutions were studied: in a first phase, the BF (Bituminous Face) rockfill dam alternative was analysed as the most promising alternative, then the RCC GD (Roller Compacted Concrete Gravity Dam) alternative was developed and selected; the RCC scheme has been also analysed through three alternative layouts.

**Alternative III: Conservation and Demand Management**: Conservation and Demand Management free up existing energy to be used elsewhere, that postponing the need for new capacity. However, just to keep pace with the growing population, this electricity generating requirement will grow annually by between 200 and 300MW, so that over the next decade, the total electricity generating requirement of the ICS could be, at the very least, some 4,250MW. Although environmentally conservation and demand management are preferable options, the demand forecasts still call for a significant increase in generation capabilities to maintain economic growth and development.

**Alternative IV: Thermal Power**: The high costs of importing fossil fuels to land-locked Ethiopia preclude thermal power options that would depend on foreign fuels. Besides replacing capacity and energy, the use of hydropower also leads to a reduction of thermal plant emission (CO₂), which is the most important Green House Gas contributor. Therefore, from an environmental viewpoint, the thermal alternative is not preferable to hydropower project implementation.

**Alternative V: Renewable Energies (Wind and Solar)**: The prospects for grid-bound solar and wind power generation are not significantly attractive in Ethiopia. The specific generation cost for these systems are not competitive for contributions to the national grid. This is not to say that solar and wind power have no future. They may well be of interest for remote small load centres.

**Analysis/Evaluation of Alternatives**: The Gibe III Hydropower project will produce electric energy without burning fossil fuels and without stack emissions and potential reduction of pollution. Therefore, this scheme is feasible, indeed exceptionally attractive from the technical, economical and environmental viewpoints.
Therefore, implementation of such a worthwhile scheme, at the earliest possible date will bring net benefits to the nation in general and the local communities in particular.

0.6 Potential Impacts and Benefit Enhancement and Mitigation Measures

0.6.1 Beneficial/Positive Impacts

Key potentially beneficial impacts associated with implementation of the Gibe III Project are all related to the post-construction phase and are as follows:

Power Generation: The Gibe III scheme is designed to supply 1,870 MW of electrical power and 6,500 GWh of average energy per year to Ethiopia’s Interconnected system.

Rural Electrification: Under the Power Sector Development Programme, the government plans to increase electricity coverage from 22% in 2005 to 50% by 2010 and the number of customers from 138,000 to 2.6 million. Establishing new connection to the grid requires that there is an adequate supply of power. The increase in generating capacity provided by Gibe III, together with ongoing rural electrification programmes will facilitate improved access to electricity for the Ethiopian population with associated downstream, benefits.

Fishery Development: The project will create a reservoir of 20,000 ha in area and 240 meter deep at the dam site. This is a large artificial lake that provides different environmental and ecological niches for diverse fish species, requiring habitats with varying depth from shallow littoral zone to deep demersal and pelagic areas. The reservoir fishery is much more productive than the riverine fishery (which is not utilized at the moment). This may directly occupy more than 300 families on a long term basis. Thus, it could be taken as an opportunity in terms of developing a more productive and flourishing fishery that helps to improve source of income in the area and to obtain additional benefit for the local fishermen.

Prospects to Export Power: The project will increase the generation capacity of the country and will make the power export programme of the country viable.

Avoidance of CO2 Emission: Hydropower offsets thermal or other types of generation. Besides replacing capacity and energy, the use of hydropower also leads to a reduction of thermal plant emission (about 4.5 million t/y of CO2 emission).

Regulation of the River Flow for Irrigation: According to the expectations of the weredas’ officials, with the construction of the dam and creation of the reservoir the Omo River will come closer to the nearby settlements and the people will have the opportunity to use the river water for small scale irrigation development. The expansion of irrigation farms would increase crop production per unit area and contributes to higher income and increased food security to the community.

Flood Protection: The presence of Gibe III reservoir will provide flood protection (will reduce floods both in peak and in frequency) to downstream areas. As a result, the damage due to floods like loss of crops, dwellings and the suffering and possibly death of affected people will reduce. The measurements carried out at occurred in August 2006 indicated a peak flood flow in the range of about 3,500-4,000 m³/sec, being a quite frequent flood with a return period of less than 10 years. The 2006 floods have caused in the area hundreds people and thousand animals dead besides 15,000 displaced population, with an estimate of millions of US$ of works needed to rehabilitate Health, Education, Shelter, Water and Sanitation,
Agriculture, Livestock, Fishing, Roads, etc facilities washed away. With this regulation, areas prone to frequent flooding can be used for agricultural purposes.

Tourism Activities: The reservoir offers potential for eco-tourism, environmental education, etc. for bird watching and sport fishing.

Job opportunity during construction: Comparison with other projects of broadly similar type and magnitude, suggests that the total workforce on construction contract comprising the overall project is likely to be more than 5,000 persons at peak time. The production of more hydropower would allow the expansion of power-requiring industries and factories in the surrounding urban areas creating more permanent job opportunities for the displaced and other people in the area.

Gender Issues: Women as well as men will benefit equally from the employment opportunities that will be created and from convenient and safe access road facility. Women often run shops and bars in the area and obviously during the construction period, there will likely be more women engaged in income-generating activities, running restaurants and bars, or selling local products to construction camp workers. These activities will benefit mainly women who are very often the sole supporters of their families. It is also recommended for the contractor to use his best endeavors to maximise local hire of labour and give priority to women, in so far as this is compatible with his skill requirements, and to maximise local procurement of supplies.

0.6.2 Adverse Impacts and Mitigation Measures: Dam and Reservoir

On the basis of the findings of this ESIA the key environmental impacts during the construction and operation and maintenance phases of the project have been identified. The potential negative impacts of the proposed Gibe III Hydropower Project on the physical, biological and socio-economic environment have been identified and benefit enhancement and mitigation measures that should be adopted to avoid or minimise potential adverse impacts are recommended. Of which, some involve good engineering practices while others viewed from socio-economic as well as humanitarian angle.

There are no confirmed occurrences of geothermal activity in dam area and because of its distance from the major Ethiopia seismic centres, located in the rift valley, any tectonical event will have negligible effects on the project area.

Impacts on Protected Areas: No adverse direct or indirect impacts are anticipated in respect of sensitive habitat, National Parks, Wildlife Reserves, or National Forest Priority Areas. The reservoir area is neither contiguous with, nor in close proximity with any of these nationally protected areas like national parks nor wildlife sanctuaries reserves and designated ecologically sensitive areas. There is also no endangerment of endemic or rare species in the impounded areas.

Impacts on Natural Vegetation: The loss of woodland grassland on the hillslopes of the valley and narrow riparian vegetation along the river and streams would not bring about marked differences in the carrying capacity. However, to compensate this loss an estimated 60,000 ha of land around the reservoir will be developed as buffer area and it is expected to support the bio-diversity conservation by enhancing the biological value of the area.

Impacts on Wildlife Resources: The area harbours only limited number of wildlife species and does not rate well with areas in Lower Omo. Therefore, there will only be a minimum opportunity cost loss suffered by
the dam construction and creation of reservoir. During survey it was observed that on average the human settlement in the area is limited to an altitude of 1,300 m a.s.l. For the wildlife there are ample sites on both side of the river (up or down stream) as the maximum water level remains at around 900 m a.s.l. Therefore, most terrestrial animals can take refuge in the area between these two altitudes (900 and 1,100 m a.s.l).

**Impacts on Farmland and other Privately owned Assets:** The direct impact of the project in terms of loss of assets and property is summarized in Table 1 below. The project will affect a total of 355 households, about 188.94 hectares of privately owned land of which 138.7 ha is farmland, (excluding the TL) 47 residential housing units, and 71,852 perennial crops and other trees (see Table 0.1). The impacts of the Gibe III-Sodo transmission line include 192 households, 129 ha of farmland and 26,892 perennial crops and other trees.

<table>
<thead>
<tr>
<th>By Wereda</th>
<th>Households (No)</th>
<th>Private Land Affected (ha)</th>
<th>Residential (No) Houses</th>
<th>Perennial Crops and Trees (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Land</td>
<td>Farmland</td>
<td></td>
</tr>
<tr>
<td>Kindo Didaye</td>
<td>165</td>
<td>81.89</td>
<td>63.62</td>
<td>31</td>
</tr>
<tr>
<td>Kindo Koyisha</td>
<td>69</td>
<td>25.56</td>
<td>19.14</td>
<td>2</td>
</tr>
<tr>
<td>Loma</td>
<td>121</td>
<td>81.49</td>
<td>55.94</td>
<td>14</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>355</strong></td>
<td><strong>188.94</strong></td>
<td><strong>138.7</strong></td>
<td><strong>47</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>By Project Component</th>
<th>Households (No)</th>
<th>Private Land Affected (ha)</th>
<th>Residential (No) Houses</th>
<th>Perennial Crops and Trees (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Land</td>
<td>Farmland</td>
<td></td>
</tr>
<tr>
<td>Reservoir</td>
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<td>97.55</td>
<td>70.14</td>
<td>0</td>
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<tr>
<td>EEPCO Camp</td>
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<td>22.95</td>
<td>14.38</td>
<td>29</td>
</tr>
<tr>
<td>Chida - Sodo Road Realignment</td>
<td>250</td>
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<td>54.18</td>
<td>18</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>355</strong></td>
<td><strong>188.94</strong></td>
<td><strong>138.7</strong></td>
<td><strong>47</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gibe III-Sodo-Transmission Line</th>
<th>Households (No)</th>
<th>Private Land Affected (ha)</th>
<th>Residential (No) Houses</th>
<th>Perennial Crops and Trees (No)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Land</td>
<td>Farmland</td>
<td></td>
</tr>
<tr>
<td>Kindo Koyisha</td>
<td>105</td>
<td>-</td>
<td>70.79</td>
<td>105</td>
</tr>
<tr>
<td>Sodo Zuriya</td>
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<td>-</td>
<td>30.90</td>
<td>20</td>
</tr>
<tr>
<td>Damot Sore</td>
<td>67</td>
<td>-</td>
<td>27.52</td>
<td>67</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>192</strong></td>
<td><strong>-</strong></td>
<td><strong>129.21</strong></td>
<td><strong>192</strong></td>
</tr>
</tbody>
</table>

As we can see from the figures in Table 0.1, one of the most important points to note is that although the Gibe III project is one of the largest hydropower projects ever undertaken in the country, the impact from the reservoir in terms of population displacement is very small. This is because the impounded water will be confined within the gorge of the river far from large population settlement areas.

The census survey (for the reservoir, EEPCO camp and the realignment road) revealed that all PAPs would prefer to receive their compensation in the form of cash for loss of farm land, perennial crops and other trees and houses and other structures. Therefore, given their preferences cash compensation and employment within the project has been recommended.

Due to the acute shortage of resources especially land and the low income and poverty of the population, it is believed that the main benefits for PAPs will come from the income restoration and social development programmes. The recommended plan has two components: the income restoration and improvement component, which directly targets PAPs and a community or social development components for communities as well as PAPs to be implemented for project affected kebeles. The communities around the future reservoir area will also be affected directly as well as indirectly by the project including among others:

- increased human and livestock health hazards,
• loss of access to natural resources (firewood, grass, lumber, traditional beehives and various other forest products) due to submergence of forest and grassland resources,
• loss of hot springs and holy waters,
• loss of salty water pond and special soil bed used for cattle fattening, and
• partial flooding cultural sites

The possibilities of establishing the PAPs in individual small-scale business or in small-scale agro-industries enterprises have proved in other areas valuable alternatives to the agricultural production.

**Impacts on Tribal People:** There are no tribal people or ethnic minorities around the Gibe III dam and reservoir area whose traditional lifestyles could become compromised through the implementation of the proposed hydropower project. Therefore, no indigenous people development plan will be required.

**Impacts of Public Health:** The predicted annual drawdown levels of approximately 90 m should ensure that neither snails nor macrophytes would flourish in the new impoundments. Therefore, public health impacts from various disease vectors species are, at this point, not considered to be a major factor affecting the implementation of the project. However, to reduce the risk of contracting malaria and to contain malaria cases, it is recommended to implement measures to manage malaria and control vectors.

The other serious issue that should be given due attention is the social issue related to the influx of labour force during the construction period. Particularly the spread of sexually transmitted diseases especially HIV/AIDS could tremendously increase unless strong control measures are taken. At the construction site, a quality health services will be provided to the construction employee’s by establishing appropriate health facility. Awareness campaign on sexually transmitted diseases (STD/HIV/AIDS) and their prevention methods will be organized for the construction workers and local communities.

**Impacts on Social Service Facilities and Infrastructure:** The long stretch of Gibe III reservoir formation on the Gibe, Gojeb and Omo Rivers, will impact upon some social service facilities and infrastructures. These include submergence of Chida-Soda road section and the Bridge on the Omo River and several river crossings. It is planned to realign the road section downstream of the proposed dam site. It is also recommended to establish a boat service at the affected nine locations to provide service to transport people and their goods and livestock.

**Impacts on Historic Sites:** The historical sites known as King Ijajo Kella Walls will be partially affected by the reservoir. The sections that will be flooded are less than 2% of the total lengths and those sections are not unique in type and location and therefore, this impact is considered to be minor. As a compensation measures, EEPCO has financially assisted ARCCH to properly study, document and register these sites as parts of Ethiopian heritage and to promote and publicize this historic sites for both local and international tourists. The result of this study will also assist to prepare a management plan to protect, conserve and manage the remaining sites (more than 98% of the existing walls) from manmade and natural hazards. The project will also finance for the construction of access road to the nearest representative sites and with associated tourist services.

Although the UNESCO World Heritage Site is located in the Lower Omo Valley downstream of the Gibe III dam and reservoir site, it will not be affected by the construction and operation of the Gibe III scheme.
0.6.3 Impacts on Downstream Environment Lower Omo and Mitigation Measures

Impacts on Recession Agriculture and Grazing Resources: Under present ‘average’ flood condition, river banks are submerged annually along the lower Omo River and around the river mouth. The annual flooding of the land bordering the Omo River soaks the land for traditional recession cultivation and dry season grazing, replenishes lakes and swamps on the floodplain and favours fish breeding.

The downstream environmental assessment indicates that to satisfy the demand for traditional recession agriculture, dry season grazing and fishery resources, seasonally more water will be released and flooding will be created on the land bordering the Omo River. These controlled floods will allow maintaining the required environmental flows also during the drought years. The regulating capacity of the reservoir will also allow controlling the natural floods peak discharges with short durations (n.d.r. which caused the 2006 floodings).

Controlled Environmental Floods: The reservoir operation will regulate the flows in the Omo River downstream of the plant. In broad terms there will be an increase in the flows during the dry season and a reduction of the flows during the rainy season, when the water is retained to fill the reservoir, with a substantial decrease of peak flood flows. Further downstream, as unregulated flow enter the river system from tributaries, the effect of the regulation decreases.

The Gibe III hydropower plant is designed to allow the optimization of the reservoir operation and energy production during the operational life basing on the requirements both of the energy market and of the downstream environment.

The current assessment envisages controlled environmental floods within the following ranges of characteristics:

- Period: August / September
- Flows: about 1600 m³/sec at lake Turkana (1000 - 1300 m³/sec released from Gibe III)
- Duration: 10 days (with Q = 1600 m³/sec at Turkana)

The design flows will compare approximately with the monthly average inflows at Gibe III site (38 years sequence) of September (Q=1,057 m³/sec) and August (Q=1,520 m³/sec). This discharged volume will allow recreating a flood reasonably similar to a natural yearly “average” flood at Lower Omo with duration of about 1 week. The wide outlet structures (two middle outlets each Q_max=725 m³/sec, spillway with nine bays each Q_max=2065 m³/sec, ecological outlet Q_max=24 m³/sec) together with the large reservoir volumes (11,750 Mm³ live storage) and the installed capacity allow a particularly relevant flexibility of the plant operation.

Daily Flow Variation Acoustic Warning System:

The first section of the river downstream Gibe III dam will experience consistent fluctuation of water levels within the riverbed in the course of normal (24 hrs) hydroelectric operations. Although, due to local geomorphology, no permanent human settlement/activities are located in areas interested by the fluctuating water levels, this does not mean that humans, especially in the proximity of villages, may not approach the river for different usages or for crossing it.

To this aim, a long-term warning system constituted by sirens will be placed and operated in river sections located in the immediate proximity of nearest villages and around major river crossing to signal in advance...
occurrence of rising waters in a number of priority spots (provisionally estimated in 50-100 locations) along the Omo river first 200 km downstream Gibe III Dam.

The sirens will advice differently for Large Water Releases (Controlled Floodings) and Ordinary Discharges occurring daily as a result of Dam operations by mean of distinct warning signals to the understanding of which the residing population will be trained beforehand.

The Warning Units will be remotely trigged by the Dam Control Station, on a pre-organised time sequence according to the river water speed, possibly coupled with water level gauges systems reacting to rising water levels placed in the immediate proximity of warning units. Sonic Devices and water level gauges with ultrasonic sensors will be operated by solar panels.

*Riparian Release/Environmental Flow:* Although there is no regulation in Ethiopia defining required minimum flow in the rivers, a minimum flow would have to be maintained naturally to meet the ecological requirements of the Omo downstream.

From the ecological point of view, the minimum flow in the normal dry season is the most relevant having little contribution from the tributaries downstream. The recorded natural minimum mean monthly flows is in the month of March (about 25 m$^3$/s) and as a priority this value has been recommended as absolute minimum monthly average compensation flow which must be sustained the under whole operation of the scheme. This flow preserves the natural regime during the dry season. However, with plant operation because the flow will be regulated there will be the added environmental benefit of reducing the incidence of extreme low monthly average flows which have been experienced in the past. During reservoir filling, it is also recommended to release a compensation flow of about 25 m$^3$/s.

*Impacts on Fishery Resources:* Concerning impacts on aquatic environment, the creation of additional water bodies would have a positive effect by significantly increasing a fishery potential in the area.

A number of commercially important species are known to migrate from Lake Turkana into the Omo River for spawning. However, none of these migrants reach the middle or upper reaches of the system. Therefore, construction of the proposed Gibe III dam will not affect the populations of migrant fishes because their spawning sites are far downstream of the dam site. Endemic fish species of the lake will not be adversely affected by the project as their spawning and feeding grounds are located in connection to the Turkana lakeshore and the river delta areas. There are no fish species listed as threatened or endangered in any of the study reports of the River Omo basin fish fauna study that could be affected by the dam. However, the reduction in flood pulse may impact the spawning activities in the lower Omo. Therefore, it is planned to seasonally release more water to create flooding on the land bordering the Omo River. However, detailed monitoring is envisaged to determine the discharge mechanism and operational program (timing and volume of water discharge) and to ascertain how essential these floods are for the breeding success of fish species with commercial importance.

**0.6.4 Adverse Impacts and Mitigation Measures: Gibe III-Sodo Transmission Line**

The principal potential adverse impacts associated with implementation of the proposed project mostly relate to the land take requirement to accommodate the transmission line and the associate facilities. Many of the other potential impacts will be short-term and reversible in nature and stem from ground disturbance, operation of equipment’s and housing of the labour force, but very few that will lead to permanenet change.
However, no adverse direct or indirect impacts are anticipated in respect to protected areas (i.e. national parks, controlled hunting areas, protected forest areas, etc.), sensitive habitat, wildlife or cultural heritage sites and no new access will be created to previously undeveloped areas.

Realization of the proposed Gibe III-Sodo Transmission Line will have a varying degree of direct impact on productive farmlands belonging to the community in the affected woredas throughout the route line. Therefore, the transmission line project will affect a total of 192 households, about 129 hectares of privately owned farmalnd, 192 residential housing units, and 26,892 perennial crops and other trees.

Therefore, it is recommended to payment full and fair cash compensation, which leaves those, affected by relocation at least no worse off than they were previously.

0.6.5 Adverse Impacts and Mitigation Measures: Chida-Sodo Road Realignment

The principal potentially adverse impact is the land and property expropriation associated with this realignment. Many of the other potential impacts will be short-term and reversible in nature and stem from ground disturbance, operation of equipment’s and housing of the labour force, but very few that will lead to permanent change. However, no adverse direct or indirect impacts are anticipated in respect to protect areas (i.e. national parks, controlled hunting areas, protected forest areas, etc.), sensitive habitat, wildlife or cultural heritage sites and no new access will be created to previously undeveloped areas.

In relation to engineering design, due consideration has been given during the detailed design stage to reduce the need for land and property expropriation without significantly compromising the functionality of the road. However, even with these considerations, although this impact has substantially reduced, the issue of land and property expropriation will still have to be addressed.

Based on the assessment result, the Chida-Sodo road realignment project will affect a total of 250 households, about 54.18 ha of farmland, 18 residential housing units, and 13,581 perennial crops and other trees. Most houses, however, are small and of simple construction, comprising wooden frameworks with mud plaster. Therefore, it is recommended to pay full and fair cash compensation, which leaves those, affected by realignment at least no worse off than they were previously.

0.6.6 Cumulative Impact Assessment

The Gibe III hydropower project will be the third development of hydropower schemes (Gibe I, in operation and Gibe II under completion) on the main Gibe/Omo river. One other hydropower scheme-known as – Gibe IV is foreseen downstream on the Omo River. As part of this ESIA, a cumulative impact assessment was undertaken to analyse the combined impacts of these four projects. Their cumulative effects on the natural and social environment appear to be negligible due to their geographic location.

0.7 Environmental Management and Monitoring Program

0.7.1 Environmental Management

The Environmental management plan describes the range of environmental issues associated with the project and outlines corresponding management strategies that will be employed to mitigate potential adverse environmental effects.
Most of the project environmental management activities will be carried out during the construction phase, since this is when most impacts can be expected to arise. These impacts are principally associated with the construction of the Gibe III Dam, the tunnels, the power station, work camps, access road and the quarries development and spoil disposal areas, and the presence of large labour force. There are also impacts linked to the initial filling of the reservoir and subsequent operation of the plant.

The environmental management plan is comprised of a series of management plans. Each plan is under separate section by environmental components. Each management plan contains specific environmental mitigation and enhancement measures.

The plan identifies and recommends protection and mitigation measures addressing environmental impacts created by the construction activities. The recommended plans are listed below:

- Forest/natural vegetation management plan
- Wildlife Resources management and protection plan
- Cultural and Historical resources management plan
- Erosion and sediment control plan
- Spoil disposal and waste management plan
- Spill contingency and response plan
- Quarries development and restoration plan
- Water pollution control
- Air Quality
- Noise and vibration
- On-site traffic management plan
- Explosive storage and handling
- Construction camps and site installations

In general terms, the EPC contractor is responsible for implementing the majority of the day-to-day, construction related environmental mitigation measures specified in this report and measures specified in the contract. EEPCO will be fully responsible for implementing the mitigation measures related to downstream impacts, resettlement action plan and buffer area development plan. Upon completion of construction, EEPCO will also be responsible for implementing environmental management measures associated with operation of the plant and the Gibe III reservoir.

### 0.7.2 Environmental Monitoring

Environmental monitoring program has been recommended and will be performed during all stages of the project (construction, commissioning and operation) to ensure that impacts are no greater than predicted, and to verify the predictions. For this project, it is recommended to carryout both compliance and effects monitoring. The monitoring has to indicate where changes to construction procedures or operations are required, in order to reduce impacts on the environment or local population.

The principal fields of interest requiring monitoring include the following and will be the responsibility of EEPCO/EMU.

- Reservoir inflow and outflow,
- Reservoir sedimentation,
Air quality and noise,
Waste management
Water quality in the reservoir and downstream of the Power House,
Aquatic Ecology and Fish stock
Breeding area survey and prevalence of vectors in the reservoir,
Periodic inspection of the reservoir area for water weed proliferation,
Wildlife resources and their habitat
Public Health and safety
Resettlement compensation and livelihood improvement,
Implementation of watershed management program and buffer area development,
Cultural and historical assets, and
Construction site restoration.

0.7.3 Monitoring Framework

Effective monitoring of all stages of the project could be managed through an Environmental Management Team. The principal aim of the environmental management team would be advising the project authorities and local administration about the best practicable means for protecting the environment during all stages of the project’s life span. It would provide the project developers and station operation manager with concrete proposals for monitoring the environment, and indicate operational procedures for protecting the environment.

The primary responsibility of this monitoring plan is of EEPCO who is the project Developer. The Gibe III Environmental monitoring plan will be administered by the Environmental Monitoring Unit (EMU) to be established within EEPCO’s project coordination office. EMU will begin the implementation of the programme by forming a team of specialists to assist in monitoring the environmental effects during construction period. Furthermore, independent external environmental monitoring may also be considered by EPA for the activities that are not under the responsibility of the owner’s engineer.

In addition, there are other agencies that have the responsibility and authority to monitor some of the measures. It is also recommended that EEPCO involves other Agencies (including EPA) and subcontractors as required to form the environmental management team.

During the construction phase, the EPC contractor will designate an Environmental Inspector who will be responsible for environmental monitoring issues regarding the Gibe III project.

It is recommended to carryout a regular audit of environmental and social performance by an independent body.

0.8 Public Consultations and Disclosure Plan

As a continuous activity, the Gibe III hydropower project has initiated public consultations and disclosure from the outset and the project is committed to continue the process throughout the project life. A Public Consultation was initiated in 2006, 07 and 08 during the initial phase of the Gibe III- Hydroelectric project. As part of this continuous process, a series of public consultations were carried out with Federal, Regional, Zonal, Wereda and local officials and institutions, PAPs, community elders and NGOs, level. Consultations
were carefully planned and conducted to ensure efficiency and effectiveness in covering key issues both from the PAPs and communities on the one hand, and the project interests on the other.

A combination of various consultation methods were used to assess knowledge, perception and attitude of the communities about the proposed project and its potential impacts. The methods used include interview with key informants/people, small group discussion and public/community meetings.

The overall number of the consultative participants drawn from administrative and community level amounts to more than 1,749, consisting of 203 Zonal and Wereda officials, 409 kebele peasant associations council members, 869 community members were consulted through community discussions and 268 individual household heads were consulted privately.

Discussion and interviews conducted with local community and their leaders indicated that their attitude towards the proposed project is positive. They believe such project contributes to the attainment of local, regional and national development goals.

However, they also expressed their fears and concerns and these are briefly presented below:

**Major Findings of Consultation for the Dam and Reservoir Area**

- Loss of common grazing land along the banks of the River;
- Loss of incense trees, gum and other important trees found along the banks of the River;
- Loss of natural forest products such as mitimita, berbere, zinjible, Korerima, etc;
- Loss of forest honey production as the result of flooding;
- Loss of holly/hot springs along Omo River which are used by the local community and their cattle;
- Loss of crossing paths on the Omo River and disruptions to the social and economic relations among different communities living on both sides of the Omo river;
- Flooding of some parts of King Halala Wall and King Ijajo Walls;
- Spread of malaria to the nearby residents due to the creation of large water body;
- Spread of HIV/AIDS to the local people;
- Flooding of wildlife habituate may cause wildlife attack on humans and their cattles;
- Extra travelling time and cost as the result of shifting the existing Chida-Sodo road bridge to as far as down strema.

**Finding of Consultation on Cultural Resources**

- They expressed concern about the potential damage the flooding will cause to the Heritage sites of King Halala Wall and King Ijajo Walls. Requested for the establishment of these sites as heritage site.
- The local leaders requested ARCCH together with Information and Culture Bureau of SNNPR to carry out research on these walls.
- Full and urgent documentation works should be carried out on the sections to be flooded.
- As compensation to this loss they proposed EEPCO to implement a social development plan.

**Major Findings of Consultation with Agro-pastoralist Community**

- The livelihood of the people is based on agro-pastoralist farming system dominantly livestock rearing.
They move to different places along the Gibe, Gojeb and Omo River banks in search of grazing land. However, they are constantly in conflict over resources use with the indigenous people from these areas. They often attack, rob of their property and set on fire their temporary dwellings.

The community views the potential flooding of their crossings and the possibility of losing their traditional grazing resources on the other side of the rivers as greatly affecting their major sources of pasture land for their livestock.

They expressed the presence of strong trade, cultural, blood and marriage ties between communities on both sides of the river. The people of Hadiya zone particularly Soro Gibe and Gembor Wereda make a weekly market with the community of Dawro and Jimma zones and Konta and Yem Special Weredas.

As a mitigation measures, the agro-pastoralist community proposed to improve livestock keeping and range amelioration forage area development and construction of a bridge across the Gibe River.

**Major Findings of Consultation at Lower Omo**

- The Community stressed the importance of the Omo River for agricultural, livestock and fishery activities both for home consumption as well as for commercial and economic aspects.
- In the absence of the Omo flood, there will be a substantial decline in the production of crop from recession agriculture, dry season grazing resources and fishing.
- They proposed as mitigation measures to release artificial floodings to guarantee overflowing of the river and thus continuation of recession agriculture and presence of riverine green grazing lands.
- Public Disclosure

It should be emphasized from the out set that the Gibe III hydropower project involves a multitude of stakeholders ranging from PAPs to the project developer, Federal and regional governments through to financiers, NGOs, and environmentalists, etc. It is the responsibility of the project to provide all stakeholders at all levels to provide them with accurate and up-to-date information about its plans and operations.

Based on the nature and scale of the project, the following methods will be adopted as a public disclosure exercise:

- **National Consultative Workshop:** The project will organize a national consultative workshop to bring all key players together to express their views and concerns on the project and its impact and discuss the contents of the ESIA and contribute to its finalization.
- **Permanent Project Web Site:** The project will design, host and maintain a project web site throughout the life of the project. This electronic medium will serve as a permanent promotion, information and public relations forum for the project making it easier to reach out both national and international stakeholders and address their concerns in addition to equipping them with accurate and up-to-date information about the project its program.

**0.9 Environmental Mitigation, Management, Monitoring and Training Costs**

Costs for implementing the environmental Mitigation, environmental management and monitoring programmes and training and capacity development have been estimated and summarised in Table 02 and it amounts to some ETB 445.2 million or about 40.5 million USD. This estimate also includes the costs for Resettlement Action Plan and downstream mitigations measures.
Costs of certain items associated with environmental management and monitoring is an integral part of specific items incorporated in overall project construction budgets, and no separate budget is necessary to cover these aspects. Marginal costs of the contractor incurred in complying with environmental protection clauses in the construction contract are incorporated in unit rates and bill items and are included in construction costs. It should be noted that no significant increase in construction costs is expected in connection with requiring compliance with environmental protection clauses, since these merely require the EPC contractor and his sub-contractors to behave in a responsible manner in relation to the environmental, in accordance with good construction practice.

The cost of the environmental mitigation plan is considered as a component of the financial requirements of the project. Marginal benefits from the exploitation of the hydropower development should be set aside for financing the long term financial needs of the social and environmental needs of the area such as resettlement, agricultural extension, watershed management, development and management of buffer zones.

**Table 0.2: Summary of estimated environmental mitigation, monitoring and training costs**

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Estimated Cost (Birr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Environmental mitigation and management cost: Dam and Reservoir</td>
<td>21,500,000</td>
</tr>
<tr>
<td>2</td>
<td>Environmental mitigation and management cost: Downstream</td>
<td>245,050,000</td>
</tr>
<tr>
<td>3</td>
<td>Resettlement action plan</td>
<td>102,195,000</td>
</tr>
<tr>
<td>4</td>
<td>Environmental monitoring</td>
<td>6,550,000</td>
</tr>
<tr>
<td>5</td>
<td>Capacity building and procurement</td>
<td>5,200,000</td>
</tr>
<tr>
<td>6</td>
<td>Training and study tour</td>
<td>5,100,000</td>
</tr>
<tr>
<td>7</td>
<td>Environmental audit (annual audit by an independent entity for 5 years)</td>
<td>1,500,000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>387,095,000</strong></td>
</tr>
<tr>
<td>8</td>
<td>Administration cost (5%)</td>
<td>19,354,750</td>
</tr>
<tr>
<td>9</td>
<td>Contingency (10%)</td>
<td>38,709,500</td>
</tr>
<tr>
<td></td>
<td><strong>Grand Total</strong></td>
<td><strong>445,159,250</strong></td>
</tr>
</tbody>
</table>
0.10 Contacts

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1 INTRODUCTION

1.1 Purpose of the study

It is a universal thought that infrastructure development and environmental protection should go hand in hand. This is inline with the national policy that the development of Hydropower infrastructures as well as other development activities has to follow the principle of development without destruction and measures must be adopted to have a stress free environment.

Any environmental consequence has to be recognised early and taken into account in project design. By making project designers and implementing agencies attentive to environmental issues early, the Environmental and Social Impact Assessment (ESIA):

- enables them to take into account environmental issues;
- helps to avoid unnecessary environmental costs in implementation;
- provides a formal mechanism for inter-agency coordination to deal with the concerns of affected groups;
- can play a major role in building capability in the country for the solution of environmental problems.

The main purpose of ESIA can be stated as:

- to identify and forecast the possible positive and negative impacts to the environment resulting from the proposed project;
- to provide mitigation measures which upon implementation will reduce or offset the negative impacts of a project resulting in a minimal level of environmental degradation;
- to measure the level of plan implementation and the degree of effectiveness of the above environmental protection provisions.

1.2 Background

Ethiopia has an abundance of rivers that 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 the one per cent of the available total quantity 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 recognised the importance of low cost energy as an incentive to industrial and economic development. At the same time, the plan realised that export sales could provide an attractive long term development opportunity. Neighbouring 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 Gibe cascade project is one of the most attractive potential hydroelectric developments in the country. The hydroelectric plants required to develop the full potential of the Gibe Omo River are:

- GIBE I (Gilgel Gibe, in operation)
• GIBE II (under construction)
• GIBE III (under construction)
• GIBE IV (future proposal)

The Gilgel Gibe I hydroelectric power plant was inaugurated on 22nd February 2004. The project involved 307 experts from 32 countries, with a cost of about 256 million Euros. The World Bank Group (IDA) covered 68% of the total cost and the European Investment Bank (EIB) and Ethiopian Electric Power Corporation (EEPCO) financed the rest. EEPCO covering 16%. 12 companies, from Italy, Spain, Germany, Austria, Bosnia, France and Ethiopia were involved in the construction of this plant.

In November 2002 a preliminary idea to exploit the very large geodetical head (i.e. 505 m) existing between the Gilgel Gibe river and the Omo river by constructing a 26 km long tunnel, which makes use of the water regulated by the Gilgel Gibe I hydroelectric project, was developed by Salini Costruttori S.p.A. This idea gave life to a project that had been developed, completed and delivered to the Ethiopian Authorities and submitted to EEPCO, including all the clarifications, modifications and observations requested by the Employer. During 2004 the Gibe II hydroelectric project has been authorized, so permitting the start of the works in June 2004.

1.3 Impact assessment responsibility and Assessment Team

CESI, with the collaboration of MDI Consulting Engineers of Ethiopia, was charged with the responsibility of preparing the ESIA and to predict the likely environmental consequences of implementing project activities.

A team was assembled and given the responsibility for conducting the ESIA and preparing the draft and final reports. The team was comprised of the following members.

CESI

Mr. Stigliano G. Paolo (Geologist, ESIA Team Leader)
Mrs. De Bellis Caterina (Environmental Land Planning Engineer)
Mr. Vendrame Paolo (Geologist)

MDI Consulting Engineers

Mr. Dejene Woldemariam (Environmentalist, Local team Leader)
Mr. Bedilu Amare (Environmentalist)
Mr. Bezawork Wondimu (Senior Surveyor)
Mr. Demeke Hailu (Archaeologist)
Mr. Habtamu Denbebo (Socio-Economist)
Mr. Issayas Tadesse (Assistant Forester)
Mr. Leykun Zerihun (Agriculture Expert)
Mr. Mesfin Alemu (Livestock Expert)
Mr. Mignote Zecharias (Gender Specialist/Water Supply Engineer)
1.4 Complementary Initiatives and Associated Reports

This Environmental and Social Impact Assessment is accompanied by the following volumes of reports:

i) Environmental Impact Assessment: Additional Study on downstream Impacts

The Downstream Impacts associated with the construction and operation of Gibe III scheme are addressed in a separate report.

ii) Environmental and Social Management Plan

The Environmental and Social Management Plan (ESMP) is also presented in a separate report. The objective of the ESMP is to ensure effective implementation of mitigation, management and monitoring measures.

iii) Resettlement Action Plan: Gibe III Hydroelectric Project

The Resettlement Action Plan (RAP) is documented in a separate report. The RAP for the Gibe III Hydroelectric facilities (dam and reservoir, EEPCO permanent camp and the Chida-Sodo Road Realignment Project, etc), details about the resettlement and compensation commitments and the process by which resettlement and compensation will be implemented are presented in this report.

iv) Environmental and Social Impact Assessment: Gibe III-Sodo Transmission Line

A 65 km long 400 kV transmission line is to be constructed between Gibe III and Sodo substation. An ESIA has been carried out and the result presented in this report.

v) Resettlement Action Plan: Gibe III-Sodo Transmission Line

A 65 km long 400 kV transmission line is to be constructed between Gibe III and Sodo substation will affect privately owned properties and farmland. Therefore, EEPCO’s EMU has prepared a standalone RAP report.

vi) Environmental and Social Impact Assessment: Chida-Sodo Road Realignment

A section of the existing Chida-Sodo road and the bridge across the Omo River will be submerged by Gibe III reservoir. This is a Federal Road and a new alignment and a sight for a bridge across the Omo
(downstream of the dam has been selected) has been proposed. An ESIA has been carried out and the finding presented in this report.

vii) Public consultation and Disclosure Plan

Since the middle of 2006 as part of the ESIA study and preparation of ESMP and RAP several public consultation have been carried out with local, regional and Federal agencies, institutions, potentially affected people and communities, Non-Governmental Organisations (NGOs) etc. to obtain information and to seek views on the design, construction and operation of the hydroelectric facilities, including their potential impacts, and means and methods of mitigation. The concerns, priorities and opinions of the affected stakeholders related to Gibe III project were recorded in this report.

1.5 Report Structure

The report has been developed following African Development Bank and the World Bank guidelines for preparing environmental impact assessments (Operational Directive 4.01) and it is composed by different parts describing all the key elements considered in the present study as necessary to assess all the positive and negative effects generated from the realization of the Gibe III hydroelectric project.

In the following Chapter 2 the study introduces the policy, legal, and institutional Framework in force and actual territorial national policies and strategies, particularly referring to the environmental matters that are potentially involved by the development of the project.

Chapter 3 describes the proposed technical project and locational solution referring to the Basic and to the successive Level 1 Design, also dealing with Roller Compacted Concrete (RCC) dam alternative in comparison with a BF rockfill dam. It defines the main technological and dimensional features of the project describing all the components and actions planned. Work programme, access roads, camps and site installations and facilities are also described, besides the definition of potential pollution and waste dumping during construction activities, as well as the related mitigative technical actions to be adopted. An analysis of project and location alternatives has been also developed.

The Environmental Impact Assessment methodology applied in the present study in order to evaluate the temporary and permanent impact of a project on the natural and human environment is presented in the Chapter 4. A matrix that links project activities to the environmental components, considering the impacts (both positive and negative) generated by the project activities during all the different temporal phases of the project has been developed.

In the Chapter 5 the Physical, Biological and Socio-Economical Environment, including the attitudes of the local communities and authorities, are specifically described, in order to give a complete framework of the environment involved by the construction and operational stage of the new hydroelectric power plant, concerning both upstream and downstream environment.

Project benefits resulting from the realization of Gibe III hydroelectric project are exposed in the Chapter 6, where, besides the energetic positive consequences represented by power generation and the prospects to export power, also socio-economical benefits such as improvements in local access, job opportunities and related gender issues, internal navigation possibility have been presented. Concerning environmental positive effects, the avoidance of CO2 emission and the improvement of fishery resources have been exposed.
The key part of the assessment study is Chapter 7, in which all the potential negative effects generated by the project on Physical, Biological and Socio-Economical Environment have been considered in relation with the impacted area (upstream or downstream the new dam). Mitigation actions, representing the ways to reduce the impacts on a specified target, allowing to find out ways to guarantee basic health and safety requirements, are indicated.

Chapter 8 reports public consultations and participation briefings and meetings, carried out since the middle of 2006 to the issue of this report, which have taken place at the local, regional, and federal levels, in order to give to the people the possibility to full consultation and to the expression of their views in the planning and implementation of environmental policies and projects that affect them directly.

In order to understand the Environmental Impact Assessment of the project in relationship with other hydroelectric projects in Ethiopia, in Chapter 9 an environmental comparison has been performed between Gilgel Gibe III Hydroelectric power project and the hydroelectric projects considered in the Ethiopian Power System Expansion Master Plan (EPSEMP) signed in 1999 between the Ethiopian Electric Power Corporation (EEPCO) and BKS Acres.

In the Chapters 10 and 11 describes EMP (Environmental Management Plan) and EMP (Environmental Monitoring Plan) have been outlined referring to Gibe III hydroelectric project, particularly dealing with management and monitoring of the negative effects on human people.

Chapter 12 consists in the Environmental cost evaluation result, considering and quantifying all the eventual environmental costs that can descend from the realization of the project.

Conclusions and recommendations about Gibe III hydroelectric power project are summarized in the Chapter 13, while the Chapter 14 lists the references of the present ESIA study.
2 POLICY, LEGAL, AND INSTITUTIONAL FRAMEWORK

2.1 Institutional and administrative framework

The following paragraphs discuss the institutional and administrative framework at the Federal and Regional level and organisations responsible for the preparation of environmental policy and technical guidelines.

2.1.1 Federal Democratic Republic of Ethiopia

The Federal Democratic Republic of Ethiopia (FDRE) comprises the Federal State and nine Regional State members. The power and duties of the Federal, Regional and Local governments have been defined by Proclamations 33 of 1992 and 41 of 1993, and 4 of 1995. Under these proclamations, duties and responsibilities of Regional States include planning, directing and developing social and economic development programmes, as well as the protection of natural resources of their respective regions.

2.1.2 Regional Government

The Gibe III Hydropower Project lies in the Southern Nations and Nationalities Peoples Region (SNNPR) and Oromiya Regional States. The largest share of the reservoir area (more than 95%) is within SNNPR.

The SNNPR Regional Government is one of the regional states established by the Federal Government; the capital of SNNPR is Awasa and the region is divided into Zones and Weredas (Figure 2.1).

![Figure 2.1: The SNNPR Region, Zones and Weredas](image)

The basic administration unit is the Wereda and each Wereda is sub-divided into Kebele and peasant/farmers associations. Each administrative unit has their own local government elected by the people. Based on the
powers and responsibilities of the regional governments, the Regional Government has established Sectoral Bureaus, Commissions and Authorities.

2.1.3 Environmental Protection Authority

The Environmental Protection Authority (EPA) was re-established in October 2002, under Proclamation 295/2002, and is an autonomous government body reporting directly to the Prime Minister. It has a broad mandate covering environmental matters at federal level. The Proclamation sets out the main responsibilities and broad organisational structure of EPA and these may be summarised as follows:

- preparation of environmental protection policies and laws and to ensure that these are implemented;
- preparation of directives and implementation of systems necessary for the evaluation of the impact of projects on the environment;
- preparation of environmental protection standards and implementation of directives concerning soil, water and air;
- the conduct of studies on desertification and the co-ordination of efforts to combat it;
- to establish a system for ESIA of projects, policies, strategies, laws and programmes;
- to enforce implementation of this ESIA process (i.e. review ESIA reports) and the recommendations which result from it for projects that are subject to Federal licensing, execution or supervision;
- to enter any land, premises or any other places that falls under the Federal jurisdiction, inspect anything and take samples as deemed necessary with a view to ascertaining compliance with environmental protection requirements;
- to ensure implementation of environmental protection laws;
- preparation of recommendations regarding measures needed to protect the environment;
- enhancement of environmental awareness programmes;
- implementation of international treaties concerning the environment to which Ethiopia is a signatory;
- provision of advice and technical support to the regions on environmental matters.

With these powers, EPA has the mandate to involve itself with all environmental issues and projects that have a federal, inter-regional (involving more than one Region) and international scope.

In view of the multi-sectoral nature of the EPA and the number of government agencies involved in various aspects of environmental management, overall co-ordination and policy review and direction is the responsibility of an Environmental Protection Council (EPC) within EPA.

The responsibilities of the council shall include:

- to review proposed environmental policies, strategies and laws, and issue recommendations to the Government;
- based on report submitted to it by the Authority, evaluate and provide appropriate advise on the implementation of the environmental policy of Ethiopia; and
- review and approve directives, guidelines and environmental standards prepared by the Authority.
2.1.4 Ethiopian Electric Power Corporation

The responsibilities of Ethiopian Electric Power Corporation (EEPCo) cover the areas of power generation, transmission, distribution and sales. EEPCo is also concerned with carrying out the majority of technical development studies in the power sector.

2.1.5 EEPCo’s Environmental Monitoring Unit

EEPCo has established the Environmental Monitoring Unit (EMU) within the Corporate Planning Department to address environmental matters arising from its development programme.

The main responsibilities of the Unit include:

- Facilitating the integration of environmental concerns into electric power projects;
- Conduct or supervise environmental assessment for EEPCo;
- Ensure that mitigation measures, conditions and specifications are fully implemented during construction and resolving problems as encountered;
- Supervise restoration of construction area to its natural state that was affected during construction period of a project;
- Facilitate and ensures compensation payment for material damage in the implementation of power projects;
- Monitoring proper implementation during resettlement and post resettlement of communities;
- Submit ESIA and other environmental review documents to EPA for review and approval and make clarification upon request;
- Conduct and supervise community safety program around electric power lines, plants, etc., and monitor its implementation;
- Conducting periodic environmental monitoring during construction activities (dumping areas, health and safety, discharge of untreated water, dust pollution etc.);
- Advise on environmental and social issues for EEPCo;
- Represent EEPCo in water shade management with GO’s and NGO’s for hydropower projects and hydropower plants;
- Conduct and supervise buffer zone management in hydropower projects and plants. (Reforestation, soil conservation, wild life restoration, activities, etc.);
- Controlling Water Hyacinth, Proliferation of aquatic weeds, and conduct Water Quality Test, in hydropower projects and plants;
- Monitor reservoir forest clearing operation before impoundment.

2.2 National policies and strategies

The following sections discuss the national policies and sectoral strategy background regarding environmental protection and ESIA in Ethiopia.

2.2.1 The Constitution

The FDRE Constitution contains a number of articles that are relevant to environmental matters in connection with development projects, as well as to the environment in general. Article 43 gives the right to
people to improve living standards and to sustainable development. Article 92 of Chapter 10 (which sets out national policy principles and objectives), includes the following significant environmental objectives:

- Government shall endeavour to ensure that all Ethiopians live in a clean and healthy environment;
- the design and implementation of programmes and projects of development shall not damage or destroy the environment;
- people have the right to full consultation and to the expression of their views in the planning and implementation of environmental policies and projects that affect them directly;
- Government and citizens shall have the duty to protect the environment.

2.2.2 Conservation Strategy of Ethiopia

Since the early 1990s, the Federal Government has undertaken a number of initiatives to develop regional, national and sectoral strategies for environmental conservation and protection. Paramount amongst these was CSE, approved by the council of ministers, which provided a strategic framework for integrating environmental planning into new and existing policies, programs and projects. Although yet to be approved by the Federal Government, the CSE is an important strategy document which views environmental management from several perspectives. The CSE itself provides a comprehensive and rational approach to environmental management in a very broad sense, covering national and regional strategies, sectoral and cross-sectoral strategy, action plans and programmes, as well as providing the basis for development of appropriate institutional and legal frameworks for implementation.

The plan comprehensively presented the exiting situation within the country and gave a plan of priority actions on the short and medium term. In particular, it recognises the importance of incorporating environmental factors into development activities from the outset, so that planners may take into account environmental protection as an essential component of economic, social and cultural development.

Following CSE, the Oromiya and SNNP Regional Governments have prepared Conservation Strategy document for their respective Regions. This Regional conservation strategy documents give details about environmental issues prevalent in the territory, and outlining the ways in which environmental problems were to be addressed.

2.2.3 Environmental Policy of Ethiopia

The Environmental Policy of Ethiopia (EPE) was approved by the Council of Ministers in April 1997 (EPA/MEDAC 1997). It is based on the CSE which was developed through a consultative process over the period 1989-1995.

The policy has the broad aim of rectifying previous policy failures and deficiencies which, in the past, have led to serious environmental degradation. It is fully integrated and compatible with the overall long-term economic development strategy of the country, known as Agricultural Development-Led Industrialisation (ADLI), and other key national policies.

The EPE’s overall policy goal may be summarised in terms of the improvement and enhancement of the health and quality of life of all Ethiopians, and the promotion of sustainable social and economic development through the adoption of sound environmental management principles. Specific policy objectives and key guiding principles are set out clearly in the EPE, and expand on various aspects of the
overall goal. The policy contains sectoral and cross-sectoral policies and also has provisions required for the appropriate implementation of the policy itself.

The section of the EPE concerning ESIA sets out a number of policies, key elements of which may be summarised as follows:

- recognition of the need for ESIA to address social, socio-economic, political and cultural impacts, in addition to physical and biological impacts, and for public consultation to be integrated within ESIA procedures;
- incorporation of impact containment measures within the design process for both public and private sector development projects, and for mitigation measures and accident contingency plans to be incorporated within environmental impact statements (EISs);
- creation of a legal framework for the ESIA process, together with a suitable and co-ordinated institutional framework for the execution and approval of ESIAs and environmental audits;
- development of detailed technical sectoral guidelines for ESIA and environmental auditing;
- development of ESIA and environmental auditing capacity and capabilities within the Environmental Protection Authority, sectoral ministries and agencies, as well as in the regions.

The thorough and holistic approach taken to development of the policy and, in particular, recognition of the importance of addressing cross-sectoral environmental issues, has led to a national approach to environmental management, which is not only comprehensive, but also provides a sound and rational basis for addressing the environmental problems faced by the country now and those which are anticipated over the next decade.

Implementation of the EPE is still very much in its early stages, but a number of key elements either has been or are in the process of realisation. Some of these are referred to in the following sections.

### 2.2.4 Ethiopian Water Resources management Policy

The Ministry of Water Resources has formulated the Federal Water Resource Management Policy (WRMP) for a comprehensive and integrated water resource management. The overall goal of the policy is to enhance and promote all national efforts towards the efficient, equitable and optimum utilisation of the available water resources of the country for significant socio-economic development on sustainable basis. The specific objectives of the policy include:

- Promote the development of the water resources of the country for economic and social benefits of the people, on equitable and sustainable basis;
- Allocate and apportion the water, based on comprehensive and integrated plans and optimum allocation principles that incorporate efficiency of use, equity of access, and sustainability of resources;
- Manage and combat drought as well as other drought associated impacts, and disasters through efficient allocation, redistribution, transfer, storage and efficient use of water resources; and
- Conserve, protect and enhance water resources and the overall aquatic environment on sustainable basis.

The policy requires water resources schemes and projects to have “Environmental Impact Assessment and Evaluation”. 
2.2.5 Wildlife Policy

The wildlife policy covers a wide range of policies and strategies relating, amongst others, to wildlife conservation and protected areas. It is developed by the forms Ministry of Agriculture and Rural Development whose prime objective is the preservation, development and sustainable utilization of Ethiopia’s wildlife resources for social and economic development and for the integrity of the biosphere.

The newly approved Ethiopian Wildlife Policy and Strategy article 1 sub article 1.1 requires the need to manage, properly administer wildlife and habitat even outside protected area (FDRE, 2006). In Art. 1 sub article 1.3 the policy also suggest wildlife resource must be taken in to consideration when changing their habitat as a result of their activity.

Based on international criteria, the protected areas of Ethiopia have been divided into four categories, each having its own laws and regulations. The policy document presents the different Categories of Conservation Managements. The highest ranked are the National Parks, where strict legislation is applicable. These are followed by Game Reserves, Sanctuaries and finally, Controlled Hunting Areas.

The National Biodiversity Conservation and Research Policy approved in April, 1998 has put as an objective among others, to ensure that the genetic resources and essential ecosystems of the country are conserved, developed and sustainable used.

2.2.6 Forest Policy and Strategy

There is no forest policy statement in place at the federal level. However, draft forest development and conservation policy is currently under discussion in the Ministry of Agriculture and Rural Development and also at regional levels. They are expected to express the determination and commitment of the government to conserve and develop and rehabilitate the forest resources of the country and region.

The most recent legislation is the Proclamation on Conservation, Development and Utilization of Forests and it was issued in 1994 (Proclamation No. 94/1994) to provide for the Conservation, Development and Utilization of Forests. The objective of this Proclamation is to provide the basis for sustainable utilization of the country’s forest resources. The Proclamation categorizes types of forest ownership (State, Regional and Private Forests). And then goes on to give some specific direction for the utilization of State and Regional Forests, and lists prohibited activities within protected forests.

2.2.7 The National Policy on Women

This Policy was issued in March 1993 and stresses that all economic and social programs and activities should ensure equal access of men and women to the country’s resources and in the decision making process so that they can benefit equally from all activities carried out by the central and regional institutions.

2.2.8 Research and conservation of Ethiopian cultural heritage

Article 51/3 of the constitution of the FDRE declares the Federal government 'shall establish and implement national standards and basic policy criteria for public health, education, science, and technology as well as for the protection and preservation of cultural and historical heritage'.

Based on this, the Council of Ministers of FDRE endorsed the cultural policy of Ethiopia in October 1997 and issued the Research and Conservation of cultural Heritage proclamation NO.209/2000.
The proclamation No.209/2000/annex 1 has regulated Research and conservation of Ethiopian cultural heritage. It has also established the Authority for Research and Conservation of Cultural Heritage within the then Ministry of Information and Culture (now Ministry of Culture and Tourism).

Protection and conservation of cultural heritage from manmade and natural hazards is one of the goals of the Authority for Research and conservation of cultural heritage. Article 42 of the same proclamation states under “Reserved Area” that the Authority has the power of issuing building permission for any work to be carried out in an area declared reserve by the Council of Ministers. There is also an article states that the removal of any cultural ruins is to be carried out under strict supervision of the responsible authority, ARCCH.

2.3 Environmental Framework Legislation

The following three Proclamations have been issued by EPA and they represent a framework building on the policies and strategies set out in the CSE and the EPE, which sets out basic and general provisions for the regulation of environmental matters in a coherent and holistic manner, and will be supplemented in due course by more sector-specific legislation.

2.3.1 Proclamation on Institutional Arrangement for Environmental Protection

The Proclamation for the Establishment of Environmental Protection Organs, No. 295/2002, was issued to establish a system that fosters coordinated but differentiated responsibilities among environmental protection agencies at Federal and Regional Levels. The proclamation recognizes assigning responsibilities to separate organisations for environmental development and management activities on the one hand, and environmental protection, regulations and monitoring on the other is instrumental for the sustainable use of environmental resources, thereby avoiding possible conflicts of interests and duplication of efforts. A series of institutional mandates that would extend the powers and duties of the Environmental Protection Authority (EPA) and the Environmental Protection Council (EPC) beyond those defined in the enabling legislation, which established these bodies are also included. Powers and duties are also proposed in relation to Zonal, Wereda and Community Environmental Coordinating Committees, which will also be established.

2.3.2 Proclamation on Environmental Impact Assessment

The primary aim of the Proclamation on Environmental Impact Assessment (No. 299/2002) is to make ESIA mandatory for specified categories of activities undertaken either by the public or private sectors, and possibly, the extension of ESIA to policies, plans and programmes in addition to projects.

The provision of the proclamation include:

- Projects will be subject to ESIA and execution is subject to an environmental clearance from the EPA or Regional Government Environmental Agency, as applies;
- EPA or the Regional Agency, depending on the magnitude of expected impacts, may waive the requirement of an ESIA;
- All other licensing agencies shall, prior to issuing of a license, ensure that either EPA or the regional Environmental Agency has authorised implementation of project; and
- A licensing agency shall either suspend or cancel a license that has already been issued, in the case that EPA or the Regional environmental agency suspends or cancels the environmental authorisation.
Procedures that must be followed in the ESIA process are described in the proclamation:

“A Proponent shall ensure that an environmental impact assessment is conducted and an environmental impact study report prepared by experts that meet the requirements specified under a directive issued by the Authority.”

The Authority or Regional environmental agency shall, after evaluating an environmental impact study report by taking into account any public comment and expert opinions:

- approve the project without conditions and issue authorisation if it is convinced that the project may not cause negative impacts;
- approve the project and issue authorisation with conditions that must be fulfilled in order to reduce adverse impacts to insignificance; or
- refuse implementation of the project if the negative impact cannot be satisfactorily avoided by setting conditionality of implementation.

The Authority or the relevant Regional environmental agency shall audit the implementation of an authorised project in order to ensure compliance with all commitments made by, or obligations imposed on, the proponent during the approval of an environmental impact study report.

For the support of ESIA studies, existence of standards is a prerequisite. In the FDRE at the moment ambient quality objectives do not exist. However, now proclamation on Environmental Pollution Control and Environmental Impact Assessment are issued and other relevant legal documentation is in the process. When this Law is adopted and comes into force, it will become an invaluable legal tool for environmental planning, management and monitoring.

2.3.3 Proclamation on Environmental Pollution Control

The Proclamation on Environmental Pollution Control (No. 300/2002) is mainly based on the right of each citizen to a healthy environment, as well as on the obligation to protect the environment of the Country. The primary objective of the Proclamation on Environmental Pollution Control is to provide the basis from which the relevant ambient environmental standards applicable to Ethiopia can be developed, and to make the violation of these standards a punishable act. The Proclamation states that the “polluter pays” principle will be applied to all persons. Under this Proclamation, the EPA is given the mandate for the creation of the function of Environmental Inspectors. Article 7(1) of this proclamation gives the authority to ensure implementation and enforcement of environmental standards and related requirements to Inspectors (to be assigned by EPA or regional environmental agencies).

2.3.4 Environmental Protection Authority’s ESIA Guideline

In May 2000, as part of the ongoing effort to develop environmental legislation and guidelines in Ethiopia, the EPA released the final draft of its ESIA Guidelines document. This guideline follows the conventional pattern adopted in many other parts of the world.

The guideline requires all projects to be submitted to an Environmental Screening to enable a decision to be taken as to whether the project is to be submitted to full ESIA (in the case of projects which may have significant impacts) and are defined as falling under Schedule 1, or are of projects such a type or scale which does not justify full ESIA, and therefore fall into Schedule 2. Schedule 3 projects are the ones who have no
impact on the environment and do not require ESIA. The proposed Gilgel Gibe II hydropower project is a
category 1 and requires full ESIA.

According to the Guideline, approval of an Environmental Impact Statement (EIS) is conditional and it is on
compliance with environmental quality criteria, or other provisions stated in the EIS, and the approving
authority may conduct audit and surveillance to ensure compliance during and after project implementation.

2.4 Legal framework for expropriation and compensation

2.4.1 Land Tenure

Land in Ethiopia is state owned by proclamation 31/1975 issued to deal with Government ownership of rural
land and proclamation 47/1975 issued to cover Government ownership of urban land. Under Article 3(1) of
the first proclamation, all rural land shall be the collective property of the Ethiopian people.

In December 1994 the new constitution was approved. It retains land under the control of the people and
Government of Ethiopia. Article 40 states that ownership of both urban and rural land is vested in the State
and the people, and is common property which is not subject to sale or other means of exchange. Peasants
have the right to obtain land without payment, and are protected against eviction from land in their
possession.

2.4.2 Expropriation

The 1960 Civil Code of Ethiopia contains relevant provisions regarding expropriation of property for public
purposes (Arts.1444-1488). Under this code the owner may be compelled to surrender the ownership of land
for public purpose.

According to the constitution of the FDRE, full right to immovable property and permanent improvements to
land is vested in individuals who have built the property or made the improvements, but government may
expropriate such property for public purposes, subject to the payment in advance of compensation
commensurate to the value of the property or alternative means of compensation, including relocation with
adequate State assistance.

2.4.3 Compensation

With regards to compensation, Article 7(2) of proclamation 4/1975 states that the government shall pay fair
compensation for property found on the land but that the amount of compensation shall not take the value of
the land into account because land continues to be state owned.

As discussed in Section 1.2.1, the Constitution lays down the basis for the property to be compensated in
case of expropriation as a result of State programs or projects in both rural and urban areas. Art. 44.2 clearly
states that “ All persons who have been affected or whose livelihoods have been adversely affected as a
result of state programs have the right to a commensurate monetary or alternative means of compensation,
including relocation with adequate state assistance.” Thus, persons who have lost their land as a result of
acquisition of such land for the purpose of constructing dam and creating reservoir are entitled to be
compensated to a similar land plus the related costs arising from relocation; assets such as buildings, crops or
fruit trees that are part of the land etc.
Hence, project plans must include an “attractive” and sustainable resettlement strategy, offering adequate compensation and incentives to the loss of livelihood.

2.4.4 Multilateral agreement

The Federal Democratic Republic of Ethiopia has ratified several international conventions and protocols and these include:

- Vienna Convention on Ozone Layer Protection (1990);
- Montreal Protocol for Substances Depleting the Ozone Layer (1990);
- Convention on Biodiversity (Rio convention) (1997);
- Framework Convention of United Nations on Climate Change (1997);
- African Convention on the Conservation of Nature and Natural Resources
- Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar)
- Convention to Combat Desertification (CCD)
- Convention concerning the Protection of World Cultural and Natural Heritage.
3 PROJECT DESCRIPTION

3.1 Project location

The Gibe III project area, as shown in the figure here below, is some 400 km South West of Addis Ababa and 50 km East-South-East of Awasa.

The project is located within the jurisdiction of the Mareka Gana Wereda of the Dawro Zone and Kindo Koyisha Wereda of Sodo zone of the Southern Nations and Nationalities People Regional State (SNNPRS)
The Gibe III hydropower plant is the third plant of the Gibe cascade developing the hydroelectric potential of the Gibe-Omo river including:

- Gilgel Gibe or Gibe I operating since 2004
- Gibe II currently under completion
- Gibe IV and Gibe V projects, for hydropower and agricultural uses, currently being planned

The figure below shows the location of Gibe III (coordinates 312,200 E, 757 200 N, dam axis) and of the other plants of the Cascade within the Omo river basin.

Figure 3.2: Gibe cascade location
3.2 General layout

The Gibe III hydropower plant includes the following main structures:

- a Roller Compacted Concrete gravity dam with spillway and middle outlets
- three hydraulic tunnels and two cofferdams for the river diversion
- two hydraulic tunnels, penstocks and surge shafts for the power waterways
- an outdoor Power House, equipped with No. 10 Francis turbines, and a switchyard
- access roads

The table below summarizes the main characteristics of the project (ref. Level 1 Design, 2008) illustrated in the following paragraphs.

**HYDROLOGY**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catchment area</td>
<td>34150 km²</td>
</tr>
<tr>
<td>Average annual runoff</td>
<td>438.2 m³/sec</td>
</tr>
<tr>
<td>(Mm³/year)</td>
<td>13820</td>
</tr>
<tr>
<td>10,000 years return peak flood</td>
<td>10600 m³/sec</td>
</tr>
<tr>
<td>Probable maximum flood</td>
<td>18660 m³/sec</td>
</tr>
<tr>
<td>Mean annual sediment yield</td>
<td>18.3 Mm³/year</td>
</tr>
</tbody>
</table>

**RESERVOIR**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme flood level (PMF level)</td>
<td>892.5 m a.s.l.</td>
</tr>
<tr>
<td>Max/Normal O.L. (max. ret. level)</td>
<td>892 m a.s.l.</td>
</tr>
<tr>
<td>Minimum O.L.</td>
<td>800 m a.s.l.</td>
</tr>
<tr>
<td>Total storage</td>
<td>14700 Mm³</td>
</tr>
<tr>
<td>Live storage (max. regulated capacity)</td>
<td>11750 Mm³</td>
</tr>
<tr>
<td>Surface area at max o.l.</td>
<td>211 km²</td>
</tr>
</tbody>
</table>

**RCC DAM**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crest el.</td>
<td>896 m a.s.l.</td>
</tr>
<tr>
<td>Crest length</td>
<td>610 m</td>
</tr>
<tr>
<td>Max. height above river bed</td>
<td>223 m</td>
</tr>
<tr>
<td>Max. height above foundations</td>
<td>243 m</td>
</tr>
<tr>
<td>Basic triangle opening</td>
<td>0.75</td>
</tr>
</tbody>
</table>

**RIVER DIVERSION**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversion tunnels (No, D)</td>
<td>3, 7/13.5</td>
</tr>
<tr>
<td>Cofferdam crest el.</td>
<td>720 m a.s.l.</td>
</tr>
<tr>
<td>Design flood</td>
<td>5200 m³/sec</td>
</tr>
</tbody>
</table>
SPILLWAY

Type: gated (overflow)
Sill: (m a.s.l.) 873
Sill length: (m) 108
Radial Gates (No, W x H): (#, m) 9, 12x19
Design flood / Safety check flood: (m³/sec) 10600 / 18660

MIDDLE OUTLETS

Type, Number: conduit in dam body, 2
Max. discharge: (m³/sec) 800
Gates (No, W x H): (#, m) 2+2, 4x5.8

ECOLOGICAL DISCHARGE

Type: conduit from the power waterways
Rated Discharge: (m³/sec) 25
Gates type, number: butterfly, No. 2

TEMPORARY ECOLOGICAL DISCHARGE

Type: conduit in diversion tunnel plug
Rated Discharge: (m³/sec) 35
Gates type, number: butterfly, No. 2

POWER WATERWAYS

Tunnels (No, D): (#, m) 2, 11
Penstocks (No, D): (#, m) 2, 7.5
Surge shaft (No, D, Top el., H): (#, m a.s.l., m) 2, 20, 915, 140

POWER HOUSE

Type: outdoor
Dimensions (W x L x H): (m) 250 x 46 x 55

EM EQUIPMENT

Turbines (No, IP): (MW) 10,187
Generators (No., phases, output): (#, #, MVA) 10, 3, 220
POWER GENERATION

Plant Load Factor (No, h/day, h/yy)  0.46, 11, 4010
Max. Net Head (m)  211
Average Net head (m)  189
Design flow (m³/sec)  950
Installed power (MW)  1870
Average energy production (GWh/year)  6500
Firm energy production (95 %) (GWh/year)  5400

3.3 Alternative layouts analysis

The final layout of the project has been selected basing on the analysis of various alternative solutions.

The investigations and the design of several layouts have been carried out during the first project phases (Preliminary, Basic, Level 1 design) to assess the comparison among the most promising alternatives.

The construction period has been one of the most relevant parameters for the selection of the layout.

The main characteristics of the reservoir (i.e. dam elevations) and the installed power of the plant have been assessed by means of a cost-benefit analysis and basing on the preliminary environmental studies.

Since the majority of the materials for the dam construction (rockfill, aggregates, and natural pozzolans) were found on site the analyzed dam types did not show substantial differences for environmental impacts.

In the preliminary phase the design of an arch-gravity structure has been prepared. This layout, while being technically feasible, has not been maintained because of the risk of delays related to the required investigations and foundation treatments in the right abutment.

Similarly the classical earth rock dam has been found feasible but time constraints due to the zoning of the embankment (in particular impervious core and filters) could not guarantee the respect of the construction schedule.

Eventually the two most promising alternatives have been investigated and designed in detail during the Basic and Level 1 design phases:

- Bituminous Facing Rockfill Dam (BFRD)
- Roller Compacted Concrete gravity dam (RCC)

The majority of the very high dams constructed in the recent years are either rockfill dams (homogeneous and permeable embankment) or RCC gravity dams.

The detailed analysis of the BFRD layout showed that:

- the rockfill embankment is feasible using materials available on site (basalts, trachyte, alluvium);
- some risks of delays due to exceptional floods during construction or reservoir drawdown after the first impounding cannot be avoided.

Eventually the RCC dam alternative has been selected having the following key positive aspects:

- the gravity structure is extremely safe where an exceptional flood occurs during construction and in all potential extreme conditions as earthquakes, terrorism, etc.;
results of the investigations showed that materials (aggregates and natural pozzolans) and foundations are suitable for the dam construction;
the energy production is slightly increased from BFRD because of the better regulation of the inflows obtained through the spillway controlled by radial gates;
the construction program can be shortened since no drawdown can be required after the end of the first impounding.

Therefore this RCC scheme has been developed considering three possible solutions for the appurtenance structures (spillway, power waterways, Power House, outlet works):

- Alt. 1 Power House at the dam downstream toe
- Alt. 2 Spillway on the right abutment
- Alt. 3: Power House of the river bank

The “Alt 3 - Power House on the river bank” has been selected as illustrated in the following paragraphs.

3.4 Reservoir

The Gibe III reservoir extends for about 160 kms over the narrow and deep Omo river gorge from elevation 670 to 892 m a.s.l.

Starting from the Gibe III site the reservoir ends about 15 km downstream of Gibe II Power House, having a main direction South-North.

The downstream reach of the Gojeb river is also comprised in the reservoir for about 15 km.

The large live capacity, about 11750 Mm$^3$, is in the range of the average annual runoffs, about 13800 Mm$^3$, allowing therefore the regulation of the runoffs for:

- Continues energy production (firm energy = 5400 GWh / year, guaranteed at 95 %)
- Downstream floods control
- Downstream releases in the dry years

This large capacity allows flexibility to the plant operation adapting the operating rules, during the operation life of the plant, to the possible variation in the requirements both of the energy market and of the downstream environment.

3.5 Access Roads

The most important town in the project area, Sodo, is connected to Addis Ababa by a federal road approximately 300 Km long crossing Mojo and Sashemene villages.

Starting from Sodo two statal roads unravel, the Chida Sodo Road, passing through Bele and Lala villages, and the Sodo-Kindo Halala-Gerera road.

Direct access roads to the dam and Power House site are envisaged by means of two new roads on the Right bank and one the Left bank of the Omo River (see Figure 3.3).

Road R1, having total length of about 27 km, starts from the Chida-Sodo Road near the village of Bele, reaches the SP_1 temporary camp on the plateau, then goes down to the dam site at river level and goes up to the right plateau. This road will be opened for construction purposes only.
Part of the Chida-Sodo road from Bele town to Lala area will be relocated since the existing bridge on the Chida Sodo road, crossing the river Omo at a low level, will be submerged by the reservoir. The foreseen “relocation road” will be opened for construction purposes and will therefore become available for public use while completing the impounding of the reservoir (see Figure 3.3).

![Access road to the dam site](image)

**Figure 3.3: Access road to the dam site**

This permanent link will therefore include:

- a 24.5 km road on the right bank starting at a small village called Yello nearby Lala;
- the foreseen Omo bridge which crosses the river slightly d/s of the dam;
- a 54.8 km road on the left bank ending about 4 km west of Bele.

### 3.6 River Diversion

#### 3.6.1 Layout

The diversion scheme is designed to divert floods up to about 5,200 m$^3$/s (30 years return period) during the construction period of the dam and the Power House.

The Omo river will be detoured into three hydraulic tunnels along the right abutment by means of two cofferdams on the river bed.

The river diversion will be achieved in two stages:

- stage 1: river closure – dry season diversion
- stage 2: river diversion

The river closure will divert the flows from the dam site area, during the cofferdams construction period, by means of the pre-cofferdams on the Omo River and the TL diversion tunnel.
This scheme (stage 1) will be operating during the dry season while the diversion works are completed. At the beginning of the wet season the complete river diversion will be achieved by means of the main cofferdams on the Omo river and the three diversion tunnels. The water levels on the diversion tunnels and at the cofferdam are illustrated in the following graph.

![Figure 3.4: Tunnels rating curve](image)

**3.6.2 Diversion tunnels**

The three quite parallel diversion tunnels are located on the right abutment of the dam. The inlets are located in the Tsida valley, about 350 m from the Omo river junction. The Omo river flows will be therefore detoured on the inlet canal along the Tsida river bed. The inlet canal basically includes the natural Tsida estuary for about 300 m and an excavated canal, broadening the natural valley, about 200 m long. The excavation carried out, varying the width in the range of 20-30 m, improves the feeding conditions of the three tunnels. The tunnel inlets are envisaged with a bell-mouth entrance in order to guide the flow until it is contracted to the dimensions of the tunnel.
Stoplogs are foreseen for the temporary closures of the tunnels allowing the bottom outlet works achievement.

The tunnels, running below the right abutment of the dam, have the geometrical characteristics indicated in the following table:

<table>
<thead>
<tr>
<th>Tunnel</th>
<th>Cross-section</th>
<th>Inlet – outlet invert level [m a.s.l.]</th>
<th>Section S [m²]</th>
<th>Length [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR</td>
<td>Horse shoe D1/D2=14/13 m</td>
<td>680 - 674</td>
<td>150.4</td>
<td>1'209</td>
</tr>
<tr>
<td>TC</td>
<td>Horse shoe D1/D2=14/13 m</td>
<td>680 - 674</td>
<td>150.4</td>
<td>1'029</td>
</tr>
<tr>
<td>TL</td>
<td>Circular D=7 m</td>
<td>687 - 681</td>
<td>38.5</td>
<td>968</td>
</tr>
</tbody>
</table>

The flows will be returned to the Omo river downstream of the Power House site with each tunnel separately discharging into the river bed through a relevant canal.

### 3.6.3 Cofferdams

The diversion works include the construction of two cofferdams (in two stages) on the Omo river bed:

- main pre-cofferdam (upstream) 696 m a.s.l. crest elevation stage 1
- main cofferdam 720 m a.s.l. stage 2
- secondary pre-cofferdam (downstream) 680 m a.s.l. stage 1
- secondary cofferdam 691 m a.s.l. stage 2

The two pre-cofferdams (stage 1) will be constructed at the beginning of the dry season.

These are zoned earth-rock embankment with basalts and trachytes used for the main body. The impervious layer is constructed using the silty sands (SM) from quarry 8 integrated with 15% of high plasticity clay (CH).

The main cofferdams (stage 2) will be constructed after the river closure.

The cutoff will be built in order to reduce the seepages in the alluvium.

Therefore the embankment construction will be carried out using the materials from the basalts, trachyte and alluvium quarries.

The impervious layer of the main cofferdam will be carried out fixing a geo-composite membrane to the cutoff and therefore raising this membrane with geotextile protections at “zig-zag” on the embankment compacted layers.

The crest and the downstream face will be constructed using selected basalt more resistant to any minor overtopping.

This main cofferdam will reach elevation 720 m a.s.l required for diverting floods with a return period of 30 years using the three diversion tunnels.
The downstream cofferdam, raised at el. 691 m a.s.l., will protect the dam foundations area from the backwater flows.

3.7 Dam

3.7.1 General

The dam is a classical gravity structure to be constructed using the technology of RCC (rolled compacted concrete).

The dam comprises a central overflow block, including the spillway structure, and two lateral emerging blocks.

The design of the transversal sections is based on the classical basic triangle with vertex at el 893 m a.s.l. and a total opening of 0.75 (u/s slope = 0.10, d/s slope = 0.65).

The large spillway, designed for $Q= 10,600 \, m^3/sec$ (10,000 yrs return period flood) includes:

- an overflow crest controlled by # 9 radial gates (12x19 m each)
- the chute on the d/s slope, divided into three independent canals, with $H = 103 \, m$ (largely lower than the $H= 140 \, m$ max. suggested by the ER)
- a deflector bucket (ski jump) energy dissipating device (lip el = 790 m a.s.l., lip angle = 20°)

Two middle outlets are foreseen through conduits embedded in the lateral blocks with the intake at el. 755. m a.s.l. and capable of discharging up to 800 $m^3/sec$ each.

The grouting screen will be carried out from the dam u/s toe, on a vertical plane, reaching a maximum length of about 80 m below the dam foundations.

The screen will be carried out in subsequent phases (from the primary injections with about 8 m distance up to the quaternary, where necessary, with an interval of 1 or 2 m) applying the Grouting Intensity Number (GIN) methodology.

A large drainage system is envisaged to control the seepages both in the dam foundations and within the dam body, comprising:

- the u/s screen in the foundations ($D=102 \, mm$, @1.5m, $H = 20m$) behind the grouting curtain, to control seepages from the reservoir
- the d/s screen in the foundations ($D=102 \, mm$, @1.5m, $H = 20m$) to control the backwater seepages from the Power House
- the transversal screens in the foundations, controlling seepages from the abutments
- the drainage curtain in the dam body ($D=250 \, mm$ @3m) behind the enriched RCC layer, will control the seepages between the lifts within the dam body

Five longitudinal inspection galleries are located at various elevations, together with the transversal ones. These galleries will collect and remove the seepages controlling the uplift pressures and allow the installation of the internal monitoring instrumentation.
3.7.2 Dam zoning

The dam structure is currently foreseen with No. 5 RCC and No. 2 concrete types with different requirements of strength, with RCC mixes having a characteristic strength (cylindrical samples) at 360 days up to 15 Mpa.

The dam facing will foresee a typical Grout Enriched RCC layer with a thickness varying from 0.6 to 2.0 m, which guarantees the impermeability of the structure.

The spillway crest and chute will require a conventional concrete layer with special finishing for high velocity flows. Structural reinforced concrete will be used for the piers and the bridge.

3.8 Spillway

3.8.1 General

The large spillway structure is located on the central block and includes:

- an overflow crest (sill el. 873 m a.s.l., L = 108 m) divided into nine bays controlled by radial gates 12x19 m each
- the chute on the d/s slope divided into three canals through the converging walls
- a deflector bucket energy dissipating device (R = 35 m, bottom el = 788 m a.s.l., lip el = 790 m a.s.l., lip angle = 20°)
- the scour pool on the river bed

The spillway is designed to discharge the following flows:

- the design flood Q = 10,600 m³/sec (10.000 yrs return period)
- the exceptional flood Q = 18,600 m³/sec (Probable Maximum Flood)

While discharging the PMF the reservoir level will reach el 893 m a.s.l., still leaving a large 3m freeboard below the dam crest at el. 896 m a.s.l.

The spillway is subdivided in three sections (L = 41 near the crest, L = 33 m near the bucket) that can be operated separately allowing therefore a flexibility both for operation and for inspection and maintenance.

Each section has three radial gates 12 m wide and 19 m high (with stoplogs and gantry crane) with the relevant piers with the front shaped in order to limit the flow contraction and optimize the hydraulic efficiency of the spillway.

The spillway structure ends with a flip bucket designed for:

- partly dissipating the energy in air
- impacting the river bed (“scour pool”) between the d/s toe of the dam and the Power House

3.8.2 Hydraulics

The spillway rating curve obtained from the hydraulic studies is given in the following figure:
Figure 3.5: Spillway rating curve (gates fully open)

The main hydraulics features of the stream associated to the relevant discharges are given in the following Table with the figure below illustrating the water profile on the chute for the PMF (approx. 18500 m³/s).
### Table 3.2: Spillway chute hydraulic analysis

<table>
<thead>
<tr>
<th>CHUTE</th>
<th>Q [m$^3$/s]</th>
<th>$E_{in}$ [m a.s.l.]</th>
<th>H_w [m]</th>
<th>$h_{max}$ [m]</th>
<th>$h_{Mix,max}$ [m]</th>
<th>V_max [m/s]</th>
<th>V$\text{take}_{off}$ [m/s]</th>
<th>$\sigma_{min}$ [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>900</td>
<td>875.5</td>
<td>2.5</td>
<td>0.4</td>
<td>0.6</td>
<td>27.9</td>
<td>23.5</td>
<td>0.26</td>
</tr>
<tr>
<td>mean</td>
<td>1,500</td>
<td>877.0</td>
<td>4.0</td>
<td>0.5</td>
<td>0.9</td>
<td>31.6</td>
<td>29.0</td>
<td>0.21</td>
</tr>
<tr>
<td>5 yr</td>
<td>3,400</td>
<td>880.0</td>
<td>7.0</td>
<td>1.0</td>
<td>1.6</td>
<td>36.0</td>
<td>34.7</td>
<td>0.17</td>
</tr>
<tr>
<td>100 yr</td>
<td>6,500</td>
<td>883.5</td>
<td>10.5</td>
<td>1.8</td>
<td>2.6</td>
<td>38.3</td>
<td>37.5</td>
<td>0.16</td>
</tr>
<tr>
<td>10000 yr</td>
<td>10,600</td>
<td>887.5</td>
<td>14.5</td>
<td>2.7</td>
<td>3.7</td>
<td>39.7</td>
<td>39.1</td>
<td>0.16</td>
</tr>
<tr>
<td>PMF</td>
<td>18,500</td>
<td>893.0</td>
<td>20.0</td>
<td>4.7</td>
<td>5.9</td>
<td>40.9</td>
<td>40.4</td>
<td>0.16</td>
</tr>
</tbody>
</table>

![Figure 3.6: Water profile and velocity on the chute with the PMF](image)

#### 3.9 Outlet works

##### 3.9.1 Middle outlets

The scope of the two middle outlets is to:

- Control the reservoir impounding
- Safely drawdown the reservoir up to the power tunnel intake elevation 780 m a.s.l.

The middle outlets are included in the lateral blocks of the dam body (non overflow sections), nearby the spillway.

Each outlet is composed of:

- Shaped inlet, protected by steel grid with very wide mesh
- A steel conduit within the dam body composed of
• a first part with length about 25 m and section 6.5 x 4m
• two sliding gates (one working fully closed or opened and the second one for emergency) having a max statical load of about 150 m and a max. operating load of about 140 m;
• a second part about 80 m long

The main results of the preliminary hydraulic computation considering max and min operating level of the outlet are listed hereafter.

Table 3.3: Middle Level Outlet – Hydraulic calculations main result

<table>
<thead>
<tr>
<th>Res.lev. m a.s.l.</th>
<th>Q/Q1 m/s</th>
<th>V1 m/s</th>
<th>V2 m/s</th>
<th>V2/g 2/2g</th>
<th>Hf1 m</th>
<th>Hf2 m</th>
<th>ΣΔHlocal m</th>
<th>ΔHfrict m</th>
<th>Ed/s m a.s.l.</th>
</tr>
</thead>
<tbody>
<tr>
<td>780</td>
<td>315</td>
<td>12.12</td>
<td>19.70</td>
<td>7.49</td>
<td>19.77</td>
<td>4.49</td>
<td>1.74</td>
<td>773.77</td>
<td></td>
</tr>
<tr>
<td>892</td>
<td>725</td>
<td>27.92</td>
<td>45.37</td>
<td>39.73</td>
<td>104.92</td>
<td>23.84</td>
<td>9.23</td>
<td>858.92</td>
<td></td>
</tr>
</tbody>
</table>

The detailed hydraulic studies will be completed by means of the physical hydraulic modeling under construction.

The Mid-Level Outlet rating curve (for one of the two outlet devices) can be defined having expressed the terms of equation as a product of a constant for Q^2 obtaining:

\[ H_w = 4 + 2.61858E4Q^2 \]

being \( H_w \) the headwater on the outlet sill (reservoir elevation – sill elevation).

The jet trajectory of the flow discharged by the middle outlet leads to the min distance of impact of about 25 m from the d/s toe of the dam (Q=315 m^3/s, Res. elev. =780 m a.s.l.) and the max distance of 135 m from the Power House u/s wall (Q=725 m^3/s, Res. elev. =892 m a.s.l.)

3.9.2 Permanent environmental discharge

The environmental releases will be possible by means of two separate devices:

• a conduit within the PH deriving from the u/s manifold and returning flows to the river bed (permanent device, operating from above el. 800 m a.s.l.)
• conduits discharging the flows into a diversion tunnel (temporary device operating during the first impounding only up to max. el. 800 m a.s.l.)

The scope of the permanent ecological discharge is to release a minimum vital flow downstream of the plant when it might be fully inoperative (maintenance, possibly during night operations, etc.).

The main components of this outlet device are:

• a penstock D = 0.8 m starting from branch of manifold of unit No. 10 and ending to valves at south corner of the PH
• two butterfly valves D = 0.8 m max design pressure = 2.8 Mpa

This device will allow a rated discharge of about 25 m^3/sec in order to guarantee, with the lowest normal reservoir operating levels, a released flow higher than 15 m^3/sec.
It can be noted that, in normal operating conditions, the device will be necessary and effective only for the very first trunk of the reach downstream of the plant.

This since, while going downstream, the lamination effects along the valley will however guarantee a continues flow during the whole day (n.d.r. in case no energy production will be envisaged during the night for some periods).

### 3.9.3 Temporary environmental discharge

The scope of the temporary ecological discharge is twofold:

- to release the required ecological discharge during the first impounding
- to contribute to the controlling of the reservoir impounding during the tunnel closure

The main components of this outlet device are:

- two pipes
  - $D = 1.6\ m$ (approx.)
  - installed through diversion tunnels plugs
  - embedded in plugging concrete (TL or TR according to construction program)
- four butterfly valves
  - $D = 1.6\ m$
  - max design pressure = 2.1 Mpa

This device will allow a rated discharge of about $35\ m^3/sec$ for each of the two pipes (for the lowest water levels about el 700 m a.s.l.) progressively increasing up to reaching about $70\ m^3/sec$ with the reservoir impounding.

The required ecological releases during first impounding will vary depending on the downstream flows (i.e. wet or dry year in the residual basin) on the impounding starting and of the inflows sequence of the specific year.

However the maximum discharges allowed by this outlet device (varying from about 35 to 70 $m^3/sec$ with water levels for each pipe) can be compared to the runoffs at Gibe III during the dry season varying from a minimum of 25 $m^3/sec$ in March 1973 to the averages of 61 to 141 $m^3/sec$ January – May.

This comparison shows that the designed device guarantees a full flexibility, together with the higher middle outlet works, to the selection of the optimum ecological release during first impounding.

### 3.10 Power Waterways

The power system, including mainly two power tunnels, two surge tanks, two vertical underground penstocks and above ground Power House, is located in the left abutment.

The inverts of the tunnels have been set at el. 780m a.s.l., that is low enough below the minimum operating level (800 m a.s.l.) in order to assure at the same time, a good submergence and avoid vortices, and to reduce the internal pressure in the tunnels as much as possible.

The trashracks will be installed to protect the EM equipment from possible debris entering the tunnels.

Downstream of the intake structures, a transition section is insuring the transition to the 11.0 m diameter circular tunnels.

The tunnel bottom is located at el 780 m a.s.l. at the intake and at el. 775 m a.s.l. at the base of the shaft.
The length of the two power tunnels equal approximately 660 m for the right tunnel and 870 m for the left one with a longitudinal slope of approximately 0.6% and 0.75%, respectively.

The flow section of 95 m² implies a maximum flow velocity in the power tunnel of about 5 m/s.

The tunnel lining will be executed by a 50 cm thick cast in place concrete with reinforcement bars over the temporary shortcrete layer.

Two surge shafts, one each line, are required for the Gibe III Power Plant, in order to mitigate the water hammer effects in the gallery due to rapid change in the flow caused by turbines maneuvers.

Internal diameter of the shafts is fixed at 20 m and an orifice diameter of 5.8 m has been selected. The two structure have been designed to be almost entirely underground having a total height of 35 m and 25 m (for the left and the right tunnel, respectively) above the ground level.

Two penstocks with a diameter of 7.7 meters have been foreseen. The diameter has been selected to maintain flow speed not much larger than 10 meters per second. At their lower end five plus five wye branches with a diameter of 3.5 m, intercepted by butterfly valves, feed the generating units. Wye branches have been designed for smooth hydraulic flow to avoid excessive head losses, vibration and cavitations.

### 3.11 Power House

The power house is located on the Omo river left bank, about 550m downstream of the dam axis.

The Power House building is disposed parallel to a steep (almost vertical) rock front, approximately along the N-S direction, slightly rotated in respect to the river alignment, in order to reduce the impact angle between the turbine tailraces and the river stream.

This location has been decided taking into account the geomorphology of the river banks, trying to reduce as much as possible the rock excavations.

The river right bank will be excavated in order to found the Power House structure on sound rock and at the same time to assure the submergence of the turbines draft tubes.

The power house will be a reinforced concrete structure with a total length of about 250m and a width of about 57m.

The main body of the building is about 37m wide; behind the building a 5m wide draft tube and a 21m wide upper transformer deck complete the structure.

Inside the power house are foreseen n.10 Francis turbines each one with an installed power of 187 MW.

The n.2 penstocks excavated inside the rock exit directly at the turbine elevation, behind the Power House, where n. 2 manifold with 5 branches each is connected to the n.10 turbines.

The main elevations of the structure are the following:

- **Upper floor (transformer deck)** (el. 702.0 m a.s.l.)
- **Machines hall floor** (el. 678.7 m a.s.l.)
- **Generator floor** (el. 674.6 m a.s.l.)
- **Turbine floor** (el. 670.3 m a.s.l.)
- **Spiral case floor** (el. 665.5-662.0 m a.s.l.)
The turbine axis are at el. 668.00 m a.s.l.
The bottom of the structure, where the draft tubes are embedded, is founded at el. 656.0 m a.s.l.

Here below are recalled the main data relevant to the elevations assumed for the design, given also in the power house transversal section drawing 361 GEN D SP 306 A:

- Exceptional flood level (Q=10,600 m³/s) 695 m a.s.l.
- Normal Tail Water Level (Q=950 m³/s) 681 m a.s.l.
- Minimum Tail Water Level 677 m a.s.l.
- Invert level draft tube outlet 658 m a.s.l.

3.12 Switchyard

The present paragraph summarises layout of the structures and of the line connecting the Power House transformers to the Switchyard.

The Switchyard is oriented along the NE-SW direction, in order to facilitate as much as possible the entrance and the exit of the lines, and to reduce at the same time the volumes of excavation on the top of the hill.

It is located about 650m far from the Power House, on the top of a plateau on the Omo river left bank.

The main characteristics of the switchyard are as follows:

- Yard elevation 1010 m a.s.l.
- Overall dimensions 128 x 418 m
- Control building 55m x 18m

A cable duct is envisaged, in order to allow the passages of the cables, from the Power House and developed underground, connecting the EM equipments among them and with the control building.

The 400kV link from the Power House to the switchyard basically comprises:

A cable-duct, coming from the Power House transformers, located in the cable gallery with the following characteristics:

- Total length about 298 m
- Horizontal gallery length about 140 m
- Horizontal gallery height 4.6 m
- Horizontal gallery width 3.2 m
- Shaft length about 158 m
- Shaft diameter 5 m
- Junction Yard for passage of the lines from XLPE cables to overhead lines. The 400kV cables exit from the cable-ducts and reach the first line of towers of the 400kV overhead line, disposed along the rock ridge above the dam at el. about 860 m a.s.l.

- Overhead line from junction yard to switchyard. The 400kV overhead line consists of stretches, divided by intermediate towers, in order to allow the 400kV line to abut on the gantry pylons of the switchyard area
The medium and low voltage and the control cables between the Power House and the Switchyard run in the same cable-duct of the 400kV line from the Power House to the junction yard. The rest of the connection up to the switchyard is carried out by means of a dedicated duct.

3.13 Electro-Mechanical equipment

3.13.1 General

The Mechanical and Electro-Mechanical equipment is listed here below while the most relevant components (turbines, generators, transformers) are briefly described in the following paragraphs.

- Turbines and Inlet Valves
  - No.10 vertical Francis type hydraulic turbines
  - No.10 digital frequency governors for the hydraulic turbines
  - No.10 inlet butterfly valves for the turbines
- Generator and Balance of Plant
  - No.10 Generators and Excitation System (Power House)
  - Power House Auxiliary Electrical Equipment (Power House)
  - Protection Control and monitoring System (Power House-Switchyard)
  - Telecommunication and tele-control System (Power House-Switchyard)
  - No.15 (+1 to spare) Main Step-Up Transformers (Power House)
  - No.5 Links between Step-up Transformers and Switchyard (Power House-Switchyard)
  - 400kV Switchyard (Switchyard)
  - Power House Cooling Water and Drainage Systems (Power House)
  - Fire Protection System (Power House - Switchyard)
  - Ventilation and air conditioning System (Power House)
  - Power House Travelling Cranes (Power House)
  - Dam electrical auxiliary equipment (Switchyard)
  - Lighting and socket system (Power House - Switchyard)
  - Cabling system (Power House - Switchyard)
  - Earthing system (Power House - Switchyard)
  - Workshop and Store equipment (Power House - Switchyard)

The Gibe III plant has a total installed capacity of 1,870 MW.

3.13.2 Turbines

The plant is equipped with n. 10 vertical shaft Francis turbines, 190 m rated net head, 187 MW capacity, 272.7 rpm, with steel spiral case and draft tube steel liners, combined expansion end dismantling joint between the spiral case and the inlet valve.

Each turbine is equipped with electronic frequency governor with pressure oil supply system.

**HYDRAULIC DATA**

- Intake maximum/normal water level 892 m a.s.l.
- Intake rated operating water level 876 m a.s.l.
• Intake minimum normal operating water level 854 m a.s.l.
• Intake minimum exceptional operating water level 800 m a.s.l.
• Tailrace normal water level (10 units) 681 m a.s.l.
• Minimum Tailwater level (one unit at 50% load) 677 m a.s.l.
• Elevation of runner centreline 668 m a.s.l.
• Maximum design pressure (including max. surge and water hammer overpr.) approx 2.7 MPa

OPERATING CONDITIONS:

The operating conditions of the turbine are as follows:

<table>
<thead>
<tr>
<th>Net Head [m]</th>
<th>Max. (1)</th>
<th>Rated (2)</th>
<th>Min (1)</th>
<th>Exc. Min (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity [MW]</td>
<td>214</td>
<td>193.5</td>
<td>176</td>
<td>122</td>
</tr>
<tr>
<td>Discharge [m³/s] (3)</td>
<td>187</td>
<td>183</td>
<td>157</td>
<td>80</td>
</tr>
<tr>
<td>Frequency of rotation [rpm]</td>
<td>94</td>
<td>102</td>
<td>97</td>
<td>75</td>
</tr>
<tr>
<td>Direction of rotation</td>
<td>272.7</td>
<td>clockwise when seen from above</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

with the following notes:

(1) One (1) unit operating
(2) Ten (10) units operating
(3) The turbine outputs are limited at maximum Power Output of 187 MW, therefore at the highest heads the wickets gate opening is limited

3.13.3 Generators

The Plant is equipped with n. 10 synchronous generators, of following characteristics:

- Type: salient pole, synchronous machine, continuous duty
- Number of phases: 3
- Connection diagram: Wye (six terminals)
- Rated output: 220 MVA
- Rated voltage: 15 kV ± 5%
- Rated power factor (p.u.): 0.85
- Rated frequency: 50 Hz ± 2%
- Number of poles: 22
- Synchronous speed: 272.7 rpm

The generator is of synchronous type, vertical shaft, directly coupled with a Francis turbine.

Each couple of generators is connected by isolated bus ducts and through generator circuit breakers with a bank of three single phase three winding step-up transformers.

The generator is of the totally enclosed type with air-water heat exchangers. The generator is with one combined thrust and guide bearing and one guide bearing.

3.13.4 Step-up transformers

The following equipment will be adopted:

- 16 (sixteen) single-phase three winding step-up transformers 15/15/400/√3 kV, 147 MVA.
• one hundred and ten percent (110%) of the insulating oil necessary for filling the above transformers (10% intended as spare).
• two (2) sets of spare parts and special tools.

The transformers and the accessories will have the following main characteristics:

<table>
<thead>
<tr>
<th>Type</th>
<th>single-phase-phase, outdoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling medium</td>
<td>mineral oil</td>
</tr>
<tr>
<td>Cooling class</td>
<td>ONAN/ONAF</td>
</tr>
<tr>
<td>Rated power</td>
<td>73.5/73.5/147 MVA</td>
</tr>
<tr>
<td>Rated voltages</td>
<td>15/15/400 kV</td>
</tr>
<tr>
<td>Rated frequency</td>
<td>50 Hz</td>
</tr>
<tr>
<td>Winding connections of the three-phase bank</td>
<td>YN d11 d11</td>
</tr>
<tr>
<td>Minimum Guaranteed Efficiency</td>
<td>99.5%</td>
</tr>
</tbody>
</table>

3.14 Hydraulic Steel Structures

3.14.1 General

The main HSS equipment envisaged for the plant is listed here below.

• SPILLWAY
  • n. 9 radial gates
  • n. 2 set of stoplogs with lifting beam

• INTAKES
  • n. 4 bulkhead gates equipped with hoist
  • n. 4 roller gates equipped with servomotor
  • n. 2 trashracks
  • n. 2 steel linings

• POWER TUNNELS
  • n. 2 tunnels steel lining

• POWER HOUSE DRAFT TUBES
  • n. 20 sliding gates equipped with servomotor and monorail
  • n. 2+2 stoplogs sets equipped with gantry crane

• MIDDLE OUTLETS
  • n. 4 sliding gates equipped with servomotor
  • n. 4 wheel gates equipped with servomotor
  • n. 2 steel linings

• ECOLOGICAL OUTLET
  • n. 2 butterfly valves
  • n. 2 penstocks

• TEMPORARY ECOLOGICAL OUTLET
  • n. 2+2 butterfly valves
  • n. 4 wheel gates equipped with servomotor
  • n. 2 steel linings

The HSS equipment design will be refined following the numerical and physical modelling tests.
3.15 Materials / Quarries

3.15.1 General

The most relevant materials for the Gibe III construction are found on site and include:

- aggregates for concrete (recent river alluvium, basalts)
- pozzolanic materials (ignimbrite, natural ashes)
- rockfill for cofferdam embankment (trachyte, basalt)

The following quarries, illustrated in the figures below, have been identified:

- Recent (River) alluvium: Quarries 2 (left side) and 3 (right side)
- Basalt: Quarries Tsida I and Tsida II
- Trachyte: Quarries on dam abutments
- Ashes: Quarry on left abutment
- Ignimbrite: Quarry on left abutment
Most of these quarries are located upstream of the dam axis and below the reservoir operating levels, therefore will be submerged during reservoir operation.

The figure in the following page illustrates in detail the river alluvium and basalt quarries.
### 3.15.2 Recent (River) alluvium

The most relevant source of aggregates for the concrete including the RCC dam (about 6 million of cubic meters) will be the recent alluvium found on the river banks upstream of the dam site.

![Photo 3.1: The alluvium quarries 2a and 2b](image)
The alluvium material will constitute more than 70 per cent of the aggregate sources. The above photo 3.1 shows quarry 2a and 2b on the left bank of the Omo river at the beginning of the rainy season.

The alluvium can be identified as GP (poorly graded gravel) or sometimes SM (low plasticity silt) particularly in the river bed terraces.

The petrographic analysis showed the basaltic, sometimes trachytic, origin of the alluvium. The chemical tests confirmed its suitability for concrete and particularly for the RCC dam construction

### 3.15.3 Basalt

A secondary source of aggregates for concrete is the basalt (columnar, vesicular and unweathered) along the Omo river Valley.

Both chemical and petrographical analysis have been performed, including mortar bar tests for alkali-aggregate reaction, confirming its suitability for the aggregate production. Basalts will be also used for the cofferdam embankment construction.

The following photo 3.2 shows the Tsida I quarry where the columnar basalts are found.

![Photo 3.2: Tsida I basalt quarry](image)

### 3.15.4 Trachyte

The trachyte materials (i.e. tout venant) coming from the excavation of the diversion tunnels will be used for the cofferdam construction.

The material is recognized as trachyte of light grey type with occasional presence of dark grey and slightly weathered type.

The following photo 3.3 shows the excavated front just after blasting operations, with excavated trachyte.
3.15.5 Pozzolanic materials (ashes, ignimbrite)

The pozzolanic materials found on site will constitute a relevant portion of the cementitious materials required for the RCC dam.

Two suitable materials are available: natural ashes and ignimbrite.

Tests have been carried to confirm the properties of these materials as RCC cementitious materials. The results show properties quite similar to those of a commercial fly ash.

Both ignimbrite and ashes will be mainly quarried in the left side being the ignimbrite layer on the top just above ashes layer.

The following photo 3.4 shows the overlapping between ignimbrite and ashes in the stratigraphic succession typical in the area.

The ignimbrite might be possibly used also as an additional aggregate source for the RCC even if in small quantities.

The sub-horizontal layer permits a regular quarrying without the opening of high fronts. This set up will facilitate the recovering of natural vegetation once the quarry will be abandoned.
Photo 3.4: Ignimbrite layer above ashes (left plateau)
4 IMPACT ASSESSMENT METHODOLOGY

4.1 Introduction

The scope of the Environmental Impact Assessment activity is to evaluate the temporary and permanent impact of a project on the natural and human environment.

In general terms the methodology of an Environmental Impact Assessment may be well described by the following flow chart (Table 4.1).

| Table 4.1: Flow chart of the Environmental Impact Assessment of a project |

```
<table>
<thead>
<tr>
<th>SCRENNING</th>
<th>SCOPING</th>
</tr>
</thead>
<tbody>
<tr>
<td>analysis of the project</td>
<td>analysis of the environment situation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENVIRONMENTAL DIRECT IMPACT PREDICTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre/during construction impacts</td>
</tr>
<tr>
<td>short-term mitigation measures</td>
</tr>
<tr>
<td>Permanent impacts</td>
</tr>
<tr>
<td>Medium long-term mitigation measures</td>
</tr>
</tbody>
</table>

| ENVIRONMENTAL MANAGEMENT PLAN |

| ENVIRONMENTAL MONITORING PLAN |
```

SCREENING analysis of the project

SCOPING analysis of the environment situation

definition of temporal boundaries of data collection
definition of spatial boundaries of data collection

baseline of data collection

natural physical resources

natural biological resources

social and economical resources

special studies

system dynamic without project

ENVIRONMENTAL DIRECT IMPACT PREDICTION

PRE/ DURING construction impacts

short-term mitigation measures

Permanent impacts

environmental indirect impacts

Medium long-term mitigation measures

PROJECT LAYOUT REVISION

ENVIRONMENTAL MANAGEMENT PLAN

ENVIRONMENTAL MONITORING PLAN
In particular, the methodologies employed for assessment and evaluation of the impacts of the project at the feasibility technical level have been:

- personal experience of CESI consultant: they have been in Ethiopia also to prepare the Gilgel Gibe I and Gilgel Gibe II project’s feasibility report. They gave information about geology, geomorphology and description of the interfered area;
- consultation with people affected by the Project and local authorities to obtain supplementary information on social, socio economic and socio-cultural conditions, to identify valid mitigation measures;
- hydraulic data collections of rivers.

### 4.2 Bounding and Scoping

The sense of scoping procedure is to analyse the environmental situation prior to project construction, in order to define the temporal and spatial boundaries of the baseline data.

The physical boundaries of the ESIA comprises the reservoir area upstream the dam and the area immediately downstream the dam, given the importance of Omo river flow for Turkana Lake, although sited in Kenya State.

Scoping has included the most important and major environmental issues, namely:

- water quantity and quality of the Gibe River and its tributary Gojeb;
- riverine vegetation and other vegetation that might be affected by construction activities;
- underground water disturbances;
- terrestrial and aquatic fauna;
- people living in the area;
- health aspect of the project;
- dislocation of people;
- employment opportunities;
- agricultural resources;
- economic development;
- gender issues.

The temporal boundaries may be strictly related to construction activity for some environmental aspects of the project, but for some others aspects may be extended to the project operation activities.

### 4.3 Public participation

The field investigation included consultation with various Project Affected Person (PAP), local authorities and extensive group discussions with wereda officials and focus groups. This was carried out in order to obtain supplementary information on social, socioeconomic and socio-cultural conditions.

The consultation was also supported from the use of other relevant PRA (Participatory Rural Appraisal) tools.
Secondary data on socio economic conditions of the affected weredas and kebeles were collected from wereda administration offices. Furthermore, site-specific data were collected through interviewing and discussions with local community members.

4.4 Assessment

The characteristics of the foreseeable impacts have been identified considering:

- the actions that may produce impact, evaluated in the description of the Gibe III Hydroelectric Project;
- basic environmental data obtained from direct field observations;
- information gathered from the available scientific publications and information derived by the study of similar projects.

A matrix that links project activities to the environmental components, considering the impacts (both positive and negative) generated by the project activities during all the different temporal phases of the project has been proposed. In particular, in Table 4.2 a blank matrix is proposed that contains the aspect whose impact will be treated in this report, giving for each aspect considered, a different weight in terms of impact. Weights for each aspect in the different phases are the results of comparisons between the technicians that have taken part to the ESIA project.

For each phase (during construction activities, and during operation stage activities), as made in studies on other project cases, the impacts are defined considering the main six activities which may have some effect on the environment:

- the dam erection;
- the relevant reservoir creation;
- the temporary and the final roads built for the construction activities and for standard operation activities;
- the Power House construction;
- the temporary site camps and related facilities;
- the substation construction.

This matrix links environmental aspects to project activities in each project phase.

Each cell of the matrix will contain the relevant value, according to the legend as determined during the Study (See Table 7.7).
Table 4.2: Synthesis of Environment Impact Matrix

<table>
<thead>
<tr>
<th>Environment Component</th>
<th>Construction Stage Activity Component</th>
<th>Operation Stage Activity Component</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dam</td>
<td>Reservoir</td>
</tr>
<tr>
<td>Physical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geothermal activity</td>
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</tr>
<tr>
<td>Seismology</td>
<td></td>
<td></td>
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<tr>
<td>Hydrology</td>
<td></td>
<td></td>
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<tr>
<td>Hydrogeology</td>
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<tr>
<td>Water quality</td>
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<tr>
<td>Climate</td>
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<td>Global</td>
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<tr>
<td>Landscape</td>
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<tr>
<td>Biological Environment</td>
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<td></td>
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<tr>
<td>National parks and protected areas</td>
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<tr>
<td>Ecologically sensitive areas</td>
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<tr>
<td>Priority Forest Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wildlife and wildlife corridor</td>
<td></td>
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<tr>
<td>Fishery Resources</td>
<td></td>
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<tr>
<td>Wetland Ecosystem</td>
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<tr>
<td>Aquatic Ecosystem</td>
<td></td>
<td></td>
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<tr>
<td>Aquatic weeds</td>
<td></td>
<td></td>
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<tr>
<td>Eutrophisation</td>
<td></td>
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<td>Socio-Economical Environment</td>
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<tr>
<td>Property residence</td>
<td></td>
<td></td>
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<tr>
<td>Agricultural land</td>
<td></td>
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<tr>
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<tr>
<td>Migrant workers and local population</td>
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<tr>
<td>Positive Impact</td>
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<tr>
<td>Negative Impact</td>
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Positive Impact: A = Very Important  B = More Important  C = Important  D = Fair Important  E = Less Important
No Impact: 0
Negative Impact: 1 = Very important  2 = More important  3 = Important  4 = Fair important  5 = Less important
5 DESCRIPTION OF THE ENVIRONMENT

5.1 Physical Environment

5.1.1 Climate

The climate is classifiable as tropical humid in the highlands that include the areas surrounding Jima and around the headwaters of the Gojeb River. For the rest, and greatest part, of the watershed the climate is classifiable as a tropical sub-humid, intermediate between the tropical humid and the hot arid climate characteristic of the southernmost part of the floodplain toward Lake Turkana. The seasonal variation in climate is associated with the oscillation of the Inter-Tropical Convergence Zone (ITCZ), a low pressure area of convergence.

Figure 5.1: Annual Isohyetal map reported in the Omo River Master Plan
The ITCZ shifts during the year northwards across southern Ethiopia from September to November and southwards from March to May, giving origin to the alternation of a wet (from May to September) and a dry (from December to April) season. During the wet season the area is under the influence of Atlantic equatorial westerlies and southerly winds from the Indian Ocean, producing strong precipitation, mainly due to the Atlantic moist component. During the dry season the moist air comes from the Gulf of Aden and the Indian Ocean, causing little rains.

As the main source of moist air is from the Atlantic Ocean, from the SW, the eastern parts of the highlands are more or less rain shadowed. This effect can be seen on the isohyetal map of the area, reported in the Omo River Master Plan (Figure 5.1). The area of greatest rainfall is to the NW of Jima (outside the Gibe Basin). Rainfall declines sharply in the lower lying southern parts of the basin. According to the isohyetal map of the OGMP, the rainfall ranges from over 1900 mm/year in the northern and western part of the basin, to about 1200 mm/year in the lower part of the project area. Rainfall rates decrease strongly southwards, to less than 300 mm/year near Lake Turkana.

In the project area, the average annual air temperature is 20.4 °C.

Table 5.1, Table 5.2 and Table 5.3 show monthly maximum, minimum and mean values of temperatures, recorded at Sekoru, Wolayita Sodo, Gojeb and Agaro stations. These stations, referring to dam location, are sited respectively upstream the reservoir, in the middle between the dam and end of the reservoir, downstream the dam.

### Table 5.1: Maximum monthly temperatures (°C)

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### Table 5.2: Minimum monthly temperatures (°C)

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### Table 5.3: Mean monthly temperatures (°C)

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<tr>
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<td>23.6</td>
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<td>22.5</td>
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</table>

The annual rainfall of the Gibe catchments area, measured in the same stations, varies from a minimum of 1,230 mm in the Wolayita Sodo station, to a maximum of about 1,640 mm in the Agaro station. Rainfall decreases throughout the catchments with a decrease in elevation. The average annual rainfall calculated over the whole Gibe III basin where the site 5 dam is located is 1,426 mm. Table 5.4 shows monthly mean
values of rainfall, recorded at the same stations considered for the evaluation of air temperature. In the table is reported also the estimation of the monthly rainfall at the selected dam site.

Table 5.4: Mean monthly rainfall (mm)

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<td>222.6</td>
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</table>

It appears that 71 per cent of the total amount of annual rainfall occurs between May and September, 14 per cent from February to May, and 12 per cent between October to January.

The natural evapotranspiration (ETP) is estimated for each considered station using the FAO Penman-Monteith. The expected ETP in Site 5 watershed (without reservoir) is computed by mean of the Thiessen polygons.

The mean ETP are reported in the following Errore. L’origine riferimento non è stata trovata..

Table 5.5: Mean monthly ETP (mm)

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<td>135</td>
<td>148</td>
<td>137</td>
<td>130</td>
<td>1702</td>
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A comparison between the losses due to evapotranspiration (in the area without reservoir) and rainfall is reported in Table 5.6: the ETP should exceed rainfall rates during the rainy season (becoming runoff), while in the dry season all the rainfall should be lost due to evapotranspiration.

However these are indicative only values since the ETP has been preliminarly estimated (i.e. not measured) and the dynamics of the control of the transformation between rainfall, infiltration and evapotranspiration are not known on a monthly basis.

Table 5.6: Comparison between Mean monthly rainfall and ETP at dam site (mm)

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5.1.2 Geology

5.1.2.1 Regional Geology

The regional geology of southern Ethiopia consists mostly of metamorphic rocks of green schist, amphibolite and granulite facies that represent the southern margins of the Arabian-Nubian shield.

The Precambrian basement rocks are the result of a complex tectonic and metamorphic history during the Proterozoic times. During the Palaeozoic, the Precambrian rocks were eroded to a vast peneplain, apparently a continuation of the Kenya -Sudan plains to the South and West.

In early Mesozoic times, a major marine incursion from the east deposited the Triassic and Jurassic Adigrat sandstones and limestones that cover much of the eastern part of Ethiopia and Somalia. The central and western parts of Ethiopia remained a continental land area throughout the Mesozoic, with a thin unit of presumed continental sediments being the only record of deposition.

Marine sedimentation was brought to an end by widespread regional uplift starting in the Eocene period, associated with the initial development of the Red Sea and the East African rift systems. This uplift was accompanied by extensive volcanic activity. At first, this took the form of huge outpourings of basalt lava (flood basalts) from long fissures that opened along the line of the rifts. These flood basalts erupted for almost 20 million years and accumulated to a total thickness of several thousand metres. They now form the foundation of the Ethiopian Plateau.

However, the details of the geological history between about 30 and 15 millions years ago has some uncertainties, owing to the scarcity of absolute ages for the felsic volcanic rocks, and it is likely that basaltic and more acid lavas erupted contemporaneously from different volcanic centres (Davidson 1983) with a progressive evolution from dominantly basaltic lavas to mainly trachytic and rhyolitic lavas.

It is inferred that volcanic activity declined about 20 million years ago, leading to the localised formations of a series of shallow lakes and swamps which developed on top of the flood basalts. This resulted in the deposited series of shallow-water lacustrine sediments containing carbonaceous shales, lignite and coal deposits.

Around 13 million years ago, the development of the main Ethiopian Rift Valley commenced, reaching something similar to its present form by the early Pliocene, about 5 million years ago (Davidson, 1983). This inaugurated a period of felsic volcanism, including rhyolites and trachytes, where the available dates indicate a duration between 10 and 3 million years ago; these felsic volcanics extended over much of the central plateau of Ethiopia.

1 Main data on which the present geological study is referred are:  
· 300 GEN R BR 001 Seismic Hazard Assessment  
· 300 GEO R SP 001 Geological Report  
· 300 GEO R SP 003 Hydrogeological Report  
· 300 GEO R SP 002 Reservoir seepage risk analysis  
In particular a large campaign of site investigations has been carried out and is presently in progress. The investigations already completed include:  
· Boreholes (also with lugeon tests) > 13000 m, 120 No  
· Geophysical Investigations  
· Geostructural Surveys > 5000 joints  
· Laboratory Tests  
· Inspection Adits > 350 m, No. 7
Finally, during the Quaternary period, the lower parts of the rift valleys were filled with alluvium poorly consolidated sediments that now make up the extensive plains of southern Ethiopia and the depressions of Lake Turkana and Chew Bahir. Numerous salic intrusions of rhyolite, trachyte, microgranite, and microsyenite occur throughout of the project area.

5.1.2.2 Tectonic Setting

According to the geostuctural interpretation from Landsat imagery described in the L1D Geological Report, two main structural blocks seem to characterize the region: i) a northern block, situated north of the village of Sodo, with lineament trends oriented NNE/SSW and E-W, and ii) a southern block located south of Sodo, which according to the authors seems affected by a clockwise movement of about 30°; consequently, the two main fault trends would be reoriented to NE-SW and ESE/WNW respectively. Hypabyssal magmatic events would occur along the main fault trends. The structural photo-interpretation led to the recognition of 8 lineament sets over the area of interest; of these, the main lineament sets are directed N20°E and N120°E whereas subordinate ones have directions N50°E, N70°E, N135°E and N160°E. Two minor sets are directed N-S and E-W anyway they are represented by too few lineaments to be considered significant at the observation scale. The photo-interpreted lineaments show coherent patterns suggesting that most of them can be associated to possible regional fault or fracture systems; it must be clear that photo interpretation allows for the recognition of steep or near-to-vertical discontinuities, whereas sub-horizontal or gently dipping structures generally escape the interpretation.

An interesting feature is represented by the tectonic control on the local morphology and especially on the Gibe river course. In particular, the N20 set, parallel to the MER trend, can be held responsible for the onset of the regional direction of the Gibe course. No regional structures at the scale of the whole riverbed exist. Rather, the Gibe river course set up along a series of minor N20 trending fault or fracture zones. Transversal discontinuities (e.g.: N70, N110, N135) may originate local deviations of the river course which are clearly tectonically controlled.

Tentatively, the N20 and the N120+N160 sets could be associated to a same regional stress field with maximum compression axis 1 directed N-S, as the intersection angles are consistent with a conjugate discontinuity system; in this interpretation, the N120 and N160 sets are associated together as the expression of a same set. Alternatively, a N20 – N70 structural association could be the expression of a regional 1 directed approximately NE-SW (N45°E).

It is opinion of the authors (300 GEO R SP 002 A) that the presence of different lineaments trends might be associated, at the reservoir scale, to variations in the regional stress field, rather than to the rotation of rigid basement blocks, as there is no clear evidence of structures allowing for such a rotation. However, field structural data are necessary to define a structural model coherent with the regional stress state. As one can see, the mean lineament length is quite low, in the order of 1.000 to 4.000 m; standard deviations are high anyway, indicating a high data dispersion around the mean value; maximum interpreted single-lineament lengths are in the order of 20.000 m or, most frequently, 10.000 m. Considering the alignments of single elements, an observed persistence in the order of 30-40 Km can be reached, especially for some lineaments intersecting the Gibe Course with NW-SE direction (i.e. N135°E to N160°E).
Referred to the project the study area was involved in a progressive positive movement of the plutonic rocks, trachytic flow and part of the older columnar basalts. It seems that the trachyte was extruded in a single phase episode. The differences found in the petrographic structure between the base and the top of the outcrop in the right bank seems due to magmatic differentiation. At first sight, the left bank seems less involved in the tertiary pre-rift movements, it appears more massive than the right bank. The trachytic rocks
are affected by sets of undulated cooling joints that create a 1-1,5 meter wide and >20 meter high vertical prismatic column. The dip direction of main joints are sub-parallel and perpendicular to the river flow while the dip is subvertical. These regulate the general structure. Toppling features occur along the scarps and in correspondence of the diversion tunnel portal. In the right bank, a fault with a vertical movement brings trachyte and columnar basalt into contact. In this bank, the sub-vertical joints are cut by a joint trend with a 45-50° dip. An important NNE-SSW fault crosses the entire study area in correspondence of the West end of the R3 plateau. Such fault divides the trachytes and basalts zone within the study area from a series of loose or semi-loose volcanic materials zone with small embedded flows. This fault seems to belong to an important NNE-SSW movement that cuts the entire area.

5.1.2.3 Geology of the project area

The main Geological Units present in the area are:

- Tertiary highland Volcanic Units (Jimma Formation Pjb-Pjr, according to Merla, or Felsic volcanics PNV, according to Omo Gibe river Master Plan and Davidson.);
- Quaternary-Tertiary Rift sediments & Volcanics with undifferentiated Quaternary cover;
- Salic intrusions.

The river bed crosses the following main units:

- the Tertiary Volcanic Unit named Jimma Volcanics Lower Unit (Pjb),
- the Western part of the overhanging Plateau with Jima Volcanics Upper Unit (PJr), and
- the Eastern part of the same plateau with one unit of Quaternary-tertiary Volcanics named Nazret Series (Nn).

According to the LID Geological Report, the geology of the project is characterized by four major lithostratigraphic groups; these units are separated by unconformity where faulting has caused tilting and the subsequent erosion of the older rocks, spaced out by pyroclastics events.

1) Tertiary volcanic units (Jima Formation, Eocene to Miocene pre-rift volcanic rocks) including flood basalts (lower unit, Pjb) and rhyolites (upper unit, PJr).

The Jima Volcanics comprise trachybasalts and rhyolites covering most parts of south-western Ethiopia. They form a thick succession of basaltic and felsic rocks with basalt dominating the lower part of most sections. The basalt flows form a succession up to several hundred meters thick, with felsic lavas intercalated towards the base of the succession.

The basalts crop out mainly along the main riverbed and over a vast area west of it; the rhyolites crop out mainly along the western overhanging plateau.

2) Tertiary to Quaternary volcanics of the so-called Nazret Series (Nn), cropping out along the eastern overhanging plateau (Mio-Pliocene, 9 to 3 M.y.).

The Nazret series includes a thick succession of ignimbrites with composition ranging from sub-alkaline rhyolites and trachytes to (rare) peralkaline varieties, characterized by flame textures, pumice and ash levels and rhyolite flows and domes with rare intercalations of basaltic flows. The Nazret ignimbrites are considered the product of eruptions from marginal rift centers.
3) Tertiary to Quaternary syn- and post-rift sediments and interlayered volcanics (late Miocene to Holocene) and hypabyssal intrusive rocks.

The Quaternary units overlying the Nazret Series include:

- the Dino Formation (Qd), formed by ignimbrites and associated (locally water-laid) pyroclastics, occasionally interbedded with lacustrine beds and aphyric basalts with a maximum thickness of 50 m.
- Peralkaline (rhyolitic) lavas and pyroclastics (Qr) derived from volcanic complexes situated along the axial zones of the main Ethiopian Rift and Afar, characterized by obsidian flows, pumice, ignimbrite, tuffs and scoriaceous basaltic lavas. Most of the basaltic flows have fissural origin from the late fractures of the Wonji Fault Belt, which is a narrow shear zone along which most of the deformation and magmatism related to the northern Ethiopian Rift is concentrated (Boccaletti et al. 1999).
- Quaternary sediments (Q) including fluval, lacustrine, eolian, and eluvial deposits are widespread all over the area.

4) A Precambrian basement unit, found in the study area south of the Gibe III reservoir, is represented by the Archean Alghe Group (AR1).

The bulk of this unit consists of a relatively homogeneous and poorly layered orthogneiss, representing deformed and metamorphosed plutonic rocks of dioritic, quartz-dioritic and tonalitic composition. Orthogneisses are locally interlayered with thin units of mafic schists, quartzo-feldspathic gneisses and paragneisses.

According to the L1D Geological Report, the riverbed and in general the lower part of the reservoir is constituted by basalt flows and by minor ignimbrite and tuff levels, while the upper part of the reservoir would rest on trachytes, rhyolites, ignimbrites and tuffs. Plugs and dikes of rhyolite, trachyte, phonolite and microgranite are reported along the valley flanks.

5.1.2.4 Geology of the Dam site

The dam site area is characterized by a deep gorge with sub-vertical walls. The river alluvium is constituted by fine sands and gravel of variable thickness, with a maximum depth up to about 15 meters. From the river banks start the 30-50 m slopes of a coarse angular colluvium in silty-sandy matrices. The slightly weathered trachyte walls, outcropping are mainly characterized by two sub-vertical joint families, being parallel and orthogonal to the river. The walls are affected also by a relevant transverse fault system with NW-SE orientation.

The Left bank is about 200 m high and appears almost intact, while the right bank is affected by a NNW-SSE fault system. The trachyte flow appears in some parts weathered and altered by fractures and hydrothermal fluids. At the top of the right bank a main NNW-SSE fault has caused a vertical displacement and put basalt and trachyte structures into contact.

Near the contact with the colluvium, the rock assumes a more plutonic look. The ends of the walls are sometimes characterized by basalt columnar flows (two at least) upset by a structural movement. At the top of this flows start a columnar basalt and vacuolar basalt flows series with horizontal asset interbedded by a metric series of pyroclastic rocks and continental erosional deposits constituted by a etherogenic pebbles.
From this point, the geological succession becomes more acid and aerated. This succession is characterized by horizontal and undisturbed ashes ignimbrite and volcanic scores.

The typical stratigraphic column can be summarized as follows:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Thickness (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGN</td>
<td>IGNIMBRITES</td>
<td>10 / 12</td>
</tr>
<tr>
<td>GS</td>
<td>CONT. DEPOSITS</td>
<td>10 / 12</td>
</tr>
<tr>
<td>ASH</td>
<td>ASHES</td>
<td>3</td>
</tr>
<tr>
<td>PY</td>
<td>PHYROCLASTITES</td>
<td>5 / 7</td>
</tr>
<tr>
<td>BAT</td>
<td>TRACHYTIC BASALT</td>
<td>20</td>
</tr>
<tr>
<td>Gs</td>
<td>CONT. DEPOSITS</td>
<td>10 / 12</td>
</tr>
<tr>
<td>BAT</td>
<td>TRACHYTIC BASALT</td>
<td>20</td>
</tr>
<tr>
<td>V-BA</td>
<td>VACUOLAR BASALT</td>
<td>10</td>
</tr>
<tr>
<td>BaC</td>
<td>COLUMNAR BASALT</td>
<td>50 / 120</td>
</tr>
<tr>
<td>IGN</td>
<td>IGNIMBRITE</td>
<td>7</td>
</tr>
<tr>
<td>S-TR</td>
<td>SLIGHT WEATHERED TRACHYTE</td>
<td>30 / 50</td>
</tr>
<tr>
<td>U-TR</td>
<td>UNWEATHERED TRACHYTE</td>
<td>150 / 200</td>
</tr>
</tbody>
</table>

The most relevant lithological types have been encountered.
UNWEATHERED TRACHYTE (lower layer)

The lower part (unweathered) of the trachyte body is less altered, or unaltered, as it is constituted by a sub intrusive body and is basically not interested by the fracturation and/or alteration phenomena. It is generally dark and hard and difficult to access for the atmospheric agents. The plutonic evolution typical of the magmatic room has produced dark, compact and resistant phases. Some few meter thick brecciate “zones” are met at various depths. It has not yet possible to adequately assess, basing on the available investigations, their correlation. Decomposed trachyte levels are met at various depths. These are composed by a few meter thick sand clay materials. The most important level is located from el. 680 to 650 m a.s.l.. The tallest level could interfere with the upstream toe of the dam (see boreholes B1, A3a, C1, A2, A1). The thickness of this level decreases moving downstream nearly disappearing in the dam axis area. The characteristics of these levels are probably related to the hydrothermal alteration. For long periods, the stabilized ground water table has deteriorated the rock by effect of the heat and chemism of the water. The river has eroded the upper softer layer of the weathered trachyte and, as of consequence, the riverbed conform with the contact between the lower harder unweathered layer grey trachyte.

SLIGHTLY WEATHERED TRACHYTE (upper layer)

This zone corresponds to the superficial and effusive part of the magmatic body. It shows sub-vertical cooling joints that have supported the development of the alteration and the oxidation like concentric bands. In the marginal areas along the scarps of the river Omo, or along the Tsida stream, the superficial flow is subject to the tilting phenomenon, while the phenomenon of oxidation is accentuated and the joints result open and often filled by plastic material. The passage from the inferior limit to the unweathered trachyte, almost always abrupt, especially when the superior layer is thin, shows somewhere the evidence of the “caterpillar track” phenomena together with the presence of breccia.

BASALT / TRACHYTE CONTACT

The contact is discordant. The basalt is constituted by subsequent flows and shows a columnar structure. It fills the very uneven structure of the Paleo-morphology constituted by the underlying trachyte. The contact surface in the depression zones is characterised by oxidized levels with the presence of paleosoil and also important levels of conglomerates (ancient alluvium) as in the borehole C5. The trachyte appears altered and oxidized (bordeaux colour). In the high contact zones (borehole A9, E5, etc.) the contact can be abrupt, as if an erosion surface. It may also be intercalated with a 7-8 meter level of pyroclastic rocks characterised by ignimbrite outcropping (RB and LB) or, as in the borehole A6, by pyroclastic sands.

COLUMNAR BASALT

Above the trachyte plug there is the columnar aphanitic basalts (Bac) involved in tertiary tectonic movements.

COLUMNAR BASALT WITH TRACHYTE HABITUS (i.e. not involved in tertiary tectonic movements)

There is a subsequent volcanic episode constituted by two or more 18-17m. thick horizontal trachytic columnar basalts is not involved in the tertiary movements. Two lenticular few meter thick intercalations of
continental deposits, constituted by well sorted sub-rounded gravel with sand having a silty matrix, pyroclastic rocks constituted by tuffs, sand and gravel are present in the upper part of the basalt flows.

**RECENT PYROCLASTIC EVENT**

The stratigraphy of the area continues with an important horizontal pyroclastic episode constituted by several types of pyroclastic rocks formed by ash, tuff, agglomerated, about 15m thick pebble gravel. A sand bench is present inside the pyroclastic rocks. This materials is rounded and is composed of heterogeneous rocks. The stratigraphic sequence ends with a thin light grey ignimbrite level with a strongly siliceous composition (>70%), and large amounts of crypto-crystalline quartz. The thickness is approximately 10-12m. The stratigraphic column of the pyroclastic event illustrates the relationships among the lithological types.

### 5.1.3 Seismology

The Gibe III dam is located in Ethiopia, in the vicinity (about 70 km) of the eastern branch of the east African rift system. It is a region of diffuse seismic activity that suffered strong earthquakes throughout its history, such as the August 25th 1906 (Ms=6.6 and 6.8), September 16th 1913 (Ms=6.2), July 14th 1960 (Ms=6.3) and October 25th 1987 (Ms=6.2 and Mw=6.2) events.

In order to perform regional seismic hazard diagnosis at the Gibe III dam site, it has been conducted an analysis taking into account active faulting as identified on digital elevation models and satellite imagery. Because the reliability of seismic hazard assessment strongly relies on a good understanding of the geodynamics of a given region at different scales, the deterministic analysis of seismotectonics and Quaternary tectonics of the east African rift region has been performed in several stages, from plate tectonics to seismic scarp scales. “International Commission on Large Dams” recommendations (1989) have been followed.

The main results of the seismic hazard diagnosis for the Gibe III dam are the following:

- Seven seismogenic faults have been considered and characterized in terms of location, extension, associated seismicity, and kinematics;
- The magnitudes of the design earthquakes recommended by ICOLD (1989) [Maximum Credible Earthquake (MCE); Maximum Design Earthquake (950 yr-MDE); Operating Basic Earthquake (145 yr- OBE)] have been derived for each of these critical faults. Moreover, curves of magnitude versus return periods have been produced for each seismogenic fault;
- Horizontal PGAs associated to design earthquakes have been derived for each critical faults at the Gibe III dam site;
- For each design earthquake, the relative significant duration (time interval between 5 and 95% of total areal intensity) was estimated using the equations of Kempton & Stewart (2006).

The detailed seismic assessment has been illustrated in the relevant report [300 GEN R BR 001 A - Seismic Hazard Assessment, February 2007]. Some additional observations are recalled here below. The occurrence in 1973 of an earthquake centred in the vicinity of the Weyto horst (about 50 km south of the study area) has been mentioned. Since the turn of the century, nine earthquakes with a magnitude greater than 4, have been recorded in the area. Three more have occurred in northern Kenya just south of the area, one to the north and three close to the northeast, the latter being associated with the Main Ethiopian Rift. Three of these have been recorded since 1950. Most were in the immediate proximity of the Chew Bahir rift and its northern
extension. None have been recorded in the area West and Northwest of the Omo river, although tremors were felt at Mizan Teferi in 1971. This information suggests that presently the Chew Bahir rift system is seismically more active than the Turkana rift system.

The project area (East-North East quaternary trending) does not seem to be active at this time, as illustrated in detail in the above mentioned report.

Despite the evidences that a certain seismic activity affected the region in historical times, according to the L1D Geological Report no evidences seem to exist of present seismic activity in the project area.

5.1.4 Reservoir Slope

As illustrated in the report [300 GEO R SP 002 A - Reservoir Seepage Risk Analysis], the possible occurrence of major landslides or of potential slope instabilities has been inferred on the basis of positive and/or negative landforms potentially related to accumulation and detachment areas along the main and lateral valley flanks. However it shall be recalled that no evidence of sliding is directly and easily extractable from the ASTER-derived photo-interpretation, as the 15 m ground resolution doesn't allow for the individuation of detailed discriminating features; to do this, an extensive aerial photographic survey will be envisaged in the following design phases. Therefore, the areas already highlighted as potentially coinciding with major landslides will be furtherly verificated on the basis of aerial photos and where necessary of field surveys.

Along the river courses some areas characterized by high relief energy, i.e. by vertical or near-vertical walls up to some tens of meters high have been detected. In most cases they probably correspond to massive volcanite flows or sills. These areas are relatable to the risk of potential rockfalls, depending on the fracturing state of the rock and on the geometric intersection relationships between the main joint sets and the topographic surface; instability mechanisms such as toppling or collapse of wall portions might be produced by saturation of the rock mass consequent to the reservoir filling. The presence of hard, fractured rocks lying upon weak horizons such as ash levels, interbedded paleosoils or weathered volcanites, may potentially increase slope instability, in consequence of the reservoir filling and saturation of the rock mass on the valley flanks, provided that appropriate topographic and fracturing conditions occur.

As referred in the document 300 GEN R SP 003 B - Main Report, the preliminary analysis of the available geological mapping and photos however has not currently identified major stability problems on the reservoir slopes.

In the reservoir area, it is possible to meet two types of landslides in relationship with the principal lithological types. Rock falls and toppling occur in Trachyte and rhyolite. Landslide occured in pyroclastic rocks (tuff, ash, agglomerate and volcanic sand).

Below the reservoir operating levels, and therefore not relevant for the operation of the plant, some stability issues might occur. The talus along the stream bed and also the presence of incoherent and semi coherent pyroclastic materials might determine sliding.
5.1.5 Hydrogeology

5.1.5.1 Hydrogeological reservoir model

The reservoir surface will extend over an area of about 206 Km$^2$, with a volume of about 14690 Mm$^3$ at the normal operating level, reaching up to 126 km north of the dam. Little information is available on geology, permeability and groundwater circulation features for the reservoir area, mainly owing to the inaccessibility of most of the area. Available data concerning the reservoir were collected from boreholes drilled at the dam site, from documents of the Gibe II project, and from remote sensing. The stratigraphy and structural geology of the reservoir banks were defined on the basis of the interpretation of ASTER scenes and other remote sensing data.

Local permeability values were acquired from boreholes drilled at the dam site. Permeability far from the dam site was estimated by comparing the information derived from the available geological maps and from records on similar rocks and soils gathered from literature. The table below displays the broad permeability classes used for this study [300 GEO R SP 002 A - Reservoir Seepage Risk Analysis]. High-permeability sectors (fault zones, weathered zones and/or highly fractures zones) are characterized by values ranging between 10-5 m/s and 10-6 m/s, whereas low permeability sectors are characterized by the presence of bedrock (10-6 m/s and 10-7 m/s) and regolith (10-7 m/s and 10-8 m/s).

<table>
<thead>
<tr>
<th>Permeability (m/s)</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.E-08</td>
<td>1.E-07</td>
<td>1.E-06</td>
</tr>
<tr>
<td>Soils, laterite, kaolinite</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trachytes, rhyolites, basalts, ignimbrites</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fault zones and/or highly fractured zones</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the geological report no relevant filtration couloirs from the reservoir have been observed along the river basin. Permeability would be of secondary type (i.e. related to fracturing of the rock mass) while primary permeability (i.e. related to porosity) would be limited to the pyroclastic units interbedded in basalt flows.

The next figure show changes in the groundwater table along the banks before (on the left) and after (on the right) the reservoir filling:

- before the filling, groundwater flows from the aquifer to the Omo river as observed from reconstruction of the piezometric surface at the dam site;
- after the filling, the opposite process takes place and the reservoir begins to feed the aquifer.
5.1.5.2 Hydrogeology at Dam Site

The hydrogeological studies at the dam site area are illustrated in the report:

- 300 GEO R SP 003 a Hydrogeological study whose findings are recalled here below.

**Hydrogeological Features of the Formations**

The main rock formations mainly present a “secondary” permeability controlled by the density of fracturing; consistent deposits of recent alluvium can fill the river bed with various thicknesses, and ancient alluvial deposits occupy limited areas on the upper sides of the plateau or they are present as intra-formation. Analyzing the hydrogeological behaviour and the permeability of the formations, the lithologies at dam site have been divided in five groups. The classification is not a recognized standard, but mainly point out the general hydrogeological features of the formations in the area. Some formations with a wide range of permeability can record a moderate or low infiltration on the basis of the proneness to fracturing, be or not to be site of suspended aquifer on the basis of the aptitude at decomposition, or being at the same time roof and body of a confined aquifer.

In light of the above the permeability degree is not “absolute” but mostly related at the behaviour of the formations in this area. Clay, laterite and silt, pyroclastic sand and ashes and their mixes have been grouped together with not any type or a very low permeability. According with a characteristic of a low permeability a second group has been selected. This class put together all the main formations present at dam site such as trachyte in dark colour, basalt, slightly vesicular basalt, brecciated basalt, tuff and silty sand. A third class has a low-moderate permeability and is shared between I (porosity) and II (fractures) type. Backfilling and soil, sand and colluvium are joined in the first type; conglomerate, slightly weathered “zoned with concentric bands” trachyte and vacuolar basalt are collected together as second type. The fourth group collects grey ignimbrite, ancient alluvium, breccia, and unweathered - weathered light grey trachyte, all of them classified as moderately permeable. High permeability characterizes the fifth group where recent alluvium and highly weathered and/or fragmented trachyte are present. The following figure lists the five groups of permeability.
Water Absorption

During the geognostic campaign of investigations at dam site, several Lugeon tests have been performed and the results at the dam axis are summarized in the figure here below.
The absorption areas at dam axis are identified by means of a blue colour range scale; colour grey has been used where no absorption has been recorded. Representative Lugeon units at the stage are added for each step or sequence with same value. The absorption areas at the dam axis are classified into two main zones. A first upper one located immediately below the Omo river rising through the left abutment. A lower second one lies below 450m a.s.l. Both of them, detected with the same shape upstream or downstream, show a high water absorption. It can be concluded that the permeability of the sound bedrock behaving as dam foundation, below an upper layer with a low/moderate absorption, is practically nil.

The Confined Aquifer

During the geognostic campaign at dam site, a confined artesian aquifer has been reached between 90 and 110 m below the riverbed, whose elevation is 678 m a.s.l. Following the course of the Omo river from upstream, the roof of the aquifer seems slightly rising, from the pre-cofferdam site (576m a.s.l.) to downstream reaching the dam toe between 585 and 598m a.s.l. The aquifer still lowers before the dam axis dropping down between 541 and 544m a.s.l. Downstream of the dam axis the level of the aquifer rises again reaching 565m a.s.l. The measured water discharges in the boreholes are very modest giving no evidence of relevant groundwater circulation, if compared to the Omo river flows.

5.1.5.3 Reservoir Seepage risk assessment

Further to document [300 GEO R SP 002 A - Reservoir Seepage Risk Analysis]:

- no receptive basins at an altitude lower than the reservoir bottom have been located within a distance of at least 100 Km from the reservoir itself; elevations below 670 m a.s.l. are recorded only downstream of the dam. The Main Ethiopian Rift east of the Gibe III reservoir lies at elevations higher than the reservoir as well. Therefore, seepage from the Gibe III reservoir towards nearby catchments can be excluded.

- the structural lineament study led to recognize two main lineament sets directed N20°E (parallel to the MER) and N120°E, and subordinate ones with directions N50°E, N70°E, N135°E, N160°E, N-S and E-W. Single lineaments have a length in the order of 1.000 to 4.000 m, whereas major composite structures have an observable persistence in the order of 30-40 Km. The structural pattern observed in the study area (no large scale interconnection) allows to exclude the risk that significant infiltration of water from the reservoir may occur along fault zones. A preferential filtration direction can be inferred parallel to the N20°E set, i.e. to the main river course, further limiting the possibility of consistent water loss away from the reservoir area.

- the supposed seepage from the reservoir towards the banks (saturation of the banks) doesn’t influence negatively the filling time being the filtered volume as much as 11% of the total reservoir volume. The filling time of the reservoir ranges between 12 and 16 months, i.e. 1 to 2 months longer than the result obtained without considering seepage into the banks.

5.1.6 Soils

The alteration of the geologic basement in the area has led to the appearance of different types of soils, that can be classified in the following groups.

To a first general soil group belong Eutric Nitosols, Ortic and Chromic Luvisols and Orthic Acrisols (according to the FAO classification), all these soils have a significant clay Bt level of dark reddish brown
colour. They generally come from the alteration of the basaltic basement and are found on the hills and ridges. They are deep sandy-clay-loam soils, quite draining, but they have a tendency to erosion.

The second ones are faintly stratified, dark reddish brown soils (named Eutric Cambisols according to the FAO classification). Found in the valleys, these sandy-clay soils are composed of colluviums taken on the near slopes.

The third group of soils that can be found in the area are dark brownish black soils (that belong to the Pellic Vertisols according to the FAO classification). These clay predominantly soils are generated by the alteration of tuffs and fine ashes deposits.

The main characteristics of this different soil types are summarized in the following Table 5.7.

Table 5.7: Description, according to FAO classification, of the soils identified in the reservoir area

<table>
<thead>
<tr>
<th>Soil type (FAO classification)</th>
<th>Description of soil characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eutric Nitosols</td>
<td>Soils having an argillic B horizon with a clay distribution where the percentage of clay does not decrease from its maximum amount by as much as 20 percent within 150 cm of the surface; lacking plinthite within 125 cm of the surface; lacking vertic and ferric properties</td>
</tr>
<tr>
<td>Ortic Luvisols</td>
<td>Other soils having an argillic B horizon</td>
</tr>
<tr>
<td>Chromic Luvisols</td>
<td>Soils having a strong brown to red B horizon (rubbed soil has a hue of 7.5YR and a chroma of more than 4, or a hue redder than 7.5YR)</td>
</tr>
<tr>
<td>Orthic Acrisols</td>
<td>Soils having an argillic B horizon; with a base saturation which is less than 50 percent (by NH4OAc) in at least some part of the B horizon within 125 cm of the surface</td>
</tr>
<tr>
<td>Eutric Cambisols</td>
<td>Soils having a cambic B horizon or an umbric A horizon which is more than 25 cm thick</td>
</tr>
<tr>
<td>Pellic Vertisols</td>
<td>Soils which, after the upper 20 cm are mixed, have 30 percent or more clay in all horizons to at least 50 cm from the surface; at some period in most years have cracks at least 1 cm wide at a depth of 50 cm, unless irrigated, and have one or more of the following characteristics: gilgai microrelief, intersecting slickensides or wedge-shaped or parallelepiped structural aggregates at some depth between 25 and 100 cm from the surface. Pellic Vertisols have moist chromas of less than 1.5 dominant in the soil matrix throughout the upper 30 cm.</td>
</tr>
</tbody>
</table>

It is estimated that Vertisols comprise about 24% of all cropped highland soils (Jutzi and Haque, 1985). Vertisols are potentially among the most productive soils of sub-Saharan Africa, but they are agriculturally underutilised within the traditional farming practices due to excess soil moisture from waterlogging during the heavy rains.

5.1.7 Hydrology

The hydrological elaborations which are reported hereafter are aimed at the study of the mean annual runoff and its monthly variability, and the extreme flood runoff, for the basins of the Gibe-Omo River with closing section located at Dam Site 5 as defined in the general plan [200 GEN D SP 007 A]:

The first important aspect is the determination of the mean runoff which is a key issue for the evaluation of the productivity of the power plant.

As no hydrometric station is located nearby the dam site, the estimation of the mean runoff is carried out with “indirect” methods which are based on the analysis both of runoff and rainfall time series. While a good
number of hydrometric stations are present in the upper part of the watershed, no instrumentation is located in the downstream part. On the contrary rainfall gauges are present all over the catchment area, even if with lower frequency in the downstream part. This circumstance makes impossible to estimate directly runoff through the elaboration of runoff series, but implies an indirect estimation by mean of rainfall rates in all or part of the basin. Due to the uncertainties introduced by this indirect estimation on such a wide area the determination of runoff was carried out with four different procedures:

1. elaboration of available runoff time series,
2. elaboration of rainfall and estimation of the runoff coefficient,
3. mixed use of runoff (on 67% of the basin) and rainfall (on the residual 33%),
4. estimation of losses by mean of evapotranspiration.

Finally the monthly variability is evaluated and the historical runoff series at Dam Site 5 determined.

All the elaborations were carried out considering the rainfall and runoff data provided mainly by gauges of the Ethiopian National Meteorological Service Agency and Ethiopian Water Resources Authority. In addition external data were used coming only from officially approved documents related to other project in the same area (listed in the following). All these documents provided very useful information both in terms of data, and in giving elements for comparison with the results obtained in the elaboration. Special attention was devoted to the “Omo-Gibe River Basin Integrated Development Master Plan Study”, Vol. VI - Water Resources Surveys and Inventories, of Dec 1996, which contains a lot of hydrological information for the entire Gibe – Omo River watershed, thus supplying those information lacking in the downstream part of the basin under investigation.

The extreme flood flows have been calculated by applying a consistent rainfall-runoff model.

5.1.7.1 **Physical and meteorological features of the area**


The following information are mainly extracted from the mentioned document.

**Description of the watershed**

The Gibe River rises just north of latitude 9°N and longitude 37°E of the Ethiopian Plateau, geologically an area comprised of Tertiary volcanics. The Gibe headwaters are at an elevation of about 2200 m asl. Although there are some important tributaries from different directions, the general direction of flow of the Gibe River is southwards, towards the Omo River/Lake Turkana Trough, a fault feature filled with alluvial and lacustrine sediments of recent origin associated with the Great Rift Valley. The northern part of the catchment has a number of tributaries from the NE, the largest ones being the Walga and the Wabi River. These drain largely cultivated land, much of it with rather impeded drainage. This is an area where erosional processes are important. The Tunjo and Gilgel Gibe Rivers are important tributaries, also draining mainly cultivated lands from the SW. These have a higher proportion of more permeable soils than the Walga and Wabi catchments.
The cultivated land in the upper catchments is usually found on the uplands. In the valley bottom the land is mainly classified hydrologically as rangeland. Going downstream another important tributary is found from the west, the Gojeb River. It drains uplands that have been less intensively used for agriculture than the area around Jima to the NE. The prevailing vegetation of the Gojeb headwaters is wooded shrubland. The Gibe River is known as the Omo River in its lower reaches, south-western from the confluence with the Gojeb River. Downstream the confluence with the Denchiya River, which is anyway outside the area under investigation, the Omo River changes its character in traversing the flood plain leading to Lake Turkana as a well-defined meandering river channel.

Many of the rivers rise in plateau areas at an elevation above 2000 m a.s.l and parts of the watershed are higher than 3000 m asl. The Gibe itself rises at an elevation of 2000 m a.s.l and crosses the 1000 m asl contour between the Megecha and the Gojeb tributaries. To the west of the river basin the watershed reaches an elevation of 3000 m a.s.l between the Gojeb and the Gilgel Gibe River.
Morphological data

For the purpose of the present study the entire Gibe III Basin has been divided in the following five contributing catchments:

1. Gilgel Gibe River at Gibe I Dam site;
2. Graet Gibe River at Abelti without Gibe I;
3. Wabe River at Wolkite;
4. Gojeb River at OM19 section (the proposed dam site in reference²);

5. Residual Catchment.

Figure 5.3 is extracted from the DTM of the area. The main watercourse and the five watersheds controlling the flood formation process at Gibe III site are indicated in the map.

The relevant morphologic parameters required in the runoff analysis are listed in the Table 5.8 below:

Table 5.8: Physical data of the watersheds

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Area [km²]</th>
<th>Basin Elevation</th>
<th>Mean Watercourse</th>
<th>Centroid²</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Max [m a.s.l.]</td>
<td>avg [m a.s.l.]</td>
<td>min [m a.s.l.]</td>
<td>L [km]</td>
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<tr>
<td>Abelti</td>
<td>11516</td>
<td>3268</td>
<td>1890</td>
<td>1084</td>
</tr>
<tr>
<td>Gibe I</td>
<td>4230</td>
<td>3340</td>
<td>2022</td>
<td>1629</td>
</tr>
<tr>
<td>OM19</td>
<td>5136</td>
<td>3261</td>
<td>1911</td>
<td>1031</td>
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<tr>
<td>Residual</td>
<td>11411</td>
<td>3390</td>
<td>1839</td>
<td>712</td>
</tr>
<tr>
<td>Wabe</td>
<td>1866</td>
<td>3611</td>
<td>2450</td>
<td>1677</td>
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</tbody>
</table>

1 - data from the hydrologic report of the Basic Design³
2 - centroid of the catchment, UTM coordinates

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Climate and rainfall features

The climate is classifiable as tropical humid in the highlands that include the areas surrounding Jima and around the headwaters of the Gojeb River. For the rest, and greatest part, of the watershed the climate is classifiable as a tropical sub-humid, intermediate between the tropical humid and the hot arid climate characteristic of the southernmost part of the floodplain toward Lake Turkana. The seasonal variation in climate is associated with the oscillation of the Inter-Tropical Convergence Zone (ITCZ), a low pressure area of convergence. The ITCZ shifts during the year northwards across southern Ethiopia from September to November and southwards from March to May, giving origin to the alternation of a wet (from June to September) and a dry (from December to April) season. During the wet season the area is under the influence of Atlantic equatorial westerlies and southerly winds from the Indian Ocean, producing strong precipitation, mainly due to the Atlantic moist component. During the dry season the moist air comes from the Gulf of Aden and the Indian Ocean, causing little rains.

As the main source of moist air is from the Atlantic Ocean, from the SW, the eastern parts of the highlands are more or less rain shadowed. This effect can be seen on the isohyetal map of the area, reported in the Omo River Master Plan (Figure 5.4). The area of greatest rainfall is to the NW of Jima (outside the Gibe Basin). Rainfall declines sharply in the lower lying southern parts of the basin. According to the isohyetal map of the OGMP, the rainfall ranges from over 1900 mm/year in the northern and western part of the basin, to about 1200 mm/year in the lower part of the project area. Rainfall rates decrease strongly southwards, to less than 300 mm/year near Lake Turkana.

Hydro-meteorological data

The hydrological elaborations reported in the following sections are mainly based on rainfall and runoff data provided mainly by gauges of the Ethiopian National Meteorological Service Agency and Ethiopian Water Resources Authority. In addition external data were used coming only from officially approved documents related to other project in the same area. These documents are:


2) the Gilgel Gibe Hydroelectric Project, Hydrological Report, Nov 1995, carried out by ELC Elettroconsult and ENEL SpA for the Ministry of Mines and Energy - Ethiopian Electric Light and Power Authority,

3) the Gojeb Medium Hydropower Project, Pre-Feasibility Study, Vol.1 - Executive Summary, Vol. 3 - Annex A, Hydrology, Oct 1996, carried out by Howard Humphreys, Coyne et Bellier, Rust Kennedy & Donkin,

Rainfall data

The rainfall data, provided in paper format, have been used in the elaborations (Table 5.9). Only the stations in or nearby the project basin were considered. There are several rainfall stations in operation, especially in the upper part of the basin, with quite long time series of observation. Most of them have over 15 years of observations; some of them have more than 40 years of records (Jima, Agro, Wolayita Sodo) even if sometime these records are not continuous. In addition the rainfall data for the stations of Nonno and Bobu were derived from the these data are official, as they were derived by the EELPA (Ethiopian Electric Light & Power Authority) report of January 1984.

For all the 40 stations the mean monthly and yearly rainfall rates were derived, as reported in Table 5.10. According to the considerations of the Omo River Master Plan, previously reported, and the isohyetal map of Figure 5.4, it can be seen that the stations located in the highlands in the northern (Gibe river) and south-western part of the watershed (Little Gibe and Gojeb river) are characterised by high rainfall rates (1800 mm/year at Babu and Cheleke Leki in the Gibe river, 1800 mm/year at Wush Wush and Bobu, 1750 mm/year at Meteso in the Gojeb basin) while the lowest valleys and the eastern part shows a general decrease (1200 mm/year at Hossana). The monthly variability of rainfall of the north-east part of the basin
has a marked seasonal nature with July and August having particularly high amounts of rainfall. The Wolkite station is indicative in this sense (Figure 5.5). The western part is characterised by a less extreme behaviour with a rainfall almost constant from April to September (Figure 5.6).

Table 5.9: Rainfall stations of the NMSA and periods of observation

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Observation</th>
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<tbody>
<tr>
<td></td>
<td>Region</td>
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<td>3 EJAJE SHEWA</td>
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<td>09°00'</td>
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<td>09°02'</td>
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<tr>
<td>5 TIKUR-ENKINI SHOA</td>
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<tr>
<td>7 AIMEJA GINDA SHOA</td>
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<td>08°34'</td>
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<tr>
<td>8 ATNAGO KEFA</td>
<td>36°52'</td>
<td>08°19'</td>
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<tr>
<td>9 CHELEKE LEKI KEFA</td>
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<td>08°13'</td>
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<tr>
<td>10 BABU KEFA</td>
<td>36°55'</td>
<td>08°06'</td>
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<tr>
<td>11 KUMBI KEFA</td>
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<td>12 ABELTI KEFA</td>
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<tr>
<td>40 BONGA KEFA</td>
<td>36°14'</td>
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*After infilling of data
Table 5.10: Mean monthly and yearly rainfall for the all the considered gauging stations

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Mean Rainfall:

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Table 5.10: Mean monthly and yearly rainfall for the all the considered gauging stations

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Mean Rainfall:

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</table>
Rainfall at Wolkite

Figure 5.5: Monthly rainfall at Wolkite station (1985-2004)

Rainfall at Bonga

Figure 5.6: Monthly rainfall at Bonga station (1953-2003)
Runoff data

Another fundamental hydrological parameter was considered in the elaborations reported in the following paragraphs: runoff. Unfortunately not as many gauging stations as rainfall ones are present in the basin under investigation, but few of them at located at key sites, thus assuming particular importance. Gauging stations are mainly maintained by the Hydrology Department of the Ethiopian Water Resources Authority which processes and archives data. The longest record is that of the Abelti station on the Gibe River, starting in 1963.

The following table reports the available hydrometric data:

| Table 5.11: Runoff stations of the EWRA and periods of observation |
|---------------------------------|-----------------|----------------|-----------------|----------------|----------------|----------------|
| **Location** | **Catchment** | **Observation** | **Region** | **Basin** | **Longitude** | **Latitude** | **Elevation masl** | **Area km²** | **Mean elevation m asl** | **Max elevation m asl** | **n. year** | **Period** |
| GIBE nr LIMU GENET | SEKA | 1 | GIBE | 36°56’ | 08°06’ | - | 533 | - | - | 14 | 84-04 |
| GIBE nr SEKORU | 3 GIBE river nr. ABELTI | 24 | GIBE | 36°45’ | 07°36’ | - | 280 | - | - | 24 | 80-03 |
| KEFA | 3 | GIBE | 37°35’ | 08°14’ | 1100 | 15746 | 2030 | 3386 | 40 | 63-04 |
| KEFA | 4 | BIDRU AWANA nr. SEKORU | GIBE | 37°24’ | 07°55’ | 1500 | 41 | 2262 | 2536 | 20 | 81-03 |
| KEFA | 5 | BULBULE nr. SERBO | GIBE | 37°02’ | 07°34’ | 1700 | 301 | 1977 | 2837 | 8 | 86-93 |
| KEFA | 6 | MEGECHA nr. GUBRIE | GIBE | 37°28’ | 08°11’ | 1500 | 286 | 1750 | 2000 | 32 | 67-04 |
| KEFA | 7 | GILGEL GIBE nr. ASENDABO | GIBE | 37°11’ | 07°45’ | 1650 | 2966 | 2200 | 3359 | 27 | 67-93 |
| SHEWA | 8 | REBU river nr. WOLKITE | GIBE | 37°47’ | 08°21’ | 1500 | 480 | 2067 | 2882 | 23 | 67-89 |
| SHEWA | 9 | WABI nr. WOLKITE | GIBE | 37°46’ | 08°15’ | 1700 | 1866 | 2487 | 3719 | 38 | 67-04 |
| SHEWA | 10 | GOGHEB river nr. ENDIBIR | GIBE | 37°54’ | 08°06’ | - | 190 | - | - | 32 | 67-99 |
| GOJE | 11 | GOJEB nr. SHEBE | GIBE | 36°23’ | 07°25’ | 1080 | 3356 | 1976 | 3358 | 36 | 70-05 |
| BONGA | 12 | GECHA nr. BONGA | GIBE | 36°13’ | 07°17’ | - | 175 | - | - | 23 | 82-04 |
| BONGA | 13 | SHETA nr. BONGA | GIBE | 36°14’ | 07°17’ | - | 191 | - | - | 25 | 80-04 |

It should be noted that for the station of Asendabo the runoff time series was derived from the Gilgel Gibe Hydroelectric Project, Hydrological Report, and November 1995. Most of the stations show a sufficiently long period of record. In some cases of particular importance (Abelti and Wabi), as will be shown in the following paragraphs, the infilling of missing data was necessary to obtain 40 years long time series. The Serbo station, with an 6 years long period of record, was excluded from the elaborations. As it can be seen the Abelti station on the Gibe River has particular importance as it represents alone a considerable percentage of the entire area under investigation (almost 46%). Most of the gauging stations listed in Tab. 3 are located upstream Abelti. Also the Wolkitite station on the Wabi River is of great importance, as it covers an area, downstream Abelti, of 5% of the total area. The same consideration can be made for the Shebe gauging station on the Gojeb River (10% of the total area), but to enlarge the area covered by this station the runoff time series at the Gojeb Dam Site OM19 location was considered (15% of the total area), as reported in the Gojeb Medium Hydropower Project, Pre-Feasibility Study, Vol.1 - Executive Summary, Vol. 3 - Annex A, Hydrology, Oct 1996. The data reported for OM19 were suitably infilled for the years following 1996 according to the Shebe runoff, following the deterministic correlation existing between these two sites.
Unfortunately no hydrometric station is located in the residual part of the basin, downstream the Gibe River at Abelti, Wabi River at Wolkite and the Gojeb River (at Shebe or at the dam site). This residual part represents almost 33% of the total area.

Integration of runoff time series

The integration of data was carried out for the hydrometric stations of Abelti on the Gibe River, Wolkite of the Wabi River and Gojeb dam site OM19 on the Gojeb River. These stations, as discussed in the previous paragraph, are of particular importance in the calculation of the mean runoff of the total project area. For these three sites 40 years long time series were obtained after infilling.

a) Abelti station on the Gibe River

Ideally, the infilling of data should be based on the correlation with other reliable flow records nearby the considered station. Unfortunately no station is present on the same river reach, with a sufficiently long record. Abelti is in fact the station with the longest time series with more than 30 years long records (1963-2004) even if not continuous. At this point the problem was to individuate a suitable station, in terms of reliability of measurements and length of recording period.

After a first unsuccessful attempt with the flow series analysed during the OGMP study of 1995, the Abelti runoff time series was filled and extended using the runoff data for the Shebe station on the Gojeb river reported in the mentioned Gojeb Medium Hydropower Project, Pre-Feasibility Study. In that study this series was integrated and extended from the OGMP Shebe record suitably adjusted, obtaining a 40 years long series (1955-1994). The series was finally completed with the more recent observation (1995-2003) available.

To obtain a full 40 years series the extension was truncated to the last complete year of observation at Shebe (2001). To account for the two missing data of Jan and Feb 1996, which is not clear if they are missing or if they are nil data (the first hypothesis is more probable), the real data of the first months of 2004 were included.

In conclusion Tab. 4 and Tab. 5 of [200 HYD R SP 001 A - Hydrological report, Vol 1] report the integrated runoff series for the Abelti station in m$^3$/s and M$^3$ respectively. In light yellow are reported the infilled data. The mean runoff is 190.35 m$^3$/s (obviously the mean runoff was calculated as a weighted average according to the number of day in each month). The yearly runoff is almost 6000 M$^3$. The monthly runoff follows the typical variability of rainfall with a dry and a wet season. The highest runoff is reached in August with a mean monthly flow of 616.5 m$^3$/s.

The mean value of 190 m$^3$/s substantially agrees with the value computed in the OGMP, that, as already noticed, tends to overestimate runoff. The addition in our elaboration of slightly wetter annual record has balanced the result to 190 m$^3$/s. The same cannot be said for the other downstream sections or sub-catchments. In fact the OGMP itself states that “it is believed that the flows upstream Abelti are reasonably well simulated. However, because of the limited number of gauging stations in the southern part of the basin, flow there are likely to be less accurate, especially the distribution of flow into sub-catchments.” In Figure8 the annual runoff for the Abelti station is reported. Moreover a five years moving average was added to the plot. It can be noted a marked trend to relatively larger runoff beginning in 1989. This is probably due, as already noted by OGMP, to a progressive deforestation which has take place in favour of agriculture in the highlands of the upper part of the basin.
b) Shebe station on the Gojeb River

Particular interest lies in the Shebe station on the Gojeb River as it drains an area not covered by the Abelti hydrometric station on the Gibe River. The data used in the elaborations were those obtained in the Gojeb Medium Hydropower Project, Pre-Feasibility Study, Vol. 1 - Executive Summary, Vol. 3 - Annex A, Hydrology, Oct 1996. In that study this series was integrated and extended from the OGMP Shebe record suitably adjusted, obtaining a 40 years long series (1955-1994). The series was finally completed with the more recent observation (1995-2003) available.

The addition of the record from 1995 to 2003 has the effect of slightly increasing the mean runoff as some of those years were particularly wet. Figure 9 shows the yearly runoff for the total record period. A 5 years moving average reveals the increasing trend of runoff during for the 1994 upwards with the only exception of 2002 and 2003.

![Figure 5.7: Annual runoff for the Shebe station on the Gojeb River](image)

Tab. 6 and Tab. 7 of [200 HYD R SP 001 A - Hydrological report, Vol 1] report the runoff series for the Shebe station in m³/s and Mm³ respectively. The mean runoff is 60.05 m³/s. The yearly runoff is almost 1894 Mm³. Even in this case the monthly runoff follows the typical variability of rainfall with a dry and a wet season, even if the behaviour is smoother than the Abelti’s one for with the increasing and decreasing of runoff is steeper. The highest runoff is reached in August with a mean monthly flow of 147.9 m³/s.

c) Dam site OM19 on the Gojeb River

To enlarge the area covered by the Shebe hydrometric station, which drains an extension equal to 10% of the total project area, the runoff time series at the Dam Site OM19 was considered (15% of the total area).

To obtain this series the data reported in the Gojeb Medium Hydropower Project, Pre-Feasibility Study, Vol. 1 - Executive Summary, Vol. 3 - Annex A, Hydrology, Oct 1996 were considered. The data reported for
OM19 were suitably infilled for the years following 1996 according to the Shebe runoff, following the
deterministic correlation existing between these two sites. The transposition of the Shebe flow series to the
dam site OM19, adopted in the mentioned report, was based only on catchment areas. The difference in
rainfall ratio (equal to 0.98) was considered negligible. So the conversion factor between Shebe (3356 km²)
and OM19 Dam site (5136 km²) was the ratio between areas.

Tab. 10 and Tab. 11 of the [200 HYD R SP 001 A - Hydrological report, Vol 1] report the runoff series for
the OM19 Dam site location in m³/s and Mm³ respectively. The mean runoff is 91.66 m³/s. The yearly
runoff is almost 2900 Mm³. The monthly variability is obviously the same of the Shebe station, due to the
deterministic transposition. The highest runoff is reached in August with a mean monthly flow of 226.3 m³/s.

d) Wolkite station on the Wabi River

Also the Wolkite hydrometric station on the river Wabi is of great interest because its catchment lies
downstream the Abelti’s one covering an area of 1866 km² equal to 5% of the total project area.

The basin is located in an area with a rainfall regime similar to that of Abelti. The south-eastern part of the
global basin, as discussed in a previous paragraph, is in general characterised by a drier climate. Nonetheless
the Wabi basin, according to the isohyetal map of Figure 5.4, is interested in the upper part by high relieves
which should sensibly increase its rainfall rates.

The hydrological series is quite long, having an average recording period of 35 years even if not continuous.
The average runoff resulting from these data is 30.9 m³/s. In order to extend the observation period to a full
40 years record, the integration and infilling of the runoff series was carried out by mean of the
contemporary observation of the Abelti station, which lies nearby showing a good correlation, and has a long
recording time.

Tables 14 and 15 of the [200 HYD R SP 001 A - Hydrological report, Vol 1] reports the integrated data: the
average runoff is 30.35 m³/s, substantially confirming the value coming from the non-integrated data set, the
mean annual runoff is 957 Mm³.

Estimation of mean runoff

As no hydrometric station is located nearby the dam sites under investigation, the estimation of the mean
runoff is carried out with “indirect” methods which are based on the analysis both of runoff and rainfall time
series.

A good number of hydrometric stations are present in the upper part of the watershed covering an extension
of almost 67% of the basin, while no instrumentation is present in the downstream part. On the contrary
rainfall gauges are present all over the catchment area, also in the remaining downstream part even if in a
small number. This circumstance makes impossible to estimate directly runoff through the elaboration of
runoff series, but implies an indirect estimation by mean of runoff in the upper part of the basin or rainfall
rates in all or part of the basin. Due to the uncertainties introduced by this indirect estimation on such a wide
area the determination of runoff was carried out with four different procedures:

1) elaboration of available runoff time series,
2) elaboration of rainfall and estimation of the runoff coefficient,
3) direct observation of runoff on 67% of the basin and elaboration of rainfall on the residual 33%,
4) estimation of losses by mean of evapotranspiration.
1. The first procedure is based only on extrapolation on a wider area of the upstream hydrometric observations. This methodology derives the climatic feature of the downstream part only through the observation of the upstream one. It should be underlined that the exclusive use of the direct measurements of the parameter of interest, that is runoff, gives to this procedure a certain robustness.

2. The second procedure is mainly based on the elaboration of rainfall rates which are available all over the basin, even if in the downstream part less accurately due to the smaller number of gauging stations. The transformation of rainfall into runoff is carried out by means of the runoff coefficient, which can be estimated with a good precision only in the upper part of the basin where hydrometric stations are present. It is then necessary to estimate the runoff coefficient for the residual downstream area. This procedure is robust in the sense that uses an information spread all over the catchment area (even downstream), but is influenced by the uncertain intrinsic nature of rainfall (both in terms of measures and in terms of spatial interpolation) and of the rainfall-runoff transformation through the runoff coefficient.

3. The third procedure can be considered a mix of the previous two. For the 67% of the basin the direct measure of runoff is used, while on the remaining 33% the estimation of runoff is carried out through the elaboration of rainfall and the estimation of the rainfall coefficient. This procedure is very robust as it uses, for the greatest part of the basin, the direct observation of the parameter of interest, and for the residual (smaller) one, the only available information that is rainfall.

4. The fourth procedure is based on the evaluation of hydrological losses on a long time period through ETP. In fact the total precipitation on a catchment may be considered to consist of precipitation excess and abstraction (losses). The precipitation excess is that part of the total precipitation that contributes directly to runoff. The abstractions are the remaining parts that eventually do not become surface runoff, such as interception, evaporation, transpiration, depression storage and infiltration. Assuming that the time scale of the hydrological balance is sufficiently long (for ex. 1 year) the only loss factor is evapotranspiration. In other words the whole rainfall volume, minus the evapotranspiration losses, becomes runoff over one year time, in different forms: direct runoff and base runoff.

The following Table 5.12 shows the mean runoff values estimated.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Mean runoff estimated (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. analysis of runoff</td>
<td>442.50</td>
</tr>
<tr>
<td>2. analysis of rainfall-runoff</td>
<td>435.80</td>
</tr>
<tr>
<td>3. mixed used of runoff and rainfall</td>
<td>436.10</td>
</tr>
<tr>
<td>4. evapotranspiration and evaporation</td>
<td>350.00</td>
</tr>
</tbody>
</table>

Concerning the monthly behavior of runoff, the considered time series were those of the Gibe River at Abelti, Wabi at Wolkite, Gojeb at the Dam Site OM19. As already discussed this areas are characterised by strong regional feature, Abelti and Wabi being almost homogeneous with a marked seasonal feature of rainfall and runoff, while Gojeb has a smoother climatic regime. The residual part of the basin downstream Abelti and Wabi belongs to the same climatic region of these ones. So for this part of the basin the monthly runoff was obtained from the estimated mean annual value attributing the same monthly variability of Wabi. Little difference would be introduced if the Abelti variability would be considered. The monthly flow at the Dam Site 5 is obtained adding the runoffs of these 4 components.
It is worth underlining the greatest mean runoff occurs in August, reaching the considerable value of 1509 m³/s.

Table 5.13: Monthly variability of runoff at Dam Site 5 in m³/s

<table>
<thead>
<tr>
<th></th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abelti</td>
<td>41.4</td>
<td>33.1</td>
<td>23.5</td>
<td>28.5</td>
<td>52.0</td>
<td>132.1</td>
<td>364.9</td>
<td>616.5</td>
<td>509.9</td>
<td>294.6</td>
<td>112.7</td>
<td>60.4</td>
<td>190.3</td>
</tr>
<tr>
<td>OM19</td>
<td>17.7</td>
<td>14.3</td>
<td>18.2</td>
<td>24.6</td>
<td>54.1</td>
<td>116.8</td>
<td>184.5</td>
<td>226.3</td>
<td>212.9</td>
<td>137.7</td>
<td>58.9</td>
<td>28.0</td>
<td>91.7</td>
</tr>
<tr>
<td>Wabi</td>
<td>3.9</td>
<td>4.7</td>
<td>4.1</td>
<td>6.9</td>
<td>7.8</td>
<td>18.3</td>
<td>77.8</td>
<td>132.2</td>
<td>65.0</td>
<td>26.8</td>
<td>8.3</td>
<td>5.3</td>
<td>30.4</td>
</tr>
<tr>
<td>Residual</td>
<td>16.2</td>
<td>19.3</td>
<td>16.9</td>
<td>28.5</td>
<td>32.2</td>
<td>76.0</td>
<td>322.2</td>
<td>547.8</td>
<td>269.1</td>
<td>110.8</td>
<td>34.5</td>
<td>21.9</td>
<td>125.7</td>
</tr>
<tr>
<td>Total</td>
<td>79.2</td>
<td>71.4</td>
<td>62.6</td>
<td>88.5</td>
<td>146.0</td>
<td>343.3</td>
<td>949.4</td>
<td>1522.9</td>
<td>1056.9</td>
<td>569.8</td>
<td>214.5</td>
<td>115.6</td>
<td>438.1</td>
</tr>
</tbody>
</table>

Table 5.14: Monthly variability of runoff at Dam Site 5 in Mm³

<table>
<thead>
<tr>
<th></th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APR</th>
<th>MAY</th>
<th>JUN</th>
<th>JUL</th>
<th>AUG</th>
<th>SEP</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Abelti</td>
<td>108.1</td>
<td>78.2</td>
<td>62.9</td>
<td>73.8</td>
<td>139.3</td>
<td>342.5</td>
<td>977.5</td>
<td>1651.4</td>
<td>1321.6</td>
<td>789.1</td>
<td>292.1</td>
<td>161.8</td>
<td></td>
</tr>
<tr>
<td>OM19</td>
<td>48.6</td>
<td>36.4</td>
<td>48.6</td>
<td>63.8</td>
<td>144.9</td>
<td>310.0</td>
<td>494.1</td>
<td>606.1</td>
<td>551.9</td>
<td>368.7</td>
<td>152.7</td>
<td>74.9</td>
<td></td>
</tr>
<tr>
<td>Wabi</td>
<td>10.5</td>
<td>11.3</td>
<td>10.9</td>
<td>17.8</td>
<td>20.8</td>
<td>47.5</td>
<td>208.3</td>
<td>354.2</td>
<td>168.4</td>
<td>71.6</td>
<td>21.6</td>
<td>14.2</td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>43.5</td>
<td>46.6</td>
<td>45.3</td>
<td>73.9</td>
<td>86.1</td>
<td>197.0</td>
<td>863.0</td>
<td>1467.3</td>
<td>697.5</td>
<td>296.8</td>
<td>89.5</td>
<td>58.7</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>210.7</td>
<td>172.5</td>
<td>167.8</td>
<td>229.4</td>
<td>391.1</td>
<td>897.0</td>
<td>2542.9</td>
<td>4078.9</td>
<td>2739.4</td>
<td>1526.3</td>
<td>555.9</td>
<td>309.6</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.15: Total annual and mean monthly runoff at Dam Site 5 in Mm³

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abelti</td>
<td>5998.2</td>
<td>499.8</td>
</tr>
<tr>
<td>OM19</td>
<td>2900.7</td>
<td>241.7</td>
</tr>
<tr>
<td>Wabi</td>
<td>957.2</td>
<td>79.8</td>
</tr>
<tr>
<td>Residual</td>
<td>3965.3</td>
<td>330.4</td>
</tr>
<tr>
<td>Total</td>
<td>13821.3</td>
<td>1151.8</td>
</tr>
</tbody>
</table>

**Extreme flood runoff**

The analysis of the extreme flood flows are based on:

- Standard statistics of the precipitation⁴, ⁵, ⁶, ⁷, ⁸;
- A largely adopted procedure for estimating the PMP⁹, ¹⁰, ¹¹;
- U.S. Weather Bureau method for transposition of point rainfall data to areal precipitation¹², ²;
- U.S. SCS rainfall-runoff model⁴, ⁵, ⁶, ⁸, ³;
- A former flood analysis for the gauged catchments included in the Omo River Basin closing at the dam site²;

---

• Hydrological studies for other regions comprised in the catchment of interest\textsuperscript{13,14}
• Gibe III Hydrological Study of the Basic Design\textsuperscript{3}.

The transformation of rainfall into runoff has been carried out developing a hydrological model of the whole watershed by means of HEC HMS 3.1.0 software in order to better control the process of formation of the flood over the contributing catchments taking into account the routing effect due to the operating upstream Gibe I Dam, the routing effect along the river, and the hydrographs combination in correspondence of the junctions.

Geomorphologic parameters of the single catchment have been derived from a digital terrain model using GIS tool.

\textbf{Rainfall analysis}

Daily precipitation records have been used to generate 3-, 5-, 7-, 10- and 15-day records.

The longest duration of 15 days has been preliminarily chosen as the critical storm duration basing on experience of catchments of comparable extension (about 35,000 km\textsuperscript{2}) and basing on some empirical expression\textsuperscript{2} such as \textit{d}_{\text{crit}} = (A/100 + 0.5)^{0.5}, which provides 18 days for the given area.

Rainfall-runoff analysis for longer durations adopting extrapolated data has shown, indeed, that peak flood increase after 15 days is practically negligible.

\textbf{Frequency analysis of extreme precipitation}

A brief analysis of the mean of the annual max records shows that this value varies in a narrow range 61.5 mm \textendash{} 49.2 mm if Gedo with 28.7 mm is excluded. This is likely due to the comparable altitude of the stations.

Gedo station is located just outside of the Gibe III catchment and its point precipitation is strongly affected by the highland which bounds the basin. Moreover Gedo is not only out of the boundary but also very close to Ejaji station, therefore as specified later on, its areal weight in the hydrological elaborations is very modest.

Consequently all the stations have been considered in the frequency analysis.

A “regional” approach, based on the assumption of the hydrological homogeneity of the sites in the Gibe III catchment area, has been applied. This approach is considered since no large number of records is available while a long dataset is mandatory for a high return period analysis in a homogeneous region. The method assumes that the probability distribution of rainfall at different sites within a region is the same except for a scale parameter, also known as “index storm”, which reflects the rainfall characteristics of the particular site and is usually assumed to be the mean rainfall at the station.

The following table lists the main results\textsuperscript{14} of the statistical elaborations for 100-, 1,000- and 10,000-year frequencies.

\textsuperscript{13} EEPCO, “Gilgel Gibe Hydroelectrical Project, Feasibility Study Main Report”, ELC Electroconsult - ENEL, Feb 1998
\textsuperscript{14} 300 HYD R SP 001 EXTREME FLOODS REPORT Jun 07 lc, studio pietrangeli, rome
Table 5.16: Frequency Analysis – Growth Factors and Point Rainfall of Gibe III

<table>
<thead>
<tr>
<th>T (years)</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>1.87</td>
<td>1.73</td>
<td>1.74</td>
<td>1.66</td>
<td>1.67</td>
<td>1.67</td>
</tr>
<tr>
<td>1000</td>
<td>2.37</td>
<td>2.15</td>
<td>2.16</td>
<td>2.03</td>
<td>2.05</td>
<td>2.05</td>
</tr>
<tr>
<td>10000</td>
<td>2.86</td>
<td>2.57</td>
<td>2.58</td>
<td>2.41</td>
<td>2.43</td>
<td>2.43</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>T (years)</th>
<th>100</th>
<th>101.63</th>
<th>145.62</th>
<th>185.13</th>
<th>212.08</th>
<th>265.56</th>
<th>338.84</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>128.71</td>
<td>180.96</td>
<td>230.21</td>
<td>260.30</td>
<td>326.55</td>
<td>416.61</td>
<td></td>
</tr>
<tr>
<td>10000</td>
<td>155.75</td>
<td>216.23</td>
<td>275.22</td>
<td>308.43</td>
<td>387.44</td>
<td>494.26</td>
<td></td>
</tr>
</tbody>
</table>

Probable maximum precipitation

The PMP is defined as “the theoretically greatest depth of precipitation for a given duration that is physically possible over a given size storm area” \(^{11}\). In the present chapter the PMP has been evaluated according to the Hershfield’s Method\(^{9,10,8,11}\).

This is a statistical method commonly adopted worldwide where a robust record of meteorological data is not available and it is based on the maximization of the observed rainfall data.

Results of the calculation and transposition of the point PMPs to the centroid of the Gibe III catchment are summarized in Table 5.17.
Gibe III – Environmental and Social Impact Assessment

300 ENV R CS 002 C - A9003099

Table 5.17:
Station

w

m
[mm]

s [mm]

ABELTI
ASENDABO
ATNAGO
BABU
BAKO
EJAJI
GEDO
KUMBI
LIMU_GENET
METESO
SAJA
SEKORU
SHEBE
WOLKITE
GIBE III

0.047
0.149
0.042
0.010
0.043
0.057
0.012
0.027
0.024
0.166
0.019
0.070
0.144
0.189

58.5
52.5
58.6
49.2
59.2
51.7
28.7
61.5
59.5
55.4
51.7
49.5
50.7
52.9

26.4
14.8
19.0
9.6
15.3
10.1
8.9
21.3
14.0
13.1
13.9
10.5
11.6
17.0

Station

w

m
[mm]

s [mm]

ABELTI
ASENDABO
ATNAGO
BABU
BAKO
EJAJI
GEDO
KUMBI
LIMU_GENET
METESO
SAJA
SEKORU
SHEBE
WOLKITE
GIBE III

0.047
0.149
0.042
0.010
0.043
0.057
0.012
0.027
0.024
0.166
0.019
0.070
0.144
0.189

122.3
111.4
140.6
133.1
143.0
126.0
81.6
146.6
144.2
136.3
126.5
121.3
122.1
138.7

30.3
23.5
24.0
16.1
33.6
23.7
24.2
24.1
33.9
33.7
20.4
24.6
23.9
36.4

D = 1 day
m ad
s ad
just
just
[mm]
[mm]
57.6
21.4
53.9
15.8
59.8
19.7
51.1
9.7
61.7
16.8
54.0
11.8
29.4
9.6
62.5
21.8
61.9
15.8
57.5
14.4
53.1
14.7
51.7
12.4
53.1
14.0
54.5
19.7

D = 7 day
m ad
s ad
just
just
[mm]
[mm]
128.3
36.7
115.7
26.3
147.2
27.1
140.7
19.5
150.4
39.2
129.5
19.3
83.5
25.8
153.5
26.6
151.1
41.2
141.8
38.6
131.9
22.3
125.8
26.7
127.6
27.4
141.3
32.8

CESI SpA - Mid-Day International Consulting Engineers

Point PMP within the project area
D = 3 day

k
17.0
17.2
17.0
17.3
16.9
17.2
18.3
16.8
16.9
17.1
17.2
17.3
17.2
17.2

k
14.3
14.8
13.7
13.9
13.6
14.3
16.0
13.5
13.5
13.9
14.2
14.4
14.3
13.9

PMP
[mm]

m
[mm]

s
[mm]

m ad just
[mm]

423.2
326.6
393.3
220.0
344.8
256.8
205.0
429.7
328.1
303.3
305.9
265.8
294.4
393.0
330.5

83.6
78.5
92.1
80.6
91.9
80.7
48.5
98.2
91.5
93.4
79.6
78.0
78.9
90.5

24.2
16.9
21.0
11.7
17.9
18.6
14.7
23.2
22.0
24.5
13.9
15.0
16.8
31.0

85.7
81.3
95.3
84.8
97.5
82.9
49.5
101.5
95.6
96.3
82.7
80.8
82.0
90.4

PMP
[mm]

m
[mm]

s
[mm]

654.2
504.5
518.0
411.2
682.6
404.9
495.4
511.8
709.1
676.4
448.1
510.2
519.8
595.9
565.6

152.7
135.3
178.1
172.2
172.6
149.2
101.6
175.6
179.2
174.9
156.9
151.4
145.0
168.0

39.9
26.8
34.0
23.2
45.4
25.0
28.9
33.6
43.9
44.9
25.9
30.3
29.3
41.5

s ad
just
[mm]
24.1
18.4
21.8
13.6
21.8
18.3
15.2
24.2
26.1
26.3
14.6
15.3
18.4
24.7

D = 10 day
s ad
m ad just
just
[mm]
[mm]
159.3
46.8
139.8
26.7
186.7
40.1
181.1
26.0
180.7
52.5
155.0
25.4
104.5
32.0
182.7
35.3
186.4
50.3
180.8
48.8
163.1
26.7
157.4
33.7
151.3
32.9
171.8
38.5

D = 5 day
k
15.9
16.1
15.5
15.9
15.4
16.0
17.4
15.3
15.5
15.5
16.0
16.1
16.0
15.7

k
13.3
13.9
12.4
12.6
12.6
13.4
15.2
12.6
12.5
12.6
13.2
13.3
13.5
12.9

PMP
[mm]

m
[mm]

s
[mm]

m ad just
[mm]

468.2
376.5
433.1
302.0
433.2
376.1
313.2
471.6
500.7
502.7
316.2
326.5
376.9
478.7
425.5

99.6
98.9
120.1
107.8
119.3
101.7
64.6
121.1
119.3
115.7
101.0
100.8
101.0
116.6

24.5
22.7
25.3
15.1
28.2
26.0
21.1
25.8
28.4
30.9
20.4
20.2
20.1
38.8

103.7
102.7
124.9
113.4
125.5
103.8
65.8
126.2
124.8
118.9
104.4
104.9
105.3
118.2

PMP
[mm]

m
[mm]

s
[mm]

780.9
511.9
686.5
509.2
844.1
495.4
589.3
626.7
813.4
797.0
514.3
606.7
596.7
667.9
652.4

191.5
170.0
228.5
224.1
212.2
195.6
131.4
222.7
231.6
217.3
202.3
190.5
190.4
222.4

51.8
34.0
39.7
30.8
52.6
26.2
38.5
55.5
55.4
51.3
31.9
37.7
31.6
61.1

s ad
just
[mm]
27.5
26.1
27.4
17.5
33.0
24.1
22.0
29.2
34.0
31.6
20.7
22.8
22.5
38.4

D = 15 day
s ad
m ad just
just
[mm]
[mm]
198.1
55.8
177.2
39.2
239.9
46.5
235.5
34.8
220.5
52.9
204.7
28.9
134.8
41.5
227.3
45.4
242.6
67.2
225.2
55.5
211.9
37.2
197.6
40.7
200.4
37.7
226.9
59.4

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k
15.2
15.2
14.4
14.8
14.4
15.2
16.7
14.4
14.4
14.6
15.2
15.2
15.1
14.7

k
12.1
12.7
11.0
11.1
11.5
11.9
14.1
11.3
10.9
11.4
11.7
12.1
12.1
11.3

PMP
[mm]
522.4
500.2
520.7
372.8
600.7
469.7
432.9
546.7
616.2
581.4
418.4
450.7
446.2
681.9
541.9

PMP
[mm]
874.5
676.2
752.0
622.4
829.6
549.4
719.7
741.2
978.3
857.4
649.1
691.7
654.9
900.8
767.4


Areal reduction factors

Computation of the areal reduction factor for the Gibe III catchment at duration of 1-, 3-, 5-, 7-, 10- and 15-day has been carried out applying the U.S. Weather Bureau method\textsuperscript{12,15}. This estimate is performed generating a record of areal rainfall for the chosen duration having multiplied each event by the relative Thiessen weighting factor.

Areal reduction factor is determined dividing the mean of the annual maxima of the areal precipitation over the entire basin by the mean of the annual maxima of point precipitation at each station for any year.

Years of observation where some station data are missing have been disregarded in the areal reduction factors definition.

The areal reduction factors so computed are given in the following table:

<table>
<thead>
<tr>
<th>Rain Duration (days)</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARF</td>
<td>0.44</td>
<td>0.59</td>
<td>0.65</td>
<td>0.67</td>
<td>0.72</td>
<td>0.79</td>
</tr>
</tbody>
</table>

Areal rainfall curves

Precipitation data are derived from daily rainfall dataset, but daily rainfall is recorded at a conventional time and therefore the dataset is not referred to an unrestricted 24hr period. Consequently results of the elaborations have been adjusted adopting the corrective factors proposed by Weiss and expressed with the following formula\textsuperscript{7,8}:

\[ R = 1 + 0.13 \left( \frac{t}{\Delta t} \right)^{-1} \]

where:

- \( t \) is the given duration;
- \( \Delta t \) is the time step of the original record, that is 1 day.

Must to be noticed that for 1 day duration the depth of rainfall is to be multiplied by 1.13, that means an increase of 13%. Obviously, for longer durations the errors tends to disappear. Table 5.19 summarizes the Weiss correction factors.

<table>
<thead>
<tr>
<th>Rain Duration (day)</th>
<th>1</th>
<th>3</th>
<th>5</th>
<th>7</th>
<th>10</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>WEISS FACTORS</td>
<td>1.13</td>
<td>1.043</td>
<td>1.026</td>
<td>1.019</td>
<td>1.013</td>
<td>1.009</td>
</tr>
</tbody>
</table>

\textsuperscript{15} Gill T. D., “Transformation of areal rainfall to point rainfall by estimating the area reduction factors, using radar data, for Texas”, Texas A&M University, May 2005
10,000 yrs and PMP Rainfall Depths assessed with two different approaches have been therefore adjusted with the Areal Reduction Factors and the Weiss Factors.

The final values are reported in Table 5.20 and plotted in a depth – duration chart. The two power law regressions built in Figure 5.8 will define the regional design rainfall curves to be adopted in the subsequent rainfall – runoff analysis.

### Table 5.20: Gibe III Areal Rainfall Depths

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Rainfall Depth (mm) vs. Duration (day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>51</td>
</tr>
<tr>
<td>1000</td>
<td>64</td>
</tr>
<tr>
<td>10000</td>
<td>77</td>
</tr>
<tr>
<td>PMP</td>
<td>164</td>
</tr>
</tbody>
</table>

### Figure 5.8: Gibe III Basin – Regional Areal Rainfall Curves

**Rainfall-runoff model**

The analysis is aimed to define not only the peak flow for a design rainfall but also the entire hydrograph entering the section of interest.

As said, the Soil Conservation Service (SCS) method\(^4\,5\,6\) has been selected to transform extreme precipitation in design flood. This model is worldwide adopted and bases on a large number of observations of basins that vary in characteristics such as size and geographic location.

The analysis is articulated in following steps:

- defining the design hyetograph;
- applying the loss model in order to convert precipitation in excess rainfall;
• determining the unit hydrograph;
• defining the routing model through reservoirs and water bodies;
• running the convolution and deriving the design flood hydrograph.

The hydrological elaborations have been performed through HEC HMS software.

A hydrologic system made of 5 contributing catchments has been created for better modelling the process of formation of the flood at Gibe III Dam site taking into consideration the routing effect due to the operating upstream Gibe I Dam and along the Omo River, and the flood hydrograph combination in correspondence of the junctions.

The HEC HMS hydrologic scheme is shown in the next figure. As described, Gibe I upstream Dam and 2 main reaches, respectively u/s and d/s of the confluence with the Gojeb River, have been added to simulate the upstream routing effects.

![Figure 5.9: Gibe III Basin - HEC HMS Hydrologic model](image)

The depth-duration curves estimated in chapter 3.5 have been adopted for selecting the total depth of rainfall at 15 days.

A total of 55 storms of duration 15 days occurred over the Gibe III Basin have been extracted from the areal precipitation records and analyzed in order to describe the most probable storm profile for the area of interest.

The non-dimensional 15-day hyetograph and the corresponding 10,000 yrs and PMP design hyetographs are numerically provided in Table 5.21 at 12 hrs time interval for computation purpose.
Table 5.21: Gibe III Basin – 360 hrs (15 days) Design Hyetographs

<table>
<thead>
<tr>
<th>Time [hrs]</th>
<th>P/Pcumulated [-]</th>
<th>P10,000yrs [mm]</th>
<th>PMP</th>
<th>Time [hrs]</th>
<th>P/Pcumulated [-]</th>
<th>P10,000yrs [mm]</th>
<th>PMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>0.014</td>
<td>5.076</td>
<td>8.284</td>
<td>192</td>
<td>0.035</td>
<td>12.561</td>
<td>20.500</td>
</tr>
<tr>
<td>24</td>
<td>0.017</td>
<td>5.972</td>
<td>9.746</td>
<td>204</td>
<td>0.031</td>
<td>11.304</td>
<td>18.450</td>
</tr>
<tr>
<td>36</td>
<td>0.023</td>
<td>8.352</td>
<td>13.632</td>
<td>216</td>
<td>0.030</td>
<td>10.766</td>
<td>17.572</td>
</tr>
<tr>
<td>48</td>
<td>0.026</td>
<td>9.280</td>
<td>15.147</td>
<td>228</td>
<td>0.030</td>
<td>10.766</td>
<td>17.572</td>
</tr>
<tr>
<td>60</td>
<td>0.032</td>
<td>11.462</td>
<td>18.708</td>
<td>240</td>
<td>0.030</td>
<td>10.766</td>
<td>17.572</td>
</tr>
<tr>
<td>72</td>
<td>0.038</td>
<td>13.485</td>
<td>22.010</td>
<td>252</td>
<td>0.029</td>
<td>10.362</td>
<td>16.913</td>
</tr>
<tr>
<td>84</td>
<td>0.046</td>
<td>16.679</td>
<td>27.223</td>
<td>264</td>
<td>0.028</td>
<td>9.869</td>
<td>16.107</td>
</tr>
<tr>
<td>96</td>
<td>0.049</td>
<td>17.557</td>
<td>28.655</td>
<td>276</td>
<td>0.026</td>
<td>9.420</td>
<td>15.375</td>
</tr>
<tr>
<td>108</td>
<td>0.056</td>
<td>20.154</td>
<td>32.894</td>
<td>288</td>
<td>0.025</td>
<td>8.972</td>
<td>14.643</td>
</tr>
<tr>
<td>120</td>
<td>0.059</td>
<td>20.994</td>
<td>34.265</td>
<td>300</td>
<td>0.024</td>
<td>8.478</td>
<td>13.833</td>
</tr>
<tr>
<td>132</td>
<td>0.060</td>
<td>21.532</td>
<td>35.143</td>
<td>312</td>
<td>0.023</td>
<td>8.075</td>
<td>13.179</td>
</tr>
<tr>
<td>144</td>
<td>0.063</td>
<td>22.430</td>
<td>36.608</td>
<td>324</td>
<td>0.021</td>
<td>7.536</td>
<td>12.300</td>
</tr>
<tr>
<td>156</td>
<td>0.050</td>
<td>17.800</td>
<td>29.052</td>
<td>336</td>
<td>0.020</td>
<td>7.177</td>
<td>11.714</td>
</tr>
<tr>
<td>168</td>
<td>0.040</td>
<td>14.355</td>
<td>23.429</td>
<td>348</td>
<td>0.020</td>
<td>7.177</td>
<td>11.714</td>
</tr>
<tr>
<td>180</td>
<td>0.036</td>
<td>13.063</td>
<td>21.320</td>
<td>360</td>
<td>0.020</td>
<td>7.177</td>
<td>11.714</td>
</tr>
</tbody>
</table>

S = 1.000

HEC HMS program internally runs the SCS loss model and operates the abstraction calculation cumulating the design hyetograph, applying

\[ P = \frac{(P(t) - 0.2S)^3}{P(t) + 0.8S} \]  

(4.1)

And finally replicating the hyetograph pattern in order to form the excess hyetograph.

CN values for Abelti, Wabe and Gojeb at Shebe catchments have been directly derived from the OGMP Flood Study which calibrated them on each of these three gauged catchments. The CNs from the OGMP were already computed considering the severe antecedent moisture condition.

CN value of Abelti and Shebe have been respectively attributed to Gibe I and Gojeb at OM19 while a weighted average according to the basin extension has been computed in order to come up with the CN value to be assigned to the Residual catchment.

Table 5.22: Gibe III HMS model – CN values

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Area [km²]</th>
<th>CN</th>
<th>S</th>
<th>Ia=0.2S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abelti</td>
<td>11516</td>
<td>74.1*</td>
<td>88.78</td>
<td>17.76</td>
</tr>
<tr>
<td>Gibe I</td>
<td>4230</td>
<td>74.1</td>
<td>88.78</td>
<td>17.76</td>
</tr>
<tr>
<td>Wabe</td>
<td>1866</td>
<td>82.1*</td>
<td>55.38</td>
<td>11.08</td>
</tr>
<tr>
<td>OM19</td>
<td>5136</td>
<td>74.3*</td>
<td>87.86</td>
<td>17.57</td>
</tr>
<tr>
<td>Residual</td>
<td>11411</td>
<td>74.8</td>
<td>85.57</td>
<td>17.11</td>
</tr>
</tbody>
</table>

* - From the OGMP²

The synthetic unit hydrograph used by the SCS was developed averaging a large number of individual dimensionless unit hydrographs. The final product was made dimensionless by considering the ratios of q/qp (flow/peak flow) on the ordinate axis and t/Tp (time/time to peak) on the abscissa, where the units of q and
qp are m³/s/mm. Its shape is characterized by a time-to-peak located at approximately 20% of its time base and an inflection point at 1.7 times the time-to-peak.

Concentration time has been here estimated on the basis of the travel time of the main channel (having conservatively neglected the rather short travel time of the unconcentrated flow). Mean velocity reference values of the stream flow in natural channels are provided in the most common international references⁶.

The following table provides the lag times estimated for the 5 basins and used in the software elaborations.

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Area [km²]</th>
<th>L  [km]</th>
<th>Slope avg [%]</th>
<th>Mean V [m/s]</th>
<th>tC [hr]</th>
<th>tlag [hr]</th>
<th>tlag [min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abeti w/o Gibe I</td>
<td>11516</td>
<td>210</td>
<td>3.6</td>
<td>0.73</td>
<td>79.74</td>
<td>47.85</td>
<td>2871</td>
</tr>
<tr>
<td>Gibe I</td>
<td>4230</td>
<td>147</td>
<td>2.8</td>
<td>0.57</td>
<td>71.77</td>
<td>43.06</td>
<td>2584</td>
</tr>
<tr>
<td>Wabe</td>
<td>1866</td>
<td>91</td>
<td>5.7</td>
<td>1.16</td>
<td>22.09</td>
<td>13.25</td>
<td>795</td>
</tr>
<tr>
<td>Gojeb at OM19</td>
<td>5136</td>
<td>188</td>
<td>4.0</td>
<td>0.81</td>
<td>65.04</td>
<td>39.02</td>
<td>2341</td>
</tr>
<tr>
<td>Residual</td>
<td>11411</td>
<td>224</td>
<td>2.1</td>
<td>0.43</td>
<td>146.66</td>
<td>88.00</td>
<td>5280</td>
</tr>
</tbody>
</table>

These values are fairly consistent with the estimates contained in the Omo Gibe Master Plan².

A time interval of 12 hrs has been adopted for defining the design unit hydrographs. This time step looks adequately stable for the purpose of the simulation with HMS.

Flood routing effect due to Gibe I Dam has been processed in the conservative assumption of complete filling of the reservoir. In this condition Gibe I spillway operates according to the rating curve of the spillway itself. For these exceptional precipitation all the 4 gates are assumed open. Although many methodologies for estimating the baseflow of the hydrograph are available, the choice of this parameter is here merely arbitrarily, since no prediction on the occurrence of such extreme events can be done. According to the usual operation of hydroelectric plant, the circumstance of having Gibe I Reservoir at the maximum operating level could happen at the end of the wet season but many factors may affect the seasonal regulation and refute this logic.

However, in the present analysis a fairly conservative value of baseflow equalling the average monthly of the wetter period (June – September) has been assigned to each catchment. Monthly flows have been taken from the hydrological report of the Basic Design¹⁶. Gibe I catchment and Abelti without Gibe I have been computed through an area proportion from the Abelti series.

**Results**

Two scenarios have been investigated in the rainfall – runoff analysis:

1. a 15 day storm of 10,000 yr Return Period;
2. a 15 day storm of PMP (Probable Maximum Precipitation).

This chapter only limits to present the relevant hydrologic parameters of any hydrologic element of the whole system (Table 5.24 and Table 5.25) and shows the two flood hydrographs at the Gibe III dam site (Table 5.26 and Figure 5.10).

¹⁶ 200 HYD R SP 001 A – Hydrological Report Vol. 1
Table 5.24: Gibe III HMS Model – 10,000 yr Analysis Main Results

<table>
<thead>
<tr>
<th>Hydrologic Element</th>
<th>Contributing Area</th>
<th>Peak Discharge</th>
<th>Time of Peak Tp</th>
<th>Total Runoff Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>[km²]</td>
<td>[m³/s]</td>
<td>[hr]</td>
<td>[Mm³]</td>
</tr>
<tr>
<td>Abeti</td>
<td>11516</td>
<td>4145</td>
<td>192</td>
<td>4038</td>
</tr>
<tr>
<td>Gibe I</td>
<td>4230</td>
<td>1533</td>
<td>180</td>
<td>1392</td>
</tr>
<tr>
<td>Gibe I Dam</td>
<td>4230</td>
<td>1295</td>
<td>228</td>
<td>1352</td>
</tr>
<tr>
<td>Gibe III Dam Site</td>
<td>34159</td>
<td>10606</td>
<td>240</td>
<td>12193</td>
</tr>
<tr>
<td>Gojeb Omo Junction</td>
<td>34159</td>
<td>10759</td>
<td>228</td>
<td>12198</td>
</tr>
<tr>
<td>OM19</td>
<td>5136</td>
<td>1997</td>
<td>180</td>
<td>1968</td>
</tr>
<tr>
<td>Omo d/s Reach</td>
<td>34159</td>
<td>10606</td>
<td>240</td>
<td>12193</td>
</tr>
<tr>
<td>Omo u/s Reach</td>
<td>17612</td>
<td>5692</td>
<td>216</td>
<td>6169</td>
</tr>
<tr>
<td>Residual</td>
<td>11411</td>
<td>3500</td>
<td>240</td>
<td>4061</td>
</tr>
<tr>
<td>Wabe</td>
<td>1866</td>
<td>913</td>
<td>144</td>
<td>786</td>
</tr>
<tr>
<td>Wabe Gibe Junction</td>
<td>17612</td>
<td>5916</td>
<td>192</td>
<td>6176</td>
</tr>
</tbody>
</table>

Table 5.25: Gibe III HMS Model – PMF Analysis Main Results

<table>
<thead>
<tr>
<th>Hydrologic Element</th>
<th>Contributing Area</th>
<th>Peak Discharge</th>
<th>Time of Peak Tp</th>
<th>Total Runoff Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>[km²]</td>
<td>[m³/s]</td>
<td>[hr]</td>
<td>[Mm³]</td>
</tr>
<tr>
<td>Abeti</td>
<td>11516</td>
<td>7354</td>
<td>180</td>
<td>6579</td>
</tr>
<tr>
<td>Gibe I</td>
<td>4230</td>
<td>2744</td>
<td>180</td>
<td>2325</td>
</tr>
<tr>
<td>Gibe I Dam</td>
<td>4230</td>
<td>2391</td>
<td>216</td>
<td>2285</td>
</tr>
<tr>
<td>Gibe III Dam Site</td>
<td>34159</td>
<td>18661</td>
<td>240</td>
<td>19741</td>
</tr>
<tr>
<td>Gojeb Omo Junction</td>
<td>34159</td>
<td>19039</td>
<td>216</td>
<td>19746</td>
</tr>
<tr>
<td>OM19</td>
<td>5136</td>
<td>3486</td>
<td>168</td>
<td>3102</td>
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<tr>
<td>Omo d/s Reach</td>
<td>34159</td>
<td>18661</td>
<td>240</td>
<td>19741</td>
</tr>
<tr>
<td>Omo u/s Reach</td>
<td>17612</td>
<td>10175</td>
<td>216</td>
<td>10061</td>
</tr>
<tr>
<td>Residual</td>
<td>11411</td>
<td>6122</td>
<td>240</td>
<td>6583</td>
</tr>
<tr>
<td>Wabe</td>
<td>1866</td>
<td>1522</td>
<td>144</td>
<td>1204</td>
</tr>
<tr>
<td>Wabe Gibe Junction</td>
<td>17612</td>
<td>10582</td>
<td>192</td>
<td>10068</td>
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</tbody>
</table>
Table 5.26: Gibe III Dam Site – Extreme Flood Hydrographs

<table>
<thead>
<tr>
<th>Elapsed Time</th>
<th>10000yrs</th>
<th>PMF</th>
<th>Elapsed Time</th>
<th>10000yrs</th>
<th>PMF</th>
</tr>
</thead>
<tbody>
<tr>
<td>[hr]</td>
<td>[m³/s]</td>
<td>[m³/s]</td>
<td>[hr]</td>
<td>[m³/s]</td>
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<tr>
<td>0</td>
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<td>859</td>
<td>372</td>
<td>8103</td>
<td>13127</td>
</tr>
<tr>
<td>12</td>
<td>859</td>
<td>859</td>
<td>384</td>
<td>7781</td>
<td>12548</td>
</tr>
<tr>
<td>24</td>
<td>860</td>
<td>860</td>
<td>396</td>
<td>7374</td>
<td>11831</td>
</tr>
<tr>
<td>36</td>
<td>862</td>
<td>867</td>
<td>408</td>
<td>6859</td>
<td>10942</td>
</tr>
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<td>899</td>
<td>420</td>
<td>6257</td>
<td>9910</td>
</tr>
<tr>
<td>60</td>
<td>895</td>
<td>1001</td>
<td>432</td>
<td>5603</td>
<td>8793</td>
</tr>
<tr>
<td>72</td>
<td>964</td>
<td>1234</td>
<td>444</td>
<td>4938</td>
<td>7660</td>
</tr>
<tr>
<td>84</td>
<td>1115</td>
<td>1666</td>
<td>456</td>
<td>4300</td>
<td>6575</td>
</tr>
<tr>
<td>96</td>
<td>1390</td>
<td>2363</td>
<td>468</td>
<td>3716</td>
<td>5582</td>
</tr>
<tr>
<td>108</td>
<td>1828</td>
<td>3376</td>
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<td>3203</td>
<td>4712</td>
</tr>
<tr>
<td>120</td>
<td>2455</td>
<td>4721</td>
<td>492</td>
<td>2765</td>
<td>3971</td>
</tr>
<tr>
<td>132</td>
<td>3278</td>
<td>6384</td>
<td>504</td>
<td>2401</td>
<td>3355</td>
</tr>
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<td>144</td>
<td>4279</td>
<td>8314</td>
<td>516</td>
<td>2104</td>
<td>2856</td>
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<td>156</td>
<td>5418</td>
<td>10426</td>
<td>528</td>
<td>1867</td>
<td>2459</td>
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<tr>
<td>168</td>
<td>6621</td>
<td>12579</td>
<td>540</td>
<td>1679</td>
<td>2146</td>
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<tr>
<td>180</td>
<td>7782</td>
<td>14581</td>
<td>552</td>
<td>1531</td>
<td>1899</td>
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<tr>
<td>192</td>
<td>8794</td>
<td>16255</td>
<td>564</td>
<td>1414</td>
<td>1703</td>
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<tr>
<td>204</td>
<td>9593</td>
<td>17500</td>
<td>576</td>
<td>1322</td>
<td>1549</td>
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<tr>
<td>216</td>
<td>10153</td>
<td>18290</td>
<td>588</td>
<td>1248</td>
<td>1428</td>
</tr>
<tr>
<td>228</td>
<td>10481</td>
<td>18653</td>
<td>600</td>
<td>1190</td>
<td>1332</td>
</tr>
<tr>
<td>240</td>
<td>10606</td>
<td>18661</td>
<td>612</td>
<td>1143</td>
<td>1256</td>
</tr>
<tr>
<td>252</td>
<td>10578</td>
<td>18408</td>
<td>624</td>
<td>1105</td>
<td>1195</td>
</tr>
<tr>
<td>264</td>
<td>10445</td>
<td>17990</td>
<td>636</td>
<td>1074</td>
<td>1147</td>
</tr>
<tr>
<td>276</td>
<td>10247</td>
<td>17481</td>
<td>648</td>
<td>1050</td>
<td>1108</td>
</tr>
<tr>
<td>288</td>
<td>10011</td>
<td>16929</td>
<td>660</td>
<td>1030</td>
<td>1077</td>
</tr>
<tr>
<td>300</td>
<td>9756</td>
<td>16366</td>
<td>672</td>
<td>1014</td>
<td>1052</td>
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<td>15809</td>
<td>684</td>
<td>1000</td>
<td>1031</td>
</tr>
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<td>8950</td>
<td>14721</td>
<td>708</td>
<td>981</td>
<td>1001</td>
</tr>
<tr>
<td>348</td>
<td>8670</td>
<td>14185</td>
<td>720</td>
<td>973</td>
<td>990</td>
</tr>
<tr>
<td>360</td>
<td>8389</td>
<td>13656</td>
<td>732</td>
<td>967</td>
<td>980</td>
</tr>
</tbody>
</table>

Peak flows determined in the two simulations equal respectively 10606 and 18661 m³/s both occurring after 10 days from the beginning of the storm. The peak of the excess rainfall happens after 6 days and consequently the total lag time at Gibe III is 4 days. The whole flood events lasts about 30 days. After this period the recession of the hydrograph is very modest.
Figure 5.10: Gibe III Dam Site – Extreme Flood Hydrographs
Conclusions

Main results of the hydrological elaborations are summarized here below:

<table>
<thead>
<tr>
<th>Gibe III Dam Site</th>
<th>Peak Discharge [m³/s]</th>
<th>Time of Peak Tp [hr]</th>
<th>Total Runoff Volume [Mm³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>10000yr</td>
<td>10606</td>
<td>240</td>
<td>12193</td>
</tr>
<tr>
<td>PMF</td>
<td>18661</td>
<td>240</td>
<td>19741</td>
</tr>
</tbody>
</table>

The whole flood events lasts about 30 days with a lag time of about 4 days.

Comparison of the results with other studies confirms the consistency of the estimates.

Table 5.27 illustrates the comparison with the results of preceding extreme flood studies for basins within the Gibe III catchment, achieved adopting the same procedure illustrated in this report.

<table>
<thead>
<tr>
<th>Dam/River Site + Reference</th>
<th>Catchment Area [km²]</th>
<th>Peak Discharge [m³/s]</th>
<th>Specific Peak [m³/s/km²]</th>
<th>Francou-Rodier’s Coefficient [-]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gojeb Shebe [12]</td>
<td>3614</td>
<td>1770</td>
<td>0.490</td>
<td>3.80</td>
</tr>
<tr>
<td>Gojeb OM19 [12]</td>
<td>5136</td>
<td>2250</td>
<td>0.438</td>
<td>3.83</td>
</tr>
<tr>
<td>Halele [15]</td>
<td>6126</td>
<td>2420</td>
<td>0.395</td>
<td>3.79</td>
</tr>
<tr>
<td>Gibe III</td>
<td>34159</td>
<td>10606</td>
<td>0.310</td>
<td>4.30</td>
</tr>
<tr>
<td>Gojeb Shebe [12]</td>
<td>3614</td>
<td>2050</td>
<td>0.567</td>
<td>3.95</td>
</tr>
<tr>
<td>GojebOM19[12]</td>
<td>5136</td>
<td>2590</td>
<td>0.504</td>
<td>3.97</td>
</tr>
<tr>
<td>Halele [15]</td>
<td>6126</td>
<td>5760</td>
<td>0.940</td>
<td>4.68</td>
</tr>
<tr>
<td>Gibe III</td>
<td>34159</td>
<td>18661</td>
<td>0.546</td>
<td>5.01</td>
</tr>
</tbody>
</table>

The highest values of the Francou-Rodier’s coefficient\(^{17}\) at Gibe III dam site prove the precautionary approach of the analysis.

It’s easy to notice in the table above that specific peak values for the 10000 yr analysis well follow a decreasing trend as the catchment extension increases.

On the contrary, Gojeb PMF data seem to reject this tendency. The PMF peak for OM19 assessed in the present study equals 3486 m³/s being about one third higher of the value in Table 5.27.

This discrepancy in the PMF calculation does not surprise if three factors are considered:

1. the adoption in the Gojeb Study of a constant ARF of 0.54 inevitably involves an underestimate of the areal PMP for longer storm duration such as 15 days (critical duration for Gibe III Basin);
2. a larger record including more intense precipitation was made available for the latest studies (Halele and Gibe III);

3. for the present study more conservative procedures have been adopted in the methodology (i.e., outliers and sample size correction of the parameters in the PMP assessment, Weiss factor adjustment of the rainfall data).

Flood routing effect of Gibe I Reservoir simulated in the analysis is consistent with the reference\textsuperscript{18}.

Last comment is to underline that the PMF of 18661 m\textsuperscript{3}/s takes place in the mentioned Gumbel frequency analysis with a return period so large to be considered timeless, further demonstrating the reliability of the estimate.

5.1.8 Water quality

In order to deeply describe water chemical characteristics upstream and downstream the dam site, a water sampling campaign has been done to define the abundance of defined chemical parameters.

Three stations have been carried out as follows:

- Downstream Gibe 2 Power House
- At Bele Bridge
- Near the Gibe 3 dam site

The sampling water has been analysed by W.W.D.S.E. (Water Works Design and Water Quality) (see Annex 6).

- Chemical parameters analysed are:
  - Dissolved Oxygen (DO)
  - Phosphate (PO\textsubscript{4}3-)
  - Chloride (Cl-)
  - Sulphate (SO\textsubscript{4}2-)
  - Nitrate (NO\textsubscript{3}-)
  - Calcium (Ca\textsuperscript{2+})
  - Magnesium (Mg\textsuperscript{2+})
  - Sodium (Na\textsuperscript{+})
  - Potassium (K\textsuperscript{+})
  - Iron (Fe\textsuperscript{2+})
  - TDS (Total Dissolved Solids)

- Other parameters measured are:
  - pH (units)
  - Electrical Conductivity (μS/cm)
  - Turbidity (NTU)

Table 5.28 shows the results of the analyses carried out in the three places of sampling. Quantities are expressed in mg/l.

\textsuperscript{18} EEPCO, “Gilgel Gibe Hydroelectrical Project, Lot 5 – Dam & Ancillary Works, Construction Design Report”, ENEL/ELC
### Table 5.28: Results of chemical analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gilgel Gibe 2 Power House (1)</th>
<th>Bele Bridge (2)</th>
<th>Gilgel Gibe 3 Dam site (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude (m a.s.l.)</td>
<td>1.000</td>
<td>900</td>
<td>730</td>
</tr>
<tr>
<td>Ionic Chemicals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca2⁺</td>
<td>10.6</td>
<td>12.3</td>
<td>14.08</td>
</tr>
<tr>
<td>Mg2⁺</td>
<td>5.94</td>
<td>6.48</td>
<td>4.32</td>
</tr>
<tr>
<td>Na⁺</td>
<td>4.6</td>
<td>5.4</td>
<td>6.7</td>
</tr>
<tr>
<td>K⁺</td>
<td>2.9</td>
<td>3.2</td>
<td>3.6</td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>1.19</td>
<td>1.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>2.82</td>
<td>1.88</td>
<td>1.88</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>5.3</td>
<td>15.4</td>
<td>4.75</td>
</tr>
<tr>
<td>PO₄³⁻</td>
<td>0.948</td>
<td>1.58</td>
<td>0.759</td>
</tr>
<tr>
<td>Fe²⁺</td>
<td>2.04</td>
<td>2.9</td>
<td>0.76</td>
</tr>
<tr>
<td>Salinity</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>

The water quality parameter measured are collected in the table below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turbidity (NTU)</td>
<td>(1) 198 – (2) 218 – (3) 116</td>
</tr>
<tr>
<td>Dissolved Organic Content (mg/l)</td>
<td>(1) 70 – (2) 78 – (3) 82</td>
</tr>
<tr>
<td>Salinity</td>
<td>Nil</td>
</tr>
<tr>
<td>PH</td>
<td>(1) 7.34 – (2) 7.33 – (3) 7.5</td>
</tr>
<tr>
<td>Electrical conductivity (µS/cm)</td>
<td>(1) 109.9 – (2) 104.7 – (3) 126.1</td>
</tr>
</tbody>
</table>

Considering very low salinity levels on the usual mineral water scale (Gualtierotti, 1978), the Omo River water can be classified as earthy-brackish, alkaline, and with bicarbonate.

The values comparison carried out in three zones of Omo River, measured at Gilgel Gibe 2 Power House, Bele Bridge and Gilgel Gibe III dam site, shows that the water quality is substantially similar if considered between the three sampling sites.

The chemical differences may be linked to the different flow rates along the river due to effluent rivers, living people and agricultural activities. Particularly this fact is evident if we consider the chemical components in the area between Gilgel Gibe 2 Power House site and Gilgel Gibe 3 dam site. The zone, corresponding to Bele Bridge is fully living, with roads and settlements and with people living on the plateau.

Due to this fact, an amount in SO₄²⁻ and PO₄³⁻ is real.

After about two years of works for providing Gilgel Gibe 2 outlet area, building roads and settlements, setting up disposal areas, it seems to be reasonable to compare chemical data in same places. In fact, during drawing up of Gilgel Gibe 2 Environmental Impact Assessment, a water sampling campaign was done to collect chemical data in specific sample points, particularly a sample was done at Gilgel Gibe 2 out coming turbined water, that is near Gilgel Gibe 2 Power House for present sampling campaign.

The data collected in the two periods are in the table below. The sample water has been analysed within the same parameters.
Table 5.29: Comparison table between two different sampling campaign (2004 and 2006) at the same place

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Altitude (m a.s.l.)</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Ionic Chemicals</td>
<td>Mg/l</td>
<td>mg/l</td>
</tr>
<tr>
<td>Ca2+</td>
<td>10.6</td>
<td>2.433</td>
</tr>
<tr>
<td>Mg2+</td>
<td>5.94</td>
<td>1.297</td>
</tr>
<tr>
<td>Na+</td>
<td>4.6</td>
<td>0.776</td>
</tr>
<tr>
<td>K+</td>
<td>2.9</td>
<td>0.513</td>
</tr>
<tr>
<td>NO3-</td>
<td>1.19</td>
<td>2.161</td>
</tr>
<tr>
<td>Cl-</td>
<td>2.82</td>
<td>3.105</td>
</tr>
<tr>
<td>SO42-</td>
<td>5.3</td>
<td>1.357</td>
</tr>
<tr>
<td>PO43-</td>
<td>0.948</td>
<td>0.402</td>
</tr>
<tr>
<td>Fe2+</td>
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<td>1.196</td>
</tr>
<tr>
<td>Salinity</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>

Since this comparison, based on average of the chemical components analysed, it’s possible to say that some parameters sensibly increased since last campaign. The last campaign was done before Gilgel Gibe 2 project starting, and the present data are to verify the eventual effects of the works on Omo River water quality.

From the comparison table above, the most part of chemical data sampled sensibly increased its value. Particularly Ca\(^{2+}\), Mg\(^{2+}\), Na\(^{+}\), K\(^{+}\), SO\(_4^{2-}\), PO\(_4^{3-}\) increased their value to a factor of more than 300%. The causes of this amount can be related to the works and the camp sites for Gilgel Gibe 2 project. It’s quite difficult that a so strong amount in some chemical parameters value is only due to enlargement of people activity (agricultural for example) above the sampled area.

It is strongly recommended that water campaigns are regularly carried out at Gilgel Gibe 3 dam site to monitor the evolution of the chemical parameters.

5.2 Biological Environment

5.2.1 Land Use and Land Cover

Land cover assessment was carried out for the Gibe III reservoir area and it was based on satellite images interpretation, field observations, field data collection and analysis. The classification which was based on GIS software supervised classification systems resulted into the following four classes:

- deciduous woodland;
- riverine forest;
- exposed surface/silt/gravel;
- water body/river.

Farming practices and settlement are concentrated in areas (outside the valley on the highland) which are not affected by the future reservoir. However, farm houses occur in relatively small and isolated areas where people practice crop cultivation and livestock keeping and this unit was not mapped because this class was not recognized clearly with patterns and reflectance characteristics. The resulting land cover map in the reservoir area is shown in Figure 5.11. The land use distribution in the reservoir area is shown in Table 5.30.
Figure 5.11: Land Cover of the Gibe III Reservoir Area
Table 5.30: Land Cover Distribution in the Gibe III Reservoir Area

<table>
<thead>
<tr>
<th>Land Cover Type</th>
<th>Area in</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deciduous Woodland</td>
<td>17'158</td>
<td>82.2</td>
</tr>
<tr>
<td>Riparian Vegetation</td>
<td>1’839</td>
<td>8.8</td>
</tr>
<tr>
<td>Silt/gravel/Exposed Surface</td>
<td>973</td>
<td>4.7</td>
</tr>
<tr>
<td>River/water body</td>
<td>892</td>
<td>4.3</td>
</tr>
<tr>
<td>Total</td>
<td>20’862</td>
<td>100</td>
</tr>
</tbody>
</table>

Deciduous woodland: This unit covers about 17’158 ha which is about 82.2% of the reservoir area. It is characterized by approximately 2% tree cover and 98% grass at the time when the field survey was carried out.

Riparian Vegetation: The riparian vegetation in the reservoir area was observed along the river sides. It occupied 1’839 ha of land that counts for about 8.8 % of the entire reservoir area.

Exposed surface/ Silt/gravel: The exposed surface and silt/gravel land cover occurs mainly along the lower parts of the river, on steep sides of rivers and degraded hillsides and rock outcrops. This cover type is also observed at the river bed. This land cover type covers 4.7 % of the reservoir area.

5.2.2 Natural Vegetation and Forest Resources

A survey and detailed data collection of the vegetation composition, abundance, cover, physiognomy and other relevant ecological information of Omo Valley was conducted at different locations.

There are four distinct terraces (Terraces I to IV) occurring at 1600, 1300, 1000 and riverine and the vegetation composition on all these terraces is monotonic except along the river banks.

The forest and vegetation assessment was carried out with the following objectives:

1) determine vegetation composition and identify community types in the Omo Valley
2) determine if there are endangered plant species or communities that would be affected by the inundation of the area
3) determine if forest/vegetation based agricultural activities would be affected by the inundation of the part of the valley
4) propose mitigation options to prevent or minimize the damage that may be caused by the creation of the reservoir.

The following activities were conducted during the field investigation:

- Extensive survey and sampling of the vegetation around the proposed dam and reservoir area;
- Formal and informal discussions with the local communities living.
- Review of some literature and other documents relevant to the purpose

Several stops were made along the road and along foot lanes leading to the river valley from different starting points. A number of stops were made irrespective of whether there is a change in the composition or diversity of the vegetation. At each stop the vegetation was traversed in different directions to obtain a complete impression and to include as many plant species as possible in the inventory. Plant species were listed and the percent canopy cover of each plant species was determined visually.
The biomass of the woodland on the hill slopes at Terraces II and III was estimated in 20m x 20m (400 m²) at three different sites. Biomass of the forest vegetation in terrace IV was estimated at two different sites.

The geographical coordinate of each stop is recorded as degree decimal and UTM using a Garmin GPS.

The presence of terrestrial and aquatic animals species i.e. insects, lizards, birds, primates, ungulates, warthogs, forest hogs, porcupines, various ungulates and their predators and aquatic animal species such as fish, crocodiles and hippos as well as birds were noted and their food web speculated.

Omo Valley is part of the Broad-leaved deciduous woodland of Western Ethiopia described in Pichi-Sermoli 1957. The vegetation on the hill slopes of the valley is characterized by deciduous phenology of the woodland species which shed their leaves during the dry season and regain them during the wet season as an adaptive mechanism for the prolonged dry season. Important species include Boswellia pirote, Lannea schimperi, Anogeissus leiocarpus, Terminallia browni, Combretum molle, Tamarindus indica, Stereospermum kunthianum and Gardenia ternifolia. There is also a distinct narrow zone of riparian vegetation along river and stream banks owing to the relatively moist conditions Pichi-Sermoli (1957). The species composition of the riparian vegetation is similar to that of the hill slopes except that the individual trees are larger in size.

The altitudinal ranges, temperature, humidity and the floristic and physiognomy composition of the vegetation in the Omo river basin along with the system in Gibe Basin provide ideal conditions for Tsetse fly infestation (Getachew, 1983; NMSA, 1996; Reid, R., et al. 1997, Reid et al., 2000).

5.2.2.1 Forest and Vegetation Resources

The existing vegetation in the project area is broadly classified into two parts, namely the woodland and the riparian. However, the proposed reservoir area is neither contiguous with, nor in close proximity with any of the nationally or regionally protected forest areas.

The landscape on either side of the valley had four distinct terraces, terrace I on the plateau (above 2300 m asl), Terrace II at 1600 m asl, Terrace III at 1000 and Terrace IV at the river bank.

The dry woodland landscape can be partitioned into three distinct types (Pichi-Semoli, 1957) namely:

- the highland vegetation which is remnant of the vegetation of the plateau referred to as the dry evergreen mountain forest and the associated grasslands at Terrace I;
- the broadleaved deciduous woodland of the low-lying altitude at terrace II and III; and
- the riparian vegetation at Terrace IV.

The Highland Vegetation: The highland vegetation could be encountered on the plateau at 2300 m asl and above at Wolayita, Waka and the vicinity before the dissent to the valley as part of the agroforestry system. The species include Erythrina brucei, Prunus africana, Podocarpus gracilior, Juniperus procera, Croton macrostachyus and Arunidnaria alpina interspaced in with enset and Eucalyptus plantations.

The Lowland Broadleaved Deciduous Woodland: The plant species of the Omo Valley have over time developed adaptive mechanisms and traits that allow them either to survive fire, to germinate after the heat shock or to regenerate after a fire episode. The selective pressure of fire on the plant communities has produced plant species, which are fire resistant, or pyrophytes (Kuhnholtz-Lordat, 1938). In the Omo valley, the bush fires occur between late February and early April. The combination of climatic factors such as
maximum temperature and low humidity contribute to the increase in the probability of fire. Fire has played an important role over evolutionary, historical, and ecological time influencing their composition, physiognomy and fuel availability and the relationship between fire and the plant and the associated animal communities is the result of mutual compromise. Thus it is possible to suggest that the vegetation provides certain properties to the ecosystem that condition the fire regime, and the fire regime (See Photo 5.1 and Photo 5.2) determines in part, the maintenance, regression, or succession of plant and animal communities. The burnt grass and herbaceous species restart at their rhizomes, bases and bulbs, which are normally subterranean.

In general vegetation, which has evolved as response to the frequent fires, is poor in species composition (Packman 1970). The vegetation on most of the length of the slopes of the Omo River System is mainly dominated by Combretum molle and Terminalia brownii. Only 33 woody species (shrub, small tree and trees species) distributed in 16 different Families were encountered. At the time of the study there was only a new sprout of grass making identification difficult. However, un-burnt pocket harbouring some grass species indicate that the herbaceous layer is dominated by Hyparrhenia hirta.

![Photo 5.1: Woodland vegetation around the dam site](image)
The Riparian Vegetation: There is a narrow band of riparian vegetation (See Photo 5.3) of almost similar species composition as the woodland on the hill slopes. Due to ample moisture, trees found at the edge of the riverbank are not affected by fire as the rest of trees in the upper parts of the study area. The species unique to the riparian vegetation include Prunus africana, Lepidotrichilia emetica and Euphorbia tirucalli and Tamarindus indica. Riparian vegetation along the riverbanks may be understood as giving ecosystem functions such as corridors connecting wet forests, being refugia for some plant species and biodiversity banks for wetter forest elements. They are also refugia for birds, invertebrates, reptiles, amphibians, ungulates, primates and their predators during the peak of bush fire period. The ungulates particularly find safe haven in the riparian forest until the bush fire culminated and the lush of grass sprout.
The species composition of the woodland and the riparian vegetation compiled after extensive survey is given in Table 5.31. Botanical nomenclature follows Cufodontis (1953-1972), Hedberg and Edwards (1989, 1995), Edwards et al. (1995), and Edwards et al. (1997). Voucher specimens have been deposited in the National Herbarium of Addis Ababa University.
Table 5.31: The species composition of Terraces III and IV

<table>
<thead>
<tr>
<th>Species</th>
<th>Family</th>
<th>Growth form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia hockii</td>
<td>Fabaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Acacia polyacantha</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Acacia seyal</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Albizia gummifera</td>
<td>Fabaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Anogeissus leiocarpus</td>
<td>Combretaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Boswellia pirotiae</td>
<td>Burseraceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Bridelia micrantha</td>
<td>Euphorbiaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Celtis africana</td>
<td>Ulmaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Combretum molle</td>
<td>Combretaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Croton macrocarpa</td>
<td>Euphorbiaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Croton macrostachyus</td>
<td>Euphorbiaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Dichrostachys cinerea</td>
<td>Fabaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Euphorbia tirucalli</td>
<td>Euphorbiaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Flueggea virosa</td>
<td>Euphorbiaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Gardenia ternifolia</td>
<td>Rubiaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Grewia bicolor</td>
<td>Tiliaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Ficus thonningii</td>
<td>Moraceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Harisonia abyssinica</td>
<td>Simaroubaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Lannea schimperi</td>
<td>Anacardiaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Lonchocarpus laxiflorus</td>
<td>Fabaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Maytenus polymorpha</td>
<td>Celastraceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Maytenus senegalensis</td>
<td>Celastraceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Ozoroa insignis</td>
<td>Anacardiaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Pappea capensis</td>
<td>Sapindaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Pistasia aethiopica</td>
<td>Anacardiaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Pliostigma thonningii</td>
<td>Fabaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Sclerocarya berrea</td>
<td>Anacardiaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Senna singueana</td>
<td>Fabaceae</td>
<td>Shrub</td>
</tr>
<tr>
<td>Sterculia africana</td>
<td>Sterculiaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Stereospermum kuntianum</td>
<td>Bignoniaceae</td>
<td>Small tree</td>
</tr>
<tr>
<td>Sisymbrium guineense</td>
<td>Myrtaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Terminalia brownii</td>
<td>Combretaceae</td>
<td>Tree</td>
</tr>
<tr>
<td>Zanthoxylum chalybeum</td>
<td>Rutaceae</td>
<td>Small tree</td>
</tr>
</tbody>
</table>

5.2.2.2 Wood Biomass of the Vegetation

The biomass of woodland and riparian forest vegetation was estimated by determining the density of each species. In general, the vegetation is under spocked and affected by frequent fire. The number of stems per hectare recorded within the woodland ranges from 20 to 230 with an average number of 170 trees per hectare. Similarly, the average volume per hectare is 12.3 cubic meter. The species encountered are shown in Table 5.31.

On the other hand, the number of stems recorded of the riparian forest ranges from 180-500 per hectare which is more dense than the woodland over the valley side. Similarly the volume per hectare is estimated at 105.5 cubic meters.

Taking the volume estimate of 12.3 per hectare and the area estimate for the total woodland in the reservoir area (17,158 ha), the total volume estimate is at 211,043 cubic meters and for the riparian woodland (1,839 ha of the reservoir area), taking the estimate of 105.5 cubic meters per hectar, the total stock estimate is 194,015 cubic meters that gives a total of 405,058 cubic meters that will be submerged by the reservoir.
5.2.3 Aquatic Ecology

The consultant has carried out an aquatic ecology assessment and the activities include the following:

- Inventoried the composition of the riverine and riparian fauna (invertebrates, plankton, benthos, etc) of the Omo river at three critical points along the future reservoir area - Omo bridge, dam site and confluence of Gojeb-Gibe rivers;
- Made a comprehensive habitat integrity assessment of the Omo river at two sites;
- Assessed the potential impact of the creation of a reservoir on the riparian and riverine fauna, disease vectors, rare biota, etc.

Available literature was reviewed for previous studies done on aquatic communities of invertebrates in the Omo basin. The major references consulted were studies conducted at the Gojeb, Gibe and Omo rivers by Golubstov and Mina (2003) which summarizes the scientific results of the Joint Ethiopian-Russian Biological Expedition (JERBE) and ESIA reports of Gilgel Gibe I, and Gojeb Hydropower Projects.

Rapid habitat integrity assessment was made at the Omo bridge and confluence sites using the criteria developed for South African rivers by Kleynhans (1996) and the Rapid Bioassessment Protocol (RBP) of EPA (1999). A few criteria were modified to suit the local conditions, such as pollution by dung and human wastes. Weights are assigned to different in-stream and riparian characters of the river reach such as flow modification, exotic macrophytes, bank erosion and vegetation cover. The ten most important habitat components are considered for analysis with each component having a score of 10 points, adding up to a total of 100 percent. A range of score points describe the habitat integrity status of the river. High scores describe unimpaired conditions and low percentages apply to impacted rivers.

5.2.3.1 Riparian fauna - Omo bridge site

Table 5.32 lists some of the dominant riparian macro-invertebrates identified at the Omo Bridge. Grasshoppers and crickets (Order Orthoptera) made up the most abundant group, in terms of biomass, and butterflies in terms of diversity. Butterfly species such as Colotis and Odonata such as dragonflies were noted on the bank. Observations of the riparian fauna indicate the predominance of grasshoppers (Acrididae and Oxyidae), damselflies, beetles and Hemipteran bugs.

<table>
<thead>
<tr>
<th>Common name</th>
<th>Scientific names</th>
<th>Relative abundance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meadow grasshoppers</td>
<td>Acrida sp.</td>
<td>+++</td>
</tr>
<tr>
<td>Field crickets</td>
<td>Oxya sp.</td>
<td>+++</td>
</tr>
<tr>
<td>Butterflies</td>
<td>Gryllus sp.</td>
<td>+++</td>
</tr>
<tr>
<td>Preying mantis</td>
<td>Colotis sp.</td>
<td>+++</td>
</tr>
<tr>
<td>Forest damselflies</td>
<td>Pieris sp.</td>
<td>+</td>
</tr>
<tr>
<td>Blue damselfly</td>
<td>Delais sp.</td>
<td>+</td>
</tr>
<tr>
<td>Beetles</td>
<td>Belineois sp.</td>
<td>+</td>
</tr>
<tr>
<td>Unidentified bugs</td>
<td>Pareronia sp.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Order Dictoptera</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Fam. Platycnemida</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Enallagma sp.</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Several species</td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>Several species</td>
<td>+</td>
</tr>
</tbody>
</table>

Note: + indicates common, ++ very common and +++ highly abundant
Similar ecological changes are anticipated at all sites of the Omo river - excessive growth of algae and macrophytes, establishment of vectors such as mosquitoes and snails and altered food webs in the standing reservoir. Previous ESIA studies done at the Gilgel Gibe I and II and other tributaries upstream document the presence of benthic communities such as Ephemeroptera (Mayflies such as Afronurus sp., Baetis sp., Centroptilum sp., Hydropsyche sp.), chironomid (phantom midges) nymphs and Tipulidae (horseflies).

5.2.3.2 Habitat Integrity Rating

Rapid habitat assessment was used at the site and the score for each component was assessed out of 10 points. Category and interpretation was done according to EPA classification (1999). Table 5.33 and Table 5.34 give the criteria and the score of the habitat components considered for the ecological integrity assessment at the dam site and at Omo Bridge respectively.

**Dam site:** The dam site is a largely natural system with very few modifications (mostly due to initiated project activities at the site). The ecosystem functions are unimpaired at the moment. The damming and operation facilities will definitely change this situation in the future.

**Omo Bridge:** This site appears more impacted than the other upstream and downstream sites on the Omo River. Both these sites are not conducive to human encroachment and still, the habitat category indicates that although some changes of the natural habitats and biota may have occurred, the basic ecosystem functions are still predominantly unchanged. Habitat integrity rating at the Omo bridge site is about 80% (Table 5.34) and this indicates that both sites (Dam site and Omo bridge) are relatively un-impacted by human activities at the moment.

### Table 5.33: Habitat integrity rating for the Omo dam site downstream

<table>
<thead>
<tr>
<th>Habitat component (instream and riparian)</th>
<th>Score (out of 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate quality and quantity</td>
<td>9</td>
</tr>
<tr>
<td>Sediment deposition</td>
<td>5</td>
</tr>
<tr>
<td>Channel alteration (modification)</td>
<td>9</td>
</tr>
<tr>
<td>Bank stability (vegetation protection)</td>
<td>10</td>
</tr>
<tr>
<td>Riparian vegetation zone width</td>
<td>10</td>
</tr>
<tr>
<td>Frequency of riffles/bends</td>
<td>10</td>
</tr>
<tr>
<td>Manure/dung wastes</td>
<td>8</td>
</tr>
<tr>
<td>Nutrient enrichment</td>
<td>6</td>
</tr>
<tr>
<td>Water quality (appearance)</td>
<td>4</td>
</tr>
<tr>
<td>Exotic plants and animals introduction</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total habitat score</strong></td>
<td><strong>81%</strong></td>
</tr>
<tr>
<td>Category and Interpretation</td>
<td>B</td>
</tr>
</tbody>
</table>

Largely natural, few modifications, unchanged ecosystem functions
### Table 5.34: Habitat integrity rating for the Omo bridge site

<table>
<thead>
<tr>
<th>Habitat component (instream and riparian)</th>
<th>Score (out of 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate quality and quantity</td>
<td>7</td>
</tr>
<tr>
<td>Sediment deposition</td>
<td>5</td>
</tr>
<tr>
<td>Channel alteration (modification)</td>
<td>9</td>
</tr>
<tr>
<td>Bank stability (vegetation protection)</td>
<td>9</td>
</tr>
<tr>
<td>Riparian vegetation zone width</td>
<td>10</td>
</tr>
<tr>
<td>Frequency of riffles/bends</td>
<td>10</td>
</tr>
<tr>
<td>Manure/dung wastes</td>
<td>9</td>
</tr>
<tr>
<td>Nutrient enrichment</td>
<td>6</td>
</tr>
<tr>
<td>Water quality (appearance and nutrients)</td>
<td>5</td>
</tr>
<tr>
<td>Exotic plants and animals introduction</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total habitat score</strong></td>
<td><strong>80 %</strong></td>
</tr>
</tbody>
</table>

#### 5.2.4 Fishery Resources

The fishery resources assessment was carried out with the following objectives:

- Assess and document the current situation with regard to the diversity of the fish fauna in the Omo River system.
- Evaluate the positive/negative impacts of Gibe III Hydropower project dam construction across the River Omo on the fish species diversity and fish stocks and recommend possible mitigation measures that may be required.
- Assess and recommend the sustainable use, development and management of the reservoir fishery that would be created as a result of the dam construction.

Published papers and unpublished reports of fish taxonomy studies in the Rivers Gibe, Gojeb and Omo were covered in the literature review. The project area was visited for primary data collection and direct observation. Fish samples were collected by experimental fishing using different mesh size gill nets, where possible, along the accessible parts of the river in the upper reaches of the proposed dam site. The study sites were at the bridge close to Bele town, Kindo Koyisha Wereda, at site near Modula town, Timbaro wereda (upstream from Bele) and at the Dam site.

Information regarding fishing activities and fish types encountered were collected from government development offices and local communities in the visited areas. Traditional fishermen were interviewed on the variety and abundance of the fish stocks in the river.

#### 5.2.4.1 Description of the Riverine Environment/Fish Habitat

The River Omo is one of Ethiopia’s major perennial rivers in the south–west of the country. The river has several large tributaries like the Gojeb and Gibe Rivers in the north. In fact these are the two rivers that converge and form the River Omo at the confluence in the south-western highlands.

The Gojeb River drains the western highlands and the Gibe River the highlands of the mid-west before they join to form the River Omo, that carries the huge amount of water southwards, draining into the lake Turkana and contributing over 90% of the river water inflow into the lake with all the allochthonous nutrient supply (Lake Turkana study, 1975). It also provides the breeding ground for many migratory fish species from the lake.
The location of the Dam at an elevation of about 655 m a.s.l is over 500 km far from the estuarine water at Lake Turkana (Omorate) (350m a.s.l). There is a difference in fish species diversity between the two locations – being less in number of species at the dam site and upstream than below the dam site at the lower altitude 400 m asl and below towards the estuarine area (Golubtsov and Mina 2003). The altitude at the sampling site at the bridge close to Bele town was 743 m asl.

5.2.4.2 Fish species diversity and Endemicity

The Omo-Gibe river basin is known to contain high diversity of fish species with over 70 species listed (Baron et al., 1997) which makes it second only to the adjacent Baro-Akobo river basin that is connected to the White Nile River system in the southwest (Golubtsov and Mina, 2003). The list of fish species in the Omo River is given in Annex 1.

The Omo Gibe river basin stretches from the mid-western highlands of over 3,500 m down to the estuary at Lake Turkana about 350 m elevation. It has been established through researches that the spatial distribution of fish species follows a pattern of increasing diversity with decreasing elevation (Golubtsov and Mina, 2003; Nikolsy, 1963). Thus, the upper reaches of river basins have relatively fewer fish species than the lower reaches of rivers. This occurrence has also been observed in the Omo basin (Golubtsov and Mina, 2003).

About 23 fish species have been described from Gojeb and Gibe Rivers in the upper reaches of the basin alone (Dgebuadze et al., 1994; Mina et al., 1997). As the river basin reaches the lower grounds of the Omo valley the fish diversity increases substantially and at the Omorate area, close to the estuary which has below 400 m elevation the very slow wide-bank river bed contains fish that migrate between the riverine and lake system.

During the current survey, the attempt to sample the species using various mesh size gill nets resulted in limited success. The gill nets set near the Bele Bridge, that was easily accessible, caught few fish that contained two families the Schilbidae, (Schilbe mystus – 30 cm TL) and Mochokidae (Synodontis schall 35-49 cm TL). The S. schall dominated in the catch of the two different mesh gill nets used. Further attempt to catch more fish at different sites was in vain as the heavy rain at the time flooded the river and damaged the fishing nets and made fishing practically impossible. Anyway the fish species encountered in the present fishing trial confirm the list described earlier from the area.

The most important literature that could be referred with regard to fish diversity (taxonomy) and distribution in Ethiopia has been the study reports of the Freshwater Biology Group of the Joint Ethio-Russian Biological Expedition (JERBE), that have widely covered the Ethiopian water bodies, the rivers and lakes, describing the fish species and distribution.

Fish species endemic to the Lake Turkana and Omo River basin have been described in different publications and reports (Lake Turkana study, 1975; Golubtsov and Mina, 2003). Golubtsov and Mina have listed nine fish species vis. The Characids Brycinus ferox, Brycinus minutes, the Cyprinids Barbus turkanae, and Neobola stellae, Aplocheilichthys rudolfianus Lates longispinnis, Thoracochromis macconneli, Thoracochromis rudolfianus, Thoracochromis turkanae, endemic to the Lake Turkana and lower delta of the Omo River. Most of these fish species have also been listed in earlier study of Lake Turkana (Lake Turkana study, 1975). The endemic species breed in different locations in or close to the lake, like in the estuarine, littoral and pelagic habitats of the lake. The endemic species have apparently evolved in the lake from the
riverine ancestors to fill up the niche created in the lacustrine system. None of the reports referred in this study indicate the occurrence of endangered or threatened fish species in the Omo River Basin or Lake Turkana – migratory or non-migratory.

5.2.4.3 **Biology of the riverine fish stocks**

Many of the riverine fish species including the Cyprinids, Characids, Mormyrids, Clariids, Schilbids, Mochokids, and others described are potamodromous species that perform local migration along the river course. Many of the species migrate upstream during the flood season for spawning and downstream during the dry season. It is indicated that many of these migrating species could move as far as 80 to 100 km upstream from Lake Turkana to spawn in the Omo River (Lake Turkana study, 1975).

The large variety of species found in the river system are distributed in all sorts of habitat like in the deep open river channel or in pools (Heterobranchus longifilis), in the floodplains, in rocky habitats like Labeo cylindricus, demersal areas (Hyperpisus bebe), etc. Similarly their feeding habit varies enormously among the species covering all available niches. They vary from detritus feeders to planktivores to small invertebrates, crustaceans, molluscs, fish, vegetation debris, plant seeds, etc. Some species change their food type, as they grow larger, to feeding on fish like Heterobranchus longifilis. Many species are known to show flexibility in their diet consuming what is available most in the water.

5.2.4.4 **Fisheries**

Information and reports on fish stocks and fisheries on the Omo River is very scarce. In general the riverine fishery is not developed partly due to lack of access to suitable fishing grounds and also the food habit or culture of most of the rural community does not favour fish consumption. The scanty information available from local government offices and from visits to the area indicates very limited commercial fishing activity only at the lower reaches of the river close to Lake Turkana. During the present survey at the Bele sampling site we found some fishermen with fishing hooks and nets. The Wereda Agriculture office indicated that there was limited occasional fishing at the river close to and around the Bele bridge and fish brought to the town. Fishing is done mainly with hooks and some gill net. Few fishermen were encountered who collaborated to work with the study team in gill net sampling at the river near the bridge. Fishing is not considered as a source of income. There is no fishery extension offered by the office. Some of the fishermen we were told had been employed with the dam construction company for a better income.

Fishing was said to be minimal at the Modula site visited. Fish supply to the town was very rare and irregular. Apparently the access to the river water was very difficult due to very steep and dangerous cliff (as observed). It takes over two hours reaching the river water from the nearest escarpment. Regarding the fish stocks and diversity, however, the local community said that there was plenty of fish and of high diversity, which has not been utilised. The presence of high crocodiles’ population in the river is also given as a reason for less fishing activity by the locals.

Commercial fishing was mainly reported in the lower course of the river far below the proposed dam site, at Omorate and at the estuarine waters (Tesfaye et al., 1987). There is no report of fishery activity along the larger part of the river course. Only seasonal fishing, during the low water and fasting period is reported by local communities at sites where the river passes close to settlements (villages/towns).
It is reported, however, that there has been substantial increase in the commercial fishing lately on the river delta, at Omorate, and Lake Turkana, following the depletion of fish in some Rift Valley lakes and subsequent shortage of supply in the main market. Fishermen and fish traders have migrated to this lower part of the river to find better catch and income from the fishery.

5.2.5 Wildlife Resources

This section examines wildlife resources that occur in and around the future reservoir area including the hillslopes and the area downstream of the Gibe III dam.

The Gibe III dam and reservoir is located in the upper middle section of the Omo-Gibe basin. During the field investigation, distribution pattern of major wildlife resources and the major types of agro-ecological zones, vegetation communities and habitats were identified. The ecological importance of these areas from global and national context is described.

5.2.5.1 Wildlife Resources in and Around the Reservoir Area

To assess the wildlife resources, secondary data and information and other documents relevant to the study have been reviewed. Detailed investigation about the wildlife resources was carried out at several observation zones/ transects. The wildlife expert and his field team have observed animals and their signs (calls, tracks, etc) along these transects.

Information is obtained through formal and informal discussions with the local communities living in the project area. This consultation with the communities based on their daily experience and historic observation had enabled us to know the animals that are occupying the area.

Based on the assessment, the number of wildlife species in the project area is low and does not rate well with areas in downstream of Gibe III dam. The fact that we encountered no large mammal except a single common Jacsca, seems that the area harbours only limited number of wildlife. However, the local residents and professionals from the offices of Agriculture interviewed during the field studies reported the presence of wildlife within the project area. The wildlife species that have been recorded for the area and birds encountered along the observed transects are listed in Annex 2.

Findings of the investigation about the wildlife resources along the four observation zones/ transects are discussed below:

The Main Bridge area on the Omo river: The site is located at 327067E and 763895N UTM. The area topographically is characterized by a deep river gorge and steep slopes along both sides of the river. The main wildlife species we are told represent the area are Black and white Colobus, Anubis baboon, Grevet monkey, Leopard, Hare, Warthog, Common Bushbuck and Hyena.

Cherta: This is an area located at specifically a place called Lala Yalo at 316504E and 769407UTM is a place where the Zao river joins Gojeb which later join Omo River. It is a wide un-inhabited area, on the South West side of Omo River sides it is open and unsettled. The area is a very important habitat for different kinds of antelopes, Bush buck, and Baboons. Birds encountered along the visited river sides are listed in Annex 2.

GG-III Dam Site: Located at 313273N and 758597E this area is narrow towards southern end where the river is constricted by two rocky hills raised up each on both sides of the river. The area further north after about
200m, is open and wide with some broad leaved vegetation and the valley surface is some grass land. This area is suitable for a considerable species of mammals (both herbivore and carnivore), birds and some reptiles. We are told a Rock Python was killed the day before.

**Hadero:** The site we visited here is Omo river part known as Bombe Farmers Association, a village known as Sangana. Located at 338480E and 711200N some 200m from this village is the Omo River gorge is uninhabited except some pastoralists visit during season of grazing shortage in their usual dwelling area. Some a kilometer distance towards the north of the river, one can overlook an area suitable for a considerable number of species of mammals antelopes, Hippopotamus, carnivores such as Hyena, Leopard and Lion.

### 5.2.5.2 Wildlife- Habitat

Interacting biophysical (elevation, soil type, moisture, flooding, slope), climate and anthropogenic factors (burning, agriculture, fuelwood collection, forest product gathering, etc.) have resulted in the development of a mosaic of vegetation types in the project area. The habitats in the project area include: broad-leaved deciduous woodland on the hillslopes of the valley and a narrow zone of riparian vegetation along the river and stream banks. These vegetations provide good habitat to support diverse wildlife species.

As explained by the settlers and also observed during field investigation, the areas along the river bank and the hill slopes are not inhabited. As a result of steep slope and Tsetse fly infestation, almost no farming is practiced. This made these sites good habitat for wildlife and birds.

### 5.2.6 National Parks and Other Protected Areas

Ethiopia is making efforts to protect biodiversity, and conserve resources through the creation of protected parks, wildlife reserves, and controlled hunting areas. However, the Gibe III reservoir area is neither contiguous with, nor in close proximity with any of these protected areas.

There are many birds in the project area (see Annex 2), however, according to Ethiopian wildlife and Natural History Society, there are no Important Bird Areas (IBA) anywhere near the reservoir area.

### 5.3 Socio-Economical Environment

The socio-economic assessment has been carried out with the objective to provide a comprehensive analysis of the existing socio-economic conditions of the population in the future reservoir area.

Mixes of methodologies have been used in this socio-economic assessment. These include: collection of documents, field investigation, extensive group discussions with wereda officials and focus groups and use of other relevant PRA (Participatory Rural Appraisal) tools.

Field investigation trip to the project sites was conducted to:

- Study the existing socio-economic conditions,
- Identify the existing socio-economic constraints,
- Assess the potential impacts both positive and negative
- Suggest measures to mitigating negative impacts
- Ascertain the expectations and attitudes of the local communities towards the project.
Secondary data on socio economic conditions of the affected weredas and kebeles were collected from wereda administration offices. Furthermore, site-specific data were collected through interviewing and discussions with local community members.

The list of persons contacted and institutions visited, and the participants for the project affected persons consultation meeting and attitude survey are listed in Annex 3. The sample minutes of meetings with stakeholders are also annexed.

5.3.1 Population

The reservoir for Gibe III hydropower is located in SNNP Regional State along the Omo and it stretches to its tributaries the Gojeb and Gibe Rivers. Within the SNNRS, the reservoir stretches over five zones and nine weredas namely, Kindo Koyisha and Boloso Sore wereda of Wolayita Zone, Genna Bossa and Loma wereda of Dawro Zone, Kacha Birra and Omo Sheleko wereda in Kembata Timbaro Zone, and Soro and Gibe weredas in Hadiya Zone and Yem Special Wereda (See Figure 5.12). In 2006, an estimated 2'337'309 people were living in these 11 weredas of which 49,7% were males and 50,3% of were females (see Table 5.35). The contribution of Omo Nada wereda of the Jimma zone side is considered relatively very small.

The average household size for all affected Kebeles is about 5.55 and it ranges from 3,9 to 7,3 and this is slightly higher than the national average which is 5,0.

The average wereda population density in the project area is estimated to be about 277.8 persons/km² (see Table 5.35). The highest population density (576 persons/km²) is observed at Kacha Birra wereda and the lowest at Loma Wereda (53 persons/km²). Within the project affected PAs, the average population density is 127,8 persons/km² and this figure ranges from 9,43 persons/km² in Mashinga PA to 696,3 persons/km² in Belela PA.
Figure 5.12: Administration Map around the Reservoir Area
### Table 5.35: Population of the Affected Weredas and Peasant Association (2006)

<table>
<thead>
<tr>
<th>Region</th>
<th>Zone</th>
<th>Wereda</th>
<th>Wereda Population</th>
<th>Affected PA Population</th>
<th>HH size of the Affected PAs</th>
<th>Population of the Wereda in Affected PAs (in %)</th>
<th>Population Density by Wereda (persons/km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNNPR</td>
<td>Wolayta</td>
<td>Kindo Koyisha and Didaye</td>
<td>99,315</td>
<td>100,362</td>
<td>199,677</td>
<td>19174</td>
<td>20021</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bolaso Sore</td>
<td>164,975</td>
<td>171,535</td>
<td>336,510</td>
<td>13312</td>
<td>12596</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gena Bossa</td>
<td>35,541</td>
<td>37,406</td>
<td>72,947</td>
<td>15143</td>
<td>15509</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Loma</td>
<td>44,121</td>
<td>45,987</td>
<td>90,108</td>
<td>6975</td>
<td>8319</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Soro</td>
<td>130,916</td>
<td>130,945</td>
<td>261,861</td>
<td>12953</td>
<td>16687</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gibe</td>
<td>191264</td>
<td>191606</td>
<td>382,870</td>
<td>11440</td>
<td>11399</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SNNPR</td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Yem</td>
<td>43134</td>
<td>43251</td>
<td>86,385</td>
<td>3783</td>
<td>3650</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kacha Birra</td>
<td>85,120</td>
<td>86,400</td>
<td>171,520</td>
<td>3622</td>
<td>3606</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Omosheleko</td>
<td>88,667</td>
<td>90,634</td>
<td>179,301</td>
<td>27229</td>
<td>21474</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Yem</td>
<td>43134</td>
<td>43251</td>
<td>86,385</td>
<td>3783</td>
<td>3650</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kembata-Timbaro</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Kacha Birra</td>
<td>85,120</td>
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<td>3622</td>
<td>3606</td>
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</tr>
<tr>
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<td>86,385</td>
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<tr>
<td></td>
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<td>Oromiya</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jimma</td>
<td>129,600</td>
<td>129,135</td>
<td>258,735</td>
<td>12720</td>
<td>12825</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Total</strong></td>
<td><strong>1,012,653</strong></td>
<td><strong>1,027,261</strong></td>
<td><strong>2,039,914</strong></td>
<td><strong>126,351</strong></td>
</tr>
</tbody>
</table>
5.3.2 Ethnic Compositions

More than 13 different ethnic groups live in the 11 weredas under study (See Figure 5.13). The major ethnic groups in the project Wereda are - Wolayita (23.0%), Dawro (6.9%), Kembata (6.7%), Tembaro (5.0%), Oromo (20.4%) and Hadiya (25.3%) and less than one percent of Amhara, Keffa and Sodo Gurage, Silte and Sebatbet Gurage. The rest of the ethnic groups constitute less than 3.3 in total. Table 5.36 shows the ethnic composition in the eight weredas.

Table 5.36: Ethnic Composition by Wereda in the Project Area

<table>
<thead>
<tr>
<th>Ethnic Groups</th>
<th>Kindo Koyisha and Didaye</th>
<th>Bolaso Sore</th>
<th>Geno Bossa</th>
<th>Loma</th>
<th>Soro</th>
<th>Kacha Birra</th>
<th>Omo Sheleko</th>
<th>Omo Nada</th>
<th>Gibe</th>
<th>Yem</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wolayita</td>
<td>99.46</td>
<td>98.42</td>
<td>0.07</td>
<td>0.56</td>
<td>0.15</td>
<td>2.63</td>
<td>1.81</td>
<td>-</td>
<td>23.0</td>
<td>6.7</td>
<td>5.0</td>
</tr>
<tr>
<td>Kembata</td>
<td>0.01</td>
<td>0.32</td>
<td>0.15</td>
<td>0.06</td>
<td>1.67</td>
<td>84.48</td>
<td>3.08</td>
<td>0.20</td>
<td>6.7</td>
<td>5.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Tembaro</td>
<td>-</td>
<td>0.09</td>
<td>0.14</td>
<td>0.49</td>
<td>1.49</td>
<td>-</td>
<td>62.85</td>
<td>0.14</td>
<td>5.0</td>
<td>6.7</td>
<td>5.0</td>
</tr>
<tr>
<td>Hadiya</td>
<td>-</td>
<td>0.28</td>
<td>-</td>
<td>-</td>
<td>89.57</td>
<td>10.91</td>
<td>13.05</td>
<td>1.32</td>
<td>5.0</td>
<td>6.7</td>
<td>5.0</td>
</tr>
<tr>
<td>Amhara</td>
<td>0.30</td>
<td>0.37</td>
<td>1.11</td>
<td>1.14</td>
<td>1.23</td>
<td>0.73</td>
<td>1.03</td>
<td>1.64</td>
<td>0.79</td>
<td>5.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Dawro</td>
<td>-</td>
<td>-</td>
<td>96.56</td>
<td>97.29</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.09</td>
<td>6.7</td>
<td>5.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Keffa</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.72</td>
<td>6.7</td>
<td>5.0</td>
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</tr>
<tr>
<td>Yemsa</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.06</td>
<td>91.87</td>
<td>4.9</td>
<td>5.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Oromo</td>
<td>-</td>
<td>0.21</td>
<td>0.19</td>
<td>0.32</td>
<td>0.25</td>
<td>0.21</td>
<td>91.19</td>
<td>5.60</td>
<td>20.4</td>
<td>5.0</td>
<td>6.7</td>
</tr>
<tr>
<td>Kulo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.1</td>
<td></td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Sodo Gurage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6.15</td>
<td></td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Silte</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.27</td>
<td></td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Sebat Gurage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.96</td>
<td>0.60</td>
<td></td>
<td>5.0</td>
</tr>
<tr>
<td>Others</td>
<td>0.23</td>
<td>0.52</td>
<td>1.76</td>
<td>0.27</td>
<td>5.57</td>
<td>1.00</td>
<td>17.97</td>
<td>0.64</td>
<td>4.85</td>
<td>0.55</td>
<td>3.3</td>
</tr>
</tbody>
</table>

5.3.3 Religion

Wilde ranges of religious groups exist in the study area with significant proportion of followers. Major religions practiced in the project wereda are Christianity (67.7%) and Muslims (24.6%). Traditional religions are practiced by about 5.3% of the population in the weredas with the highest concentration in Gena Bosa (41.85%) and Loma (43%) weredas. The followers of Muslims are concentrated on the right bank of the Gibe River (Omo Nada (95.6%) wereda) whereas Christians are dominant on the rest of the weredas.

Table 5.37: Population of the Weredas by Type of Religion in Percentage

<table>
<thead>
<tr>
<th>Wereda</th>
<th>Christianity</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Orthodox</td>
<td>Protestants</td>
<td>Catholic</td>
<td>Total</td>
<td>Muslims</td>
<td>Traditional</td>
<td>Others</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omonada</td>
<td>3.24</td>
<td>1.06</td>
<td>0.01</td>
<td>4.31</td>
<td>95.64</td>
<td>-</td>
<td>0.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soro</td>
<td>19.04</td>
<td>60.15</td>
<td>11.39</td>
<td>90.58</td>
<td>0.95</td>
<td>3.96</td>
<td>4.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Omo Sheleko</td>
<td>24.42</td>
<td>57.64</td>
<td>3.47</td>
<td>85.53</td>
<td>2.73</td>
<td>7.76</td>
<td>3.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kacha Bira</td>
<td>14.64</td>
<td>72.12</td>
<td>11.85</td>
<td>98.61</td>
<td>0.25</td>
<td>0.35</td>
<td>0.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolaso Sore</td>
<td>60.22</td>
<td>33.20</td>
<td>4.91</td>
<td>98.33</td>
<td>0.39</td>
<td>0.33</td>
<td>0.95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kindo Koyisha and Didaye</td>
<td>32.10</td>
<td>39.74</td>
<td>1.08</td>
<td>72.92</td>
<td>0.31</td>
<td>13.83</td>
<td>12.94</td>
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</tr>
<tr>
<td>Loma</td>
<td>29.39</td>
<td>25.80</td>
<td>0.47</td>
<td>55.66</td>
<td>0.57</td>
<td>43.02</td>
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<tr>
<td>Gena Bosa</td>
<td>37.95</td>
<td>19.43</td>
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<td>57.39</td>
<td>0.48</td>
<td>41.85</td>
<td>0.28</td>
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</tr>
<tr>
<td>Gibe</td>
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<td>58.30</td>
<td>3.05</td>
<td>91.03</td>
<td>7.43</td>
<td>0.42</td>
<td>1.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yem</td>
<td>71.24</td>
<td>3.48</td>
<td>0.02</td>
<td>74.74</td>
<td>25.14</td>
<td>0.02</td>
<td>0.10</td>
<td></td>
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</tr>
<tr>
<td>For the Weredas</td>
<td>28.00</td>
<td>36.10</td>
<td>3.70</td>
<td>67.7</td>
<td>24.60</td>
<td>5.30</td>
<td>2.40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 5.13:  Ethnic Groups Map in the Omo Valley
5.3.4  Gender Issues

Like the gender distribution on national level, the proportion of female population is slightly higher (50.3\%) than that of male in the project area. 15.2\% of the total households are female headed households.

As in the case of other communities, it was discovered that across the project area many of the constraints including cultural, social, economic, legal, environmental factors affect both genders. However, the magnitude of the problems is found to be critical when it comes to women and children. Due to the disproportional division of labour, women are forced to lead hard and tedious lives that require them to work very long hours, usually over 18 hours per day to complete their domestic chores. The study has also indicated that women are active participants in almost all types of agricultural production activities and that their contribution is crucial, without their work the survival of family and the community would be at stake. It was also discovered that women play a significant role in community management roles mainly on the social duties.

The share of children is also found to be significant particularly for girls who spend much of their time assisting their mothers. The fact that agricultural production depends on intensive labour has a direct bearing on children as they are forced to work hard when they should be attending school.

The disparity between women and men is also observed in their literacy rate where more women than men are illiterate. As the women pointed out, their illiteracy situation has a negative impact on household management and participation in the development activities. Most of the boys and girls are brought up without an opportunity to education with significant difference between girls and boys enrolment rate. High demand for child labour has contributed for the high dropout rates.

Women being over burdened by too many tasks are exposed to enormous consequences with the immediate effects being physically stressful and weak as well as affecting their health. With similar effect reflected on children. They are also hindered from participation in the development process and continue to be further aggravated by poor living conditions where there are no basic facilities that could alleviate their burden of work and improve their health status.

The tendency of giving greater value for too many children as a source of labour, security and prestige for their family has also aggravated the condition of women and children as they are forced to share the meagre resources among many children which is a serious matter for the community that could not even produce for bare survival. Such a complex gender issues not only have affected women and children negatively but also have been posing greater implications on the community in particular and the country in general. All of these barriers have increased the vulnerability of women and children in food security and other disasters.

As gender is a cross cutting-issue, its consideration of targeting disadvantageous groups of women, children and other vulnerable groups has strong advantages on ground of equity in the economic social and political spheres. Obviously, it has also greater linkage with poverty reduction and environmental sustainability that is why gender is being addressed across all programs and policy measures.

Some 95\% of the energy needs of Ethiopia are covered by biomass, mostly in the form of fuel wood and charcoal and almost all of it for cooking. The extraction of wood has led to large-scale deforestation. As deforestation takes place, the distance between settlements and nearest forest increases, making it more and more cumbersome and time consuming to go and collect fuel wood. This is a gender issue, as this work is
generally done by women. Therefore, implementation of the Gibe III scheme will contribute to improve the quality of life for women in particular.

5.3.5 Settlement Pattern and Housing Condition

The degree of urbanisation in the project weredas is still negligible with only 4.6% of the weredas population living in urban centres while 95.6% of the population live in a rural setting.

Settlement in the project area is biased towards the cooler and more habitable highlands (above 1,300 m asl) where almost all of the population live. However, during field investigation few numbers of households scattered over the flat valley bottoms were observed. Discussion held with elders in the project area also revealed that, traditionally, either sides of the river gorge had remained unoccupied by humans chiefly for reasons related to health (malaria and tsetse).

Housings in rural areas are mostly tukuls and temporary shelters/structures made of twigs, rugs, mud and grass. They are without partitioned rooms and windows for ventilation and daylight. They are often smoke-filled and dark inside and with earth floors. There are at least 7 persons living in such houses. These unhealthy dwelling houses are favourable environment for the transmission of communicable diseases like pulmonary tuberculosis, ARI, louse-borne diseases (typhus and relapsing fever), skin infections, etc. However, recent development in the housing pattern of the project area is that farmers have moved away from construction of tukuls with thatched roofs to corrugated iron sheets.

However, the Wereda Offices have planned to resettle people from the most densely populated parts of the Wereda into areas where land pressure is less severe like the Omo valley. Therefore, demographic landscape of the project area particularly that areas along the Gibe, Gojeb and Omo River banks will change in the future.

5.3.6 Agriculture

5.3.6.1 Agro-Ecological Zone

The project area falls into the Kolla agro-ecological zone and has one annual growing period during the time of the summer monsoon (Keremt). The length of the growing period in the project area ranges between 46 and 90 days depending on elevation.

5.3.6.2 Agricultural System

The farming system around the project area on the highland is well known for its complexity and variety of crops that are grown. The farmers in the project area (mainly on the high land) produce small quantities of a wide range of crops (as many as 15-20 different crops), including cereals, roots, tubers, pulses, spices, coffee and fruits. Agronomically, such use of the land is very sound, allowing the land to be converted with vegetation throughout most of the year, which helps to reduce the erosion effects of the heavy rain which occurs in the area in July and August. Furthermore the use of pulses in the mixed crops also provides some additional plant nutrients to the non-leguminous crops. Additionally, there is also considerable amount of animal forage produced in this intensive crop production system. This is important to the farmers’ livestock, notably cattle which are an integral component of the farming system in the project area.
The main areas of farming are confined to the middle or upper slopes of the hills where the settlements are situated. In these areas, there are much terracing using stones. Rows of enset stabilise the soil. The valley bottom lands are not cultivated as a result of less favourable rainfall. As the result of the Tsetse fly infestation and the consequent occurrence of cattle disease, trypanosomiasis, there is very little farming activity especially in the Omo valley. The steepness of the slope on either side of the valley appears to be another important factor which has discouraged the use of the valley for agricultural purposes.

The highland around the Gibe III reservoir is characterised by a high human population density, with extreme levels of land pressure and consequently small average farm sizes. The average farm size (on the highland) for the woredas is about 1.0 ha, but farm sizes as small as 0.2 ha are not unknown. Because of over-population, the ability of the area to resist natural calamities has become very fragile. The land resources are no longer sufficient to maintain its inhabitants.

In the low land areas, between 800 – 1,500 m asl, the cropping pattern involves fewer crops, as the Belg rains are less plentiful and reliable, and the evaporation is considerably higher. In these areas, maize and sorghum are the major cereals, with teff, haricot bean and sweet potato being the other important crops. Average yields are relatively low, reflecting the shorter growing season, compared to the production from the higher altitude areas. Crop failures are fairly common because of failure of the rains and currently most of the project woredas are receiving food aid.

Few farmers own oxen, although this varies throughout the project area. The widespread lack of draught oxen has meant that a greater proportion of the land preparation has to be done using various types of hoes. Farm labour demands are very high. However, a large family facilitates such an intensive use of the land.

The main constraints to the farming system in the project area are summarized below.

- In many of the Weredas there is shortage of arable land on the highland.
- The widespread loss of farm livestock due to animal disease, including draught oxen, has seriously interfered with the capacity of farmers to cultivate their land.
- Widespread incidence of human diseases, notably of malaria and water-borne pathogens, together with the lack of health facilities and medicines.
- The comparatively large losses of cereals crops to field and storage pests which occur during the growing season and subsequently during storage. Average losses are between 20 - 40 % of the final yield.
- Lack of rural infrastructural and marketing facilities to improve the possibilities for the rural poor to diversify their income generating opportunities.

5.3.7 **Livestock**

The agricultural system is basically mixed crop-livestock traditional peasant agriculture. Hence, livestock play an important role in that oxen are the main suppliers of draft power for ploughing and preparing the land. In addition, livestock provide income, milk and meat as well as produce hides and skins, manure and are source of prestige and wealth. They also serve as an asset, which could fetch cash income in time of need.
5.3.7.1 Livestock Population

The livestock resources of Weredas are composed of cattle, sheep, goats, equines (donkeys, horses and mules), poultry and beehives. With the exception of few introduced improved poultry breeds as well as improved beehives almost all the livestock are indigenous. The livestock population within the project weredas is shown in Table 5.38. As shown in the table, among the different livestock species of the Weredas, cattle rank first (920,509) followed by poultry (957,258) and sheep and goats (331,963) population. However, the number of pack animals (84,848) and beehives (75,304) are relatively smaller in the Weredas.

<table>
<thead>
<tr>
<th>Types of Animals</th>
<th>Kindo Koyisha and Didaye (Affected Kebeles)</th>
<th>Geno Bossa</th>
<th>Loma</th>
<th>Soro</th>
<th>Omo Sheleko</th>
<th>Boloso Soro</th>
<th>Kacha Birra</th>
<th>Misha (Konteb)</th>
<th>Yeme</th>
<th>Omonad a</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>23,533</td>
<td>49,630</td>
<td>21,060</td>
<td>143400</td>
<td>90284</td>
<td>132678</td>
<td>3394</td>
<td>194276</td>
<td>51386</td>
<td>210868</td>
<td>920,509</td>
</tr>
<tr>
<td>Sheep and goat</td>
<td>9,120</td>
<td>15,921</td>
<td>9,360</td>
<td>51750</td>
<td>20669</td>
<td>16629</td>
<td>5368</td>
<td>73591</td>
<td>32717</td>
<td>96837</td>
<td>331,962</td>
</tr>
<tr>
<td>Pack animals</td>
<td>562</td>
<td>3821</td>
<td>350</td>
<td>10890</td>
<td>3708</td>
<td>2805</td>
<td>2839</td>
<td>30698</td>
<td>3114</td>
<td>26061</td>
<td>84,848</td>
</tr>
<tr>
<td>Poultry</td>
<td>15,427</td>
<td>33,821</td>
<td>10,000</td>
<td>235,000</td>
<td>53337</td>
<td>84636</td>
<td>6120</td>
<td>287550</td>
<td>52005</td>
<td>177362</td>
<td>957,258</td>
</tr>
<tr>
<td>Beehives</td>
<td>1023</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5202</td>
<td>-</td>
<td>1687</td>
<td>16611</td>
<td>9517</td>
<td>41264</td>
<td>75,304</td>
</tr>
</tbody>
</table>

Though livestock are an integral part and play an important role to the mixed crop livestock production system, the production and productivity of the indigenous livestock is very low. In general, low production and productivity of the indigenous livestock is primarily associated to the low genetic potential, poor nutrition and inadequate health, breeding and marketing services.

5.3.7.2 Livestock Feed Source

Majors feed sources are primary the communal natural pastures, aftermath grazing and crop residue. Small individual plots of grazing land around homesteads are use for milking cows and young calves. Cattle are usually grazed in herds of about 100 heads representing the cattle of about 20 households.

Generally, in Ethiopia all land belongs to the Government, though using rights of grasslands may be either under governments, communal or private responsibility. However, in the case of future reservoir area grazing land is mostly government owned and although there are also communally owned. However, there is no privately owned grazing land within the future reservoir area. In general terms most of these grazing resources are not in good conditions.

There is wide variation in the availability of different feed types in all the weredas around the reservoir area. Natural pastures are available for livestock throughout the year and communal pastures are grazed for most parts of the year without rest. The biomass is abundant during the wet season and a few months thereafter. However, in times of feed shortage during the dry months of the year, animals are taken, except milking cows and young calves, to the lower altitude closer to the Omo River where water and pasture is available and with the risk of Tsetse infestation. In these areas farmers move their cattle only in times of the lowest risk into this area. With the beginning of the rain, when the occurrence of trypanosomiasis increases, farmers take back their livestock from the rivers to their permanent villages.

The other source of livestock feed is obtained from crop residue of various food crops including cereals, straws, stalks, hauls from pulse crops and oil crops. Crop residues are stored and fed to animals during the
dry months of the year when feed shortage occurs. Additional feed source is also obtained from aftermath grazing from crops harvested.

5.3.7.3 Livestock Diseases

The prevalence of livestock diseases is a serious concern in the project areas. The major livestock diseases in terms of economic importance are Trypanosomiasis followed by internal parasites, external parasites and infectious diseases.

Trypanosomiasis is one of the major diseases in the project area highly affecting both animal and human. According to study report of the National Tsetse Fly Investigation and Control Centre (NTTICC) the entire project area except the mountain ranges are reported to have trypanosomiasis. At present, because of adaptation to higher altitudes, tsetse flies infested areas are gradually advancing to adjacent areas. Tsetse infestation has gradually started to invade even higher altitudes of 2,000 m a.s.l. range.

At present, taking the livestock resources into account, the animal health services rendered in the project area are not adequate. In general, veterinary personnel and facilities are far below the livestock population that requires the health services and requires more attention in terms of providing better services. The only institution undertaking livestock health service in these areas is the Wereda Office of Agriculture.

5.3.7.4 Livestock Marketing

Livestock and livestock products are marketed in small sized open markets where buyers and sellers bargain on specific items. Animals are usually taken to the market when farmers have surplus to their requirement or when they are in need of cash for home expenditure, such as purchase of agricultural inputs, consumer goods as well as payment to taxes. In addition, farmers also sell livestock either when prices are attractive or during severe drought and animal disease outbreaks in order to avert and minimize their risk.

5.3.8 Cultural, Religious, Historical and Archaeological Sites

The importance of the Gibe III reservoir area and the immediate surrounding has been investigated in terms of religious and cultural site relics and archaeological importance. Based on this assessment the historical site known as King Ijajo Kella and King Halala Walls were found on both sides of the Omo River. Officials of the Weredas were interviewed in regards to the historical, cultural and archaeological importance of the reservoir area vis-a-vis the execution of the Gibe III Hydroelectric Project.

A joint rapid archaeological impact assessment was initiated with the Authority for the Research and Conservation of Cultural Heritage (ARCCH) to the elongated stone ramparts in Wolayita and Dawro zones, along the Omo River. The Team conducted a preliminary archaeological survey and a rapid impact assessment along the Omo River, in Wolayita and Dawro Zones.

The main objective of this survey was to assess the values of the stone fortifications, which are found in Wolayita and Dawro zones, and evaluate the impact of the Gilgel Gibe III hydroelectric dam construction on these cultural remains.

Archaeological impact assessment is primarily concerned with the location and evaluation of archaeological resources. In this section endeavours made to describe the archaeological survey results, which are carried out in Wolayita and Dawro Zones along the Omro River.
5.3.8.1 Methodology

Secondary data obtained from written historic sources, maps, proposals, Gilgel Gibe III Project documents and other archival materials are used.

Oral history is collected from Wolayita and Dawro elders and from people who have local knowledge about the history and culture of the region. Based on the oral history, the location, history and culture of the stone fortifications are documented.

Pedestrian reconnaissance field survey is carried out in areas where the consulting firm and the local authority have identified endangered sections of the stone ramparts. This has helped to locate the parts of the cultural remains, which will be submerged by the reservoir. This also provided data about the type of the site, the cultural remains, the topography and vegetation of the areas.

The geographic locations and elevations of each site are obtained from GPS /Geographic position system/ readings.

The dimensions of stone ramparts are obtained using tape measurements. The height and width of the walls at specific locations are taken. Cultural remains and the surrounding landscapes are photographed.

The gathered data are analyzed qualitatively and quantitatively. The oral history is discussed scientifically and crosschecked with written historic sources.

5.3.8.2 Ijajo Kella (the Wall of Ijajo), Wolayita

From the Wolayita Zone side the team has surveyed five kebeles of the Kindo Koyisha Wereda, which is the only Wereda that will be affected by the project. From our survey we observed and confirmed the existence of elongated stone ramparts in those kebeles.

Local people call the stone ramparts Ijajo Kella or the Wall of Ijajo. They are constructed at different rows to serve as a defensive wall against any enemy who might have crossed the Omo River. Elders claimed that a person named Ijajo, who was a boarder commissioner (Washi moconaa) during the reign of kawo Aggatoo (c.1753-1792), constructed the wall. Other stone rampart were also made on the eastern frontiers of Wolayita, from kucha to Blate River, which is called Amadoo kella (the Wall of King Amado). Local informants claim that the dimension of the stone rampart is more than 67km, and made to protect Wolayita’s frontiers from outside invaders.

The dimension of the wall is between 1.5 to 2.5m in height and 1.0 to 2.5 m in width. The wall of Ijajo was made with slabs of locally available basaltic stones, carved carefully that no mortar was required to hold them together (See Photo 5.4). However, there are no observable stone artefacts, potsherds or other archaeological materials near these sites.
5.3.8.3 **Halala Kella (the wall of Halala)**

Local officials and informants have confirmed the presence of extended stone rampart throughout Dawro named Halala Kella. They claim that the wall was built during the reign of Kati Halala (c1757-1782) to protect Dawro’s frontiers from outside invaders. This stone fortification was constructed on the Gofa, Wolayita, Kembata, and Kaffa and on the Jima frontiers. Local authorities and elders of Dawro also claimed that the total length of the walls of Halala is about 170km.

During the consultations, local authorities and elders have identified specific localities, which appear to be located near the Omo River, who suspected that the sites will probably submerged by the reservoir of the Gilgel Gibe III reservoir. These include Decha Denba, Gereda Bachera, Zaba Dilba, Buri, Beza Shota and above all Zimawaruma. All however agreed that among these localities where the Halala Kella found nearer to the Omo river (at lower elevation) is at Zimawaruma, at a place called Kala.

As observed the stone fortifications of Halala sites were made with basaltic stones. The heights of the walls vary between 2-3m high depending on the landscape. In Dermesa 2 site we observed and measured a stone ramparts, which has 5m width and 3m in height. The stones used for construction of the walls carved to use for appropriate purpose, without fastening with mortar (See Photo 5.5).

Although it is widely accepted that the kings of Wolayita and Dawro constructed these walls to protect their people from ground-fighters, the history and culture of the walls of Ijajo and Halala have only been told orally for centuries in Wolayita and Dawro and written historic sources are barely mentioned about them. Thus, the presence of these stone fortifications was not known to the outside region until recently. As a result, both the walls of Ijajo and Halala have not yet been studied, documented and registered as parts of Ethiopian heritage.
5.3.8.4 UNESCO’s “Heritage Site” and other Archaeological Sites

The lower valley of the Omo river (downstream of the Gibe III dam), was designated a UNESCO World Heritage Site in 1980, because of geological and archaeological importance. The prehistoric site near Lake Turkana, the lower valley of the Omo is renowned the world over. The discovery of many fossils there, especially Homo gracilis, has been of fundamental importance in the study of human evolution.

Several hominid fossils and archaeological localities, dating to the Pliocene and Pleistocene, have been excavated by French and American teams. Fossils belonging to the genera Australopithecine and Homo have been found at several archaeological sites, as well as tools made from quartzite, the oldest of which date back to about 2.4 million years ago.

Experts believe that for thousands of years the lower valley of the Omo was a crossroads of a wide assortment of cultures where early humans of many different ethnicities passed as they migrated from and to lands in every direction. To this day, the cultures and people of the Lower Valley of the Omo are in fact studied for their incredible diversity.

According to experts from ARCCH, Regional office of culture and Information and Wereda Offices, the proposed dam and reservoir area is not in close proximity to the UNESCO designated heritage site and The Gibe III reservoir area also has no signs of archaeological artefacts which could give such importance as to hinder the execution of the project.

5.3.9 Public Health

5.3.9.1 Public Health Status

The major health problems of the project area are reported to be infectious diseases and malnutrition. Most illnesses are communicable and are related, either directly or indirectly, to lack of adequate and safe drinking water supplies and sanitation, low living standards and poor nutrition. Waterborne and vector borne diseases are also prevalent in the area.

The ten top diseases and their prevalence in the project area as reported by the Wereda health divisions are shown in Table 5.39. The prevalent diseases in the project area include malaria, intestinal parasites, upper
respiratory tract infection, diarrhoea, etc. Most of these ten-top diseases are not only causes of illness and suffering of the people but also cause hospital admission and hospital deaths.

The widespread incidence of human diseases, notably of malaria and water-borne pathogens, is prevalent together with the lack of health facilities and medicines. The human health factor has a very significant impact on the ability of members of the rural community to farm their land because of their reduced physical vigour. This effect is further compounded by an often inadequate level of nutrition, which may occur even in good years, between the planting of main crops and the harvest.

5.3.9.2 Water-related and water Borne Diseases

In and around the project area, both water related and water based diseases are the most significant public health problems. The environmental factors that may contribute to the changing health situation for vector borne diseases are altitude, climate, migration and seasonal variation. The project area is endemic to the following vector borne diseases: malaria, trypanosomiasis, schistosomiasis and onchocerciasis.

Malaria: The project areas are highly endemic for malaria with continuous transmission. Malaria is by far the most important of the diseases under consideration (see Table 5.39) and it is due to the number of people annually infected (and whose quality of life and working capacity are reduced) and the death rate from it. As shown in Table 5.39, a total of 32,753 cases were recorded in 2004/5 and the entire population in these weredas is at risk of malaria. Infants, children under 5 years of age and pregnant women are the most at risk group from malaria infection.

The presence of several rivers (tributaries to Omo River) provides ideal breeding habitats for mosquitoes. However, there is a considerable seasonal variation (depending on the climatic condition) in Malaria transmission and the highest pick of malaria case are reported towards the end and after the rainy season.

Schistosomiasis: Schistosomiasis, often known as bilharziasis, is a parasitic disease and prevalent in Ethiopia. Results of several studies show that the Omo-Gibe River basin is conducive for the propagation of the schistosomiasis parasite. Therefore, the communities around the Omo-Gibe River and its tributaries are under a constant threat as they perform daily activities in aquatic environment such as swimming, fishing, farming, washing and bathing.

Two genera of fresh water snails serve as intermediate hosts in Ethiopia: Biomphalaria snails for schisstosoma mansoni intestinal and bulinus snails for schistosoma haematobium (urinary). Biomphaloria snails like stable slow flowing water and are dominant in long-established water bodies. Bulinus snails prefer unstable, semi-stagnant water and colonise newly inundated water bodies.

The disease can spread with the construction of Gibe III dam and creation of reservoir. The prevalence of schistosomiasis is a reasonable indication of the lack of personal hygiene, proper disposal of faecal materials and lack of safe water supply.

Onchocerciasis: The disease is widespread in Ethiopia, over an area that stretches from the Blue-Nile in the north to the Omo Valley in the south and west toward the Sudan Boarder. Simulidium damnosum and simulidium woodi Ethiopians have been identified as the vectors of the disease. The vectors mainly inhabit fast flowing streams and rivers with envisaged development of Gibe III scheme involving water impoundment and possible in-migration of infected and uninfected individuals from other places, the project area has the potential for spread of the disease.
Trypanosomiasis: it is one of the major diseases in the project area highly affecting both animal and human. According to study report of the National Tsetse Fly Investigation and control centre the entire project area is reported to have trypanosomiasis. The disease-causing parasite is Trypanosoma rhodesiense in man and Trypanosoma bruci in livestock.

**Prevalence of HIV/AIDS**

HIV/AIDS has become a national health problem in Ethiopia and the disease is availing itself everywhere in the country; tuberculosis is known to be one of the opportunistic infections of HIV carriers and or AIDS patients. Though it is not among the top ten diseases, HIV cases are also found in the Weredas. Infections occur among adults between 15 and 49 years of age. This age range encompasses the most economically productive segment of the population; the HIV/AIDS epidemic negatively impacts on labour productivity. Work-time is lost through frequent absenteeism, and decreased capacity to do normal work as the disease advances. There are also social consequences of the epidemic as care-givers and income generating members of the family die leaving behind orphans and other dependants.

5.3.9.3 **Health Infrastructure**

The Health Bureau is responsible for providing health care in the Region and operates a comprehensive health care network within the limits of the available resources. In addition to the Health Bureau, Non-Governmental Organizations (NGOs) and Other Governmental Agencies (OGAs) are involved in the Region.

The general policy of the Ministry of Health proposes Central referral hospital, Regional hospitals, Rural hospitals and Health care centres to be installed in each Zone in order to allow minimum health services to be provided to the population.
Table 5.39: Ten Top Diseases, 2004/05

<table>
<thead>
<tr>
<th>Ten Top Diseases</th>
<th>Kindo Koyisha</th>
<th>Geno Bossa</th>
<th>Loma</th>
<th>Soro</th>
<th>Kacha Birra</th>
<th>Boloso Soro</th>
<th>Omo Sheleko</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank</td>
<td>Number of Cases</td>
<td>Rank</td>
<td>Number of Cases</td>
<td>Rank</td>
<td>Number of Cases</td>
<td>Rank</td>
<td>Number of Cases</td>
</tr>
<tr>
<td>Malaria</td>
<td>1</td>
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<td>1</td>
<td>2183</td>
<td>1</td>
<td>4818</td>
<td>1</td>
</tr>
<tr>
<td>URTI</td>
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<td>5</td>
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<td>2</td>
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<tr>
<td>Intestinal parasite</td>
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<td>2028</td>
<td>2</td>
<td>833</td>
<td>3</td>
<td>1461</td>
<td>2</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td>705</td>
<td>4</td>
<td>781</td>
<td>4</td>
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<tr>
<td>Gastritis</td>
<td>4</td>
<td>819</td>
<td>8</td>
<td>173</td>
<td>9</td>
<td>749</td>
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<tr>
<td>Skin infection</td>
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<td>504</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td>407</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>5</td>
<td>1033</td>
<td>9</td>
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<td>Rheumatic</td>
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<td>253</td>
<td>8</td>
<td>318</td>
<td>-</td>
</tr>
<tr>
<td>Eye infection/ Conjunctives</td>
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<tr>
<td>Typhoid</td>
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<td>278</td>
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<tr>
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<td>All types of tuberculoses</td>
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<td>-</td>
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<td>-</td>
</tr>
</tbody>
</table>

Total Cases 11752 5826 10738 16531 19732 18326
The health coverage in the affected Weredas ranges from 39.0% to 83.6% (that is the population living within 10km radius of a health station). As shown in Table 5.40 Boloso Sore and Kacha Birra have better health coverage compared to others, and for the rest the coverage level is very poor.

Table 5.40: Health Coverage of the Affected Weredas

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of Wereda</th>
<th>Health Coverage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kindo Koyisha</td>
<td>62.0</td>
</tr>
<tr>
<td>2</td>
<td>Genna Bossa</td>
<td>39.0</td>
</tr>
<tr>
<td>3</td>
<td>Loma</td>
<td>65.0</td>
</tr>
<tr>
<td>4</td>
<td>Omo Sheleko</td>
<td>63.0</td>
</tr>
<tr>
<td>5</td>
<td>Boloso Sore</td>
<td>83.6</td>
</tr>
<tr>
<td>6</td>
<td>Kacha Birra</td>
<td>81.9</td>
</tr>
<tr>
<td>7</td>
<td>Soro</td>
<td>54.0</td>
</tr>
<tr>
<td>8</td>
<td>Yem</td>
<td>70.0</td>
</tr>
</tbody>
</table>

Source: wereda offices

The available health institutions and health personnel of the affected weredas are presented in Table 5.41. As shown in the Table, there are 1 hospital, 24 health centres, 12 clinics, 201 health posts and 18 drug stores/pharmacies. Taking the total population of the selected eight weredas as 2,039,914, the number of people per health stations is estimated at 85,000 far below the standard of 10,000 per health station set by the ministry of health. Moreover, most of the health care facilities (including health stations) are located in towns that may not be within 10km of most people.

Staffing pattern and human resources available are very important for the health care of the population in the project area. According to data obtained from wereda health offices, there were 13 health officers, 198 nurses, 25 health assistants, 10 pharmacists, 17 lab technicians and 12 sanitarians.

Table 5.41: Health Institutions and Personnel in the Weredas

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Kindo Koyisha and Didaye</th>
<th>Genna Bossa</th>
<th>Loma</th>
<th>Soro</th>
<th>Omo Sheleko</th>
<th>Boloso Sore</th>
<th>Kacha Birra</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Institution</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Hospital</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Health Centre</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>Clinic/Developing HC</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Health post</td>
<td>49</td>
<td>21</td>
<td>33</td>
<td>4</td>
<td>29</td>
<td>40</td>
<td>25</td>
<td>201</td>
</tr>
<tr>
<td>Pharmacy/ drug store</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Health Personnel</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doctors</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Health officer</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Nurses</td>
<td>48</td>
<td>6</td>
<td>31</td>
<td>19</td>
<td>29</td>
<td>40</td>
<td>25</td>
<td>198</td>
</tr>
<tr>
<td>Health assistants</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>Health extension agents</td>
<td>83</td>
<td>69</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>152</td>
</tr>
<tr>
<td>Pharmacists</td>
<td>5</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Lab. Technicians</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Sanitarians</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>12</td>
</tr>
</tbody>
</table>

More services for the prevention, control and cure of infections diseases, particularly vector-borne ones, are required. Based on preliminary field assessment, it has been possible to identify the following problems associated with health service system:

- health institutions are limited and yet most of the existing ones are concentrated in urban centre and/or along main roads neglecting the rural hinterland,
- lack of qualified health staff,
- inadequate supply of drugs and equipment, and
- shortage of budget.
5.3.10 Water Supply

The urban and rural water supply coverage of Kindo Koyisha, Gena Bossa, Loma, Soro, Omo Sheleko, Boloso Soro and Kacha Birra woredas are on the lower side and therefore significant number of population of the woredas use unsafe water for drinking (see Table 5.42). As of 2006, only 61.1% of the rural and 29.7% of the urban population of the project area had an adequate and safe water supply. This figure ranges from 2.9% in Gena Bossa wereda to 65.2% in Kindo-Koyisha wereda. Most of the available existing water supply schemes have quality problems. As a result, many people who use unclean sources suffer from water borne diseases as it is impossible to have a clean and sanitary environment without adequate water.

Table 5.42: Water Supply Coverage of the Affected Woredas (in %)

<table>
<thead>
<tr>
<th>Water supply Coverage</th>
<th>Kindo Koyisha</th>
<th>Gena Bossa</th>
<th>Loma</th>
<th>Soro</th>
<th>Omo Sheleko</th>
<th>Boloso Soro</th>
<th>Kacha Birra</th>
<th>Yem</th>
<th>Omo Nada</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>65.0</td>
<td>5.0</td>
<td>23.6</td>
<td>86.0</td>
<td>2.0</td>
<td>35.0</td>
<td>75.0</td>
<td>-</td>
<td>67.9</td>
</tr>
<tr>
<td>Rural</td>
<td>65.2</td>
<td>2.9</td>
<td>3.6</td>
<td>27.3</td>
<td>18.0</td>
<td>34.0</td>
<td>27.8</td>
<td>-</td>
<td>5.7</td>
</tr>
<tr>
<td>Woreda level</td>
<td>65.2</td>
<td>2.9</td>
<td>3.9</td>
<td>30.8</td>
<td>17.3</td>
<td>34.0</td>
<td>33.4</td>
<td>23.8</td>
<td>7.2</td>
</tr>
</tbody>
</table>

5.3.11 Other Social Service and Infrastructures

The existing infrastructure that are located in the future reservoir area were investigated and these include: administrative and cooperative office, schools, health institutions, local and regional markets, water supply schemes, electric lines, public roads and bridges, important footpath connections, etc.

The existing infrastructures were first identified on the 1:50,000 scale topographic map and followed by field investigation. Visits were made to the project area and discussions held with key informants to find the presence of social services.

The only access road that serves the Dawro, Wolayita and the other communities in the area is the Chida – Sodo road. This road connects Wereda capitals with the zonal and Regional capitals and serves a number of villages and is the only road access to serve the community to get agricultural inputs and to take their products to the market. However, to reach to most kebeles of the woredas people use horse and mule back or foot. The problem of access road within the project area has contributed for the low standard of living.

Based on the information obtained during the field investigation and discussions held with key informants, no other social service facilities like public buildings and cooperative office, schools, health institutions, local and regional markets, water supply schemes and electric lines are located within the proposed Gibe III reservoir area.

On the Western side of the Omo, no wereda towns have access to electricity. However, in rural towns very few individuals use generators for personal and business activities.

5.3.12 Tourism

The Omo Valley is considered to be an important tourist site. The tourist attraction sites include the Omo-river system with its rich national parks in the lower part of the Omo river. Omo Gorge is used for river rafting on a stretch of about 500 km.
5.3.13 NGOs working in and around the affected Weredas

There are few NGOs involved in the affected weredas in the area of rural road construction, soil conservation, rural water supply, provision of health service and other conservation activities. The lists of NGOs involved in the weredas are shown below.

Table 5.43: NGOs working in the affected Wereda

<table>
<thead>
<tr>
<th>Name of NGOs</th>
<th>Kindo Koyisha</th>
<th>Gena Bossa</th>
<th>Loma</th>
<th>Soro</th>
<th>Omo sheleko</th>
<th>Bolo Soro</th>
<th>Kacha Birra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kale Hiwot</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inter Aid</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>World Food Programme</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catholic Mission/church</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action Aid</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acts of compassion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African humanitarian action</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>World Vision</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mekane Eyesus</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5.4 Baseline Information: Downstream Area

Additional studies on downstream area has been carried out and presented in a separate report\(^\text{19}\) and summarised in this section.

5.4.1 Geology

The lower Omo Basin geology can be divided into two large groups:

- Rock formations crowning the lower Omo basin
- Sediments forming the lower Omo basin

5.4.1.1 Rock formations crowning the lower Omo basin

“Hammar Domain” rocks form the crystalline basement. The domain in the study area underlies the lower part of eastern Omo river area and the northern part of Lake Turkana. This area contains two Precambrian major rock groups: a complex of older gneiss and granulite, which is highly deformed, re-crystallized and partly migmatized, as well as a suite of younger plutonic rock not necessarily related to the other and far less or not deformed / re-crystallized.

The geological structure is oriented NNW-SSE and develops in subsequent plates whose width varies from 6 to 12km. Subsequently, the structure bends and develops northwards encircling the plutonic masses.

The principal faults are oriented ENE-WSW. Traces of faults and fractures are also observed in the sediments that fill the Omo River valley.

On the crystalline basement are the Pre/post-rift sediments/volcanic, characterised by four principal formations: Main volcanic sequences, basalt, rhyolite, trachyte, tuff, ignimbrite (Eocene, Oligocene), Omo group (Mursi formation basalt), Shungura formation (Pliocene), Nakwa formation basalt (quaternary). The Main formation sequence rims the western side of the lower and middle Omo valley reaching the Jbai range.

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and the inner zone of the eastern part, to the east of the Mursi plain, while the Nakwa formation generates the Korath ranger located in the lower part of the western Omo, and the Mursi formation covers the eastern part of the mid-Omo valley (Mursi plain).

The undivided part of the pre-rift volcanic succession is separated almost everywhere from the crystalline basement by the basal residual sandstone. Basalt dominates the lower part of most sections, followed by a thick unit of salic rocks. However, salic flows and breccias lie directly on the sandstone in some places. The thickest salic succession lies astride a north-north-east axis along the mid-Omo plain trend. The main faulting trend is oriented NNE-SSW according to the rift valley orientation.

The Mursi Fm is divided into two units, the lower being sedimentary and the upper one formed by flood basalt. The well-studied lower-sedimentary unit, divided into three members, is exposed at the west side of the southern part of the Nyalibong range.

It lies uncomfortably on west-tilted pre-rift rhyolite and is composed of some 150m of clays, silts and sand with subordinate tuff and pebble beds. These sediments are conformably overlain by flood basalts having a total thickness probably less than 100m.

The Mursi basalt underlies much, if not all, of the cover of the middle Omo plains, (Mursi people plains) and its extension could continue southward beyond the Nyalibong ridge.

The Shungura formation is exposed for about 60m along the west side of the Omo river north of Lake Turkana, and includes 760 m of brown, grey, and buff clays, silts, sand, gravel, tuffs, marls and freshwater limestone. These sediments are tilted gently to the west and are overlain by the shallow unconformity of the Kibbish formation. The faults develop both parallel and oblique to the north with respect to the axis of tilting and have an offset bedding of several metres locally. The sedimentation records fluctuating fluvial and lacustrine cycles.

Nakwa Formation (quaternary) Mont Nakwa is located in the middle of a chain of very recent and well-preserved volcanic cones known as the Korath range which lies 55Km north of the Turkana Lake. These cones stand 400m above the monotonous surrounding plains that are effusive events for volcanic rocks with basic alkaline affinity. The main lavas are basanites with minor thephirite.

The cones are aligned north northeasterly, i.e. the same trend as the Turkana rift and many of the prominent faults in the region.

5.4.1.2 Sediments forming the lower Omo basin

Local lacustrine, fluvial and fluviolacustrine sediments divide into five formations which all belong to the Pleistocene Holocene.

These include Kibish formation; Undivided alluvial, fluviatile, lacustrine sediments; Fluviatile sand and silt; Lacustrine silt and clay; Alluvium.

A sequence of horizontal sediments, related to the major fluctuations in the ancestral Lake Turkana level, lies unconformably above the various formations of the Omo Group while dissected, and in its turn overlain, by the late Holocene deposits. The sequence is termed “Kibish” Formation and is well exposed where the Omo river and its ephemeral side tributaries have cut through the otherwise flat and unravelling plain that
apparently marks its top surface. It comprises four members with a measured thickness of 120m, while a slightly greater thickness is inferred.

The lowest unit, Member I, is at least 31m thick; it has gravelly sand at the base, which is followed by a partly laminated and ripple-marked succession of clay, silt and sand, and contains reworked tuff close to the base. Its top is marked by a soil horizon.

Member II, 22m thick, is composed prevailingly by massive silts, deposits on the basal tuff blanketed and dissected surface of member I.

Member III, 46m thick, records two Lake Turkana advance and retreat cycles and is separated by a prominent 3m thick subaqueous tuff bed.

Clays, silts and sands, form its sediments as well as shell beds associated with the second cycle. Another erosional interval separating Members III and IV is marked by a soil horizon and the subsequent dissection.

Member IV is divided into two units: Unit IVa comprises 13.5m of sand, silts and clays with a gravelly base while IVb is formed by 8m of sands and silts with minor tuff. The two sub-members represent the transgression of Lake Turkana, separated by a regression close to the present lake level.

In the northern part of the mid-Omo Plain, undivided Quaternary alluvium is located adjacent to the northern limit of the Kibish Formation, as shown on the map that partially overlies the Kibish Fm and is therefore younger than the Kibish sediments. This may also be partially equivalent in age and represents the terrestrial fluviatile and alluvial faces.

In the northern lower Omo basin Lacustrine and Deltaic sediments were interpreted as belonging to the Kibish Fm. The interpretation of the surface geomorphic features suggests that it may be younger. At its highest level, about 80m above the present level, the ancestral Lake Turkana was able to overflow through a low divide southwest of the Kibish settlement into the Logitipi swamp in north-western Kenya, and thence to the Nile drainage system.

The overflow levels were last reached at the end of the Kibish member IVb time of deposition formation about 3250 years ago.

Since then, the Lake has retreated and risen again perhaps by as much as 40m, which was sufficient to flood northward along the eastern side of the Turkana depression into the Usno plains (A2c).

The lacustrine sediments originating from this stage are now exposed on the banks of the Omo river south of the Usno river confluence.

Thence, although interpreted as Holocene, their extrapolated extent is shown in the geological map as Unit Q1 rather than QH1 in order to distinguish them from the far more recent alluvial fan (Qha) and fluviatile (QHr) deposits in the region.

The successive formations bear witness to the complicated system of tributaries during the numerous Lake Turkana ingressions and recessions.
5.4.2 Hydrogeology

Basement rocks with low permeability are found in the catchment area on the left bank of the Omo river. In this area the faults system is orthogonal with respect to the river. Here we find Precambrian Metamorphic and Plutonic rocks, and Pre rift main volcanic sequences, basalt, rhyolite, trachyte, tuff, ignimbrite (Eocene-Oligocene).

On the river right bank the rocks are more permeable and absorb large quantities of rain water. The quantity of water absorbed by these rocks highly reduces the surface flow of water. The underground water resources are dispersed in the infinitesimal voids in between the rocks.

In the Lower Omo area there are primary permeability rocks with intrinsic porosity and secondary permeability depending on the rock faulting. Primary permeability rocks are composed of the sediments forming the Lower Omo basin while secondary permeability rocks encircle the Lower Omo basin.

5.4.3 Land Use/Cover units

The land use/cover units along the Omo River downstream of the Gibe III dam site are mainly attributed by major classes of Bush land, Shrub land, Grassland and wetland. Further descriptions of these classes are briefly presented below and also shown in Figure 5.14.

Bush land: This unit occurs predominantly between altitudes of 300 m and 900 m, but with a strong emphasis between 300 m and 600 m. Climatic conditions in these areas do not support tree growth; normally this results from inadequate moisture, although in the delta area trees may be suppressed by seasonal flooding to which the bush land appears more resistant. This category occupies much of the Lower Omo valley and the low hills east of Omo River.

Shrub land: Shrub land is a response to moisture excess; the depression, heavy clay soils of the lower Omo are generally occupied by shrub vegetation.

Grassland: Grasslands represent the most important grazing resources in the lower Omo and extends to about 1,534 million ha. They are typical of Omo National Park, the plains of lower Omo and the Mursi Bodi plains. Species like Cenchrus sp. Digitaria sp., Pennisetum sp, Enteropogon macrostachyus, and Elusine sp. were found in the lower Omo. The saline area of lacustrine pasture near Lake Turkana is very heavily grazed for much of the year and the close swards are composed almost entirely of two grasses: sporobolus spicatus and brachiara sp. Leptochloa fusca also occurs near the water’s edge. The grassland suffers from seasonal surface water logging and burning. However this site is used as dry season grazing.

Wood land: The open and dense reverine woodland classes are much dominated in the Lower Omo area. The value of woodlands for grazing livestock is frequently limited by tsetse fly. Trees were represented by Combertum molle, Terminalia sp, Piliostigma thonningii and acacia sp. An under storey of Harrisonia abyssinica, Dichrostachys cinerea, Grewia sp, Acacia mellifera, Baranites aegyptica and Acacia tortolis is also typical.

Marshland: Seasonal swamp/marshlands are used for flood recession cultivation and dry season grazing. Marshlands used for recession cultivation occupies around 11,000 ha, exclusively in the delta area where they are mixed with marshland used for dry season grazing. Presumably these areas are better drained than those used for dry season grazing, draining earlier and more completely to allow recession cultivation. However, the whole of the unit is not used for recession cultivation in any one year. The extent and location
of the cultivation may vary with the extent and length of the flood, which may be quite variable from year to year.

Photo 5.6: View of Bush land and Shrub land Along the Lower Omo River

Photo 5.7: Typical Grass Land in the Lower Omo
Figure 5.14: Land Cover along the Lower Omo River
5.4.4 Hydrology

Downstream of the dam the Omo river flows “entrenched” for about 200 km and through an “incision”, generally more than 10 m deep, for about 150 km.

Along the reach heading W several small though perennial effluents (Sana, Deme, Zage, Irgene) join the river draining the highlands from E/S. Average rainfall in these sub-basins ranges from about 1500 mm/year (south) to 1000 mm/year (east).

Along the reach heading SW the Zinga and Mansa tributaries (smaller) and the Denchiya and Toshi/Sherma rivers (larger) join the Omo after draining the upper highlands (mainly covered with a vegetation of wooden shrubland). The average rainfall ranges from about 1600 mm (north) to 900 mm (south).

About 80 km downstream the longitudinal slope of the riverbed flattens and gorge opens as the river crosses a hilly and semi-arid landscape.

The river changes in characters with a meandering river channel ending at the river delta area. In this stretch the river is clearly in an evolutionary process, probably related also to the “shrinking” of the Turkana lake, where abandoned meanders and upcoming ones are clearly visible.

Along this stretch the Aku and particularly the Maiki, tapering streams with perennial tributaries, drain the highlands along the Omo basin boundaries.

Average rainfall in this area ranges from about 1500 mm/year (north-west) to 500 mm/year (south).

The Omo River then flows south across the arid plains and the Delta for some 100 kms.

The total catchment of the Omo at the Lake Turkana is about 73500 km$^2$.

The average rainfall within the whole Omo River watershed varies from 1900 mm/year (north-west) to less than 300 mm/year (south).

The mean annual flows of the Omo River at the Lake Turkana have been evaluated\(^{20}\) by means of an estimate of the mean flows in the residual basin Gibe III-Turkana.

Since no robust flow measurements series are available downstream Abelti/Gojeb the analysis has been carried out by elaborating rainfall data of the residual basin.

The table below shows the rainfall rates, the runoff coefficient and the mean flows for the main sub-catchments of the Omo basin: the mean annual rainfall for the residual basin downstream Gibe III site (denoted as “Residual 2”) is 870 mm/year.

This value is far below the rainfall rate of the upper part of the basin, characterised by a wetter climate.

\(^{20}\) 300 ENV RAG003A Additional Study on Downstream Impact – April 2008
Table 5.44: Rainfall rates, runoff coefficients and flows for the main sub-catchments of the Omo River.

<table>
<thead>
<tr>
<th></th>
<th>A (km²)</th>
<th>H (mm/year)</th>
<th>Φ</th>
<th>Q (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibe nr. Abelti</td>
<td>15853</td>
<td>1450</td>
<td>0.26</td>
<td>190.0</td>
</tr>
<tr>
<td>Wabi nr. Wolkite</td>
<td>1869</td>
<td>1430</td>
<td>0.39</td>
<td>33.0</td>
</tr>
<tr>
<td>Gojeb dam site</td>
<td>5186</td>
<td>1710</td>
<td>0.32</td>
<td>91.3</td>
</tr>
<tr>
<td>Residual 1</td>
<td>11251</td>
<td>1253</td>
<td>0.27</td>
<td>120.7</td>
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<tr>
<td>Dam site 5</td>
<td>34159</td>
<td>1424</td>
<td>0.28</td>
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<td>Residual 2</td>
<td>43847</td>
<td>871</td>
<td>0.19</td>
<td>230.0</td>
</tr>
<tr>
<td>Lake Turkana</td>
<td>78006</td>
<td>1113</td>
<td>0.21</td>
<td>663.9</td>
</tr>
</tbody>
</table>

The estimation of the runoff coefficient for the Residual 2 catchment was carried out through the extrapolation of the values of ETP (Potential EvapoTranspiration) of the upstream catchments.

Table 5.45: Runoff coefficients for the main sub-catchments of the Omo River.

<table>
<thead>
<tr>
<th></th>
<th>ETP (mm/year)</th>
<th>Φ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gibe nr. Abelti</td>
<td>1124</td>
<td>0.266</td>
</tr>
<tr>
<td>Wabi nr. Wolkite</td>
<td>1108</td>
<td>0.360</td>
</tr>
<tr>
<td>Gojeb dam site</td>
<td>1101</td>
<td>0.333</td>
</tr>
<tr>
<td>Residual 1</td>
<td>1215</td>
<td>0.266</td>
</tr>
<tr>
<td>Residual 2</td>
<td>1369</td>
<td>0.19</td>
</tr>
</tbody>
</table>

For the Residual 2 catchment a reasonably conservative value of $\phi = 0.19$ was adopted, well below the values obtained for the upstream part of the basin.

This assumption leads to a mean flow at Lake Turkana of about 650 m³/s.

The monthly variability of natural flows has been assumed to be the same as that reported in the Master Plan, shifted to the mean value of 650 m³/s.

The result put in evidence that the monthly variability at Lake Turkana is smoother than the one at Gibe III. This is basically due to the variation of the rainfall pattern of the Gibe III basin and of the southern residual basin, which, however, produces proportionally less flows.

At Gibe III the summer peak is higher than at Lake Turkana (the coefficient is equal to 3.5, against the 2.5 at Lake Turkana). On the contrary the dry season flow is generally higher at Lake Turkana.

While the mean annual flow is higher at Lake Turkana, the summer peak is proportionally less evident and the August flow is not much higher than that at Gibe III. On the contrary high flow rates persist in September also due to the “ponding” effect of such a wide catchment.

The table below, illustrating the monthly variability of the flow rates at Lake Turkana, indicates that highest flows are to be found within the months of August / September.
Table 5.46: Monthly variability of runoff at Lake Turkana.

<table>
<thead>
<tr>
<th>Average flows m³/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
</tr>
<tr>
<td>Feb</td>
</tr>
<tr>
<td>Mar</td>
</tr>
<tr>
<td>Apr</td>
</tr>
<tr>
<td>May</td>
</tr>
<tr>
<td>Jun</td>
</tr>
<tr>
<td>Jul</td>
</tr>
<tr>
<td>Aug</td>
</tr>
<tr>
<td>Sep</td>
</tr>
<tr>
<td>Oct</td>
</tr>
<tr>
<td>Nov</td>
</tr>
<tr>
<td>Dec</td>
</tr>
<tr>
<td>Year</td>
</tr>
</tbody>
</table>

The contribution of the residual catchment is particularly relevant, if compared to the upstream basin, in May (slightly less than 400 m³/sec) and in the dry season.

During these months a natural regulation of the Omo river flows at the Lake Turkana derives from the contributions of the residual basin Gibe III - Turkana.

Figure 5.15: Average monthly runoffs at Gibe III, Residual and Lake Turkana.
The annual peak floods discharges some kms before the Turkana section can be estimated, however with a reasonable confidence range of about +- 25% due to the few recorded data available for a flood estimate within the residual basin, to be for a 10-, 30- and 50-year return period respectively, 4800, 5800 and 6300 m³/s.

These extreme high peak flows cause a serious threat especially to the Dasenech population having destructive effects on human and animal life, private assets and public infrastructure.

The measurements carried out at Gibe III during the catastrophic inundation occurred in August 2006 indicated a peak flood flow in the range of about 3500-4000 m³/sec, being therefore a quite frequent flood with a return period of less than 10 years.

Conclusions

On the basis of the studies summarized here above the following comments can be made:

- The hydrological regime of the Omo River has been modified by the deforestation of the watershed determining higher peak floods flows with sudden variations of the water levels (i.e. from 800 to 2300 m³/sec in about 36 hours as recorded in July 2007);
- Quite frequent floods (as for example in 2006 with a return period of less than 10 years) cause destructive effects on human and animal life, private assets and public infrastructure in the river delta;
- Evaporation losses, due to uncontrolled flooding, contribute to the current recession of the Lake Turkana;
- Extended drought periods (for example 1986-1987 ones) cause famine crisis in the Lower Omo valleys.

5.4.5 Ethnic Groups of the Lower Omo Valley

The area is rich in both cultural diversity and natural resources. Its total population is estimated at nearly half a million in 2005 (Awoke 2007: 66) belonging to 16 original ethnic groups with widely different backgrounds. Amongst these, a few are on the verge of disappearance and absorption by larger groups. The ethnic groups are Dasenech (Galeb), Nyangatom (Bume), Murile, Kara(Karo), Hamer, Banna, Arbore (Hor), Birale (Ongota), Tsemako, Ari, Maale, Mursi, Bodi, Dime, Atse, and Kewegu (Bacha, Yidinit, Muguij).

Figure 5.13 shows the location of Ethnic groups in the Lower Omo (Downstream of the Gibe III Dam).

This section describes the main features of the ethnic groups living in the Lower Omo Valley with special reference to those inhabiting Salamago, Hamer, Nyangatom and Dasenech Weredas. Except the land of the Dasenech that is only inhabited by that particular ethnic group, more than two ethnic groups inhabit the other three Weredas. The Kara, Hamer and Arebore live in Hamer Wereda, whereas Mursi, Dime, Bodi and the northern section of Kewegu (Bacha) live in Salamago Wereda. The Nyangatom Wereda is inhabited by the Nyangatom, Murile and the southern section of Kewegu (Muguij).

The Mursi inhabit the area between the Mago River and the Banna ethnic group on the east, the Omo River on the south and west, the Bodi (Me'en) and Ari on the north and northeast, respectively. Mursi speak the Surma language, which belongs to the Nilo-Saharan language sub-family. This ethnic group, as an agro-pastoral people of the Lower Omo Valley, subsists both on livestock and agricultural products. They mainly raise cattle, sheep and goats. Crops are grown along the Omo riverbanks and in the bush belt, in which the
latter is a type of rain-fed agriculture. Main crops grown are varieties of Liba (sorghum), Kono (maize), Oggo (haricot beans), cowpeas, and squash. The tribe further engages in fishing, hunting and apiculture.

Pastures are mostly located in the Elma valley. Livestock is of crucial cultural, social, and economic importance. In addition, livestock is the source of status, prestige and wealth, besides its value as food at cattle camps and in the settlements. Agricultural activities are performed according to their own calendar, which is based on specific seasonal events.

The settlement pattern of the Mursi is organized according to their lifestyle, namely pastoralism and agriculture. However, they have no permanent residence. They move from one locality to another depending on the seasonal activities they need to perform.

*The Kara* (meaning fish) is a small ethnic group inhabiting the east bank of the Omo River, within the Hamer Woreda. The Omo in the west, the Hamer in the east and the Banna in the northeast border these people. Linguistically, the Kara are speakers of the South-Omotic language, one of the dialects spoken by the Banna and Hamer. The means of subsistence of these people are both cultivation on the Omo River banks and small stock herding. On the riverbanks they grow different crops among which Isni (sorghum), Kormosho (maize) and Wahha (beans), whereas small stock husbandry is based on sheep and goats. However, they supplement their livelihoods through fishing, hunting and apiculture.

*The Dasenech*, also known as Galeb live in the former Kuraz and the present Dasenech. They are bounded by Kenya and Lake Turkana on the south, the Sudan on the west, the Nyangatom on the northwest, the Hamer on the north and northeast. The Dasenech are speakers of the Cushitic language, which belongs to the East Cushitic Sub-family. These people are the third largest population in the South Omo Administrative Zone, after the Ari and Hamer ethnic groups.

Similar to the other people in the Lower Omo Valley the Dasenech are agro-pastoral people, basing their subsistence both on livestock products and riverbank cultivation. They raise cattle, sheep, goats and donkeys and engage in recession agriculture. Fishing and hunting are also important activities in supplementing their livelihood.

The western bank of the Omo with higher concentration of villages is more habitable than the east bank. The population sizes in each settlement, including the riverine villages, vary from one season to another. During the heavy rains period, people return to the settlement and more people are found in each village. Again early in the dry-season, people start to leave their settlements, men to the pastureland, women to the world of cultivation.

*The Bodi* call themselves Me'en. They are a group of people living with the Mursi and Dime ethnic groups in the Salamago Woreda of South Omo Administrative Zone. Geographically, they are located east of the Omo River although there is another group of people known as Me'en (Tishana) inhabiting the opposite bank of the Omo River. The Bodis' have more sources of permanent water, in addition to the Omo and is therefore better endowed with resources for both grazing and rain-fed agriculture. They depend economically on the cultivation of millet, though cattle are a central preoccupation of their society.

*The Nyangatom or Bume* inhabit Nyangatom Wereda. Kangaton, the seat of the Wereda administration, located on the shore of the Omo River. They are bordered by the Mursi on the northeast, by the Kewegu (Yidinit), the Kara and the Omo River on the east, the Surma on the north, the Dasenech on the southeast, Kenya and Lake Turkana on the south and the Sudan on the west. The Nyangatom perform recession
agriculture and livestock keeping, cultivating crops both along the Omo and Kibish Rivers such as sorghum, maize and beans both on the riverbanks and in the flood plains. Cattle, sheep, goats and donkeys make up their livestock. In addition, they supplement their livelihoods with hunting and beekeeping.

*The Murle (Murule):* The Omo Murule used to live on east bank of the Omo North of Shungura and South of Lake Dipa. Under pressure from the Hammer they moved to the West bank and sought protection from the Nyangatom, integrated within that society. The Murule people like that of the Nyangatom and the Karo used the Omo River and Lake Dipa for river bank cultivation and produce crops like sorghum and for fishery activity. Lake Dipa, after flooded by the Omo, is used for flood retreat cultivation and fishing activities and has a paramount importance for the local community. Sorghum cultivation on the riverbank, hunting and gathering of wild foods and collection of honey are important activities for the Murle. Besides, they keep a small number of goats, sheep and chicken.

*The Kewegu:* The Kwegu live on both banks of the Omo, and number some 200. They are riverine dwellers who subsist on riverbank and flood plain cultivation. Their principal crop is sorghum, but they also grow maize, cow peas, beans and tobacco. During the dry season they cultivate small pockets of flood land along the Omo River bank, and, following the first heavy rain in March or April, they plant a second crop in forest clearings, farther back from the river. They are also experts in hunting and fishing. They supplement their livelihoods with collection of forest honey, and wild foods and keeping a few sheep and goats.

### 5.4.5.1 Rainfed agriculture

Rainfed cropping takes place at higher altitudes, where rainfall is higher and more reliable, and will therefore not be directly concerned with the present study. However, most of the families in the study Weredas who practice some rainfed cropping, actually rely more on flood recession crops and livestock for their subsistence than they do on rainfed crops and the potential loss of recession crop area as well as the loss of grazing, should planned mitigation actions not properly be carried out, could make the contribution of rainfed agriculture to household economies more important in future.

Rainfed crops are cultivated in three out of the four Weredas where flood recession cropping is important; Hamer, Salamago and Nyangatom, at higher altitudes towards the west and eastern margins of the valley. Rainfall at lower altitudes, e.g. in Dasenech Wereda, is insufficient to support any rainfed cropping.

Rainfed cropping systems can be broadly identified as: (1). Maize dominated mixed cropping at the middle to higher altitudes, (2). Sorghum dominated mixed cropping at lower altitudes and (3). Small-scale riverbank mixed cropping, also at lower altitudes. The main crops grown are maize, sorghum, haricot beans, cowpeas, tobacco and occasionally pumpkins. Inter-cropping is the norm and low plant populations, due to wide plant spacing, reflect the little amount of rainfall expected.

Labour for hoe cultivation and weeding is the main input, and is generally said to be in short supply due to the demands of livestock herding, low population levels and poor general health. Oxen are very rarely used, partly due to cultural objections and also because of losses to disease. These factors all tend to limit the size of the cultivated area. No fertiliser use is recorded and, in any case could be a wasted expense in view of the erratic rainfall. Farmers use their own seed of traditional, locally adapted short duration crop varieties.

Livestock dominate the farming systems in all weredas, although less so for the Hamer which are said to be 40% pastoralist and 60% agricultural in terms of subsistence dependency. In the other three Weredas, crop
products only provide food for 3-6 months of the year and most of that is from post-flood recession cropping, rather than dryland crops. Blood, milk, butter, fish and food aid cereals make up the rest of the diet for the majority.

Crop production is an important source of forage, in the form of crop by-products such as maize and sorghum stalks, as well as grazing on field residues. Pastoralists move animals to the plains during the dry months, except for milking cows and calves, to take advantage of the grazing made possible by the annual flooding of the river. They move back when the rains start and the risk of tsetse-fly borne trypanosomiasis increases in the riverine forests.

Some NGOs are providing improved seed, of short duration crops - maize particularly, and trying to encourage some crop diversification, e.g. with pigeon peas. NGOs active in South Omo, include Farm Africa, PACT, EPARDA and the Catholic Church. Activities tend to be mainly aimed at supporting the livestock sector and include; animal health services, range management, establishing livestock markets, provision of a few sheep and goats to the poorest households who have no livestock, and establishing “resource areas” to extend grazing by creating watering places and mineral licks.

Some of the factors limiting rainfed crop production are summarised as follows:

Low and unreliable rainfall: Low rainfall results in a short growing season which limits the choice of crop varieties, to those which have a lower yield potential. It also restricts the farmer to growing one crop per year. Where rainfall is low it is also likely to be unreliable and unevenly distributed during the growing season, resulting in regular crop failures.

Shortage of good soils: Higher altitude areas where rainfed cropping is practiced are mostly hilly and eroded and the amount of good arable land is limited.

Shortage of labour: Labour shortage limits the area that can be cultivated and livestock herding takes many of the men and boys away during the cropping season. Compared to flood recession cropping, rainfed agriculture requires a lot more labour for land preparation, especially where oxen are seldom used.

Low yield potential: Traditional varieties may have the advantage of being tried and tested but usually have a low yield potential. Improved short duration varieties could increase yields under the same conditions.

Limited crop types: Reliance on relatively few crop types, especially maize which is not very tolerant of drought, is a poor insurance against losses from drought or disease etc. and there is a need to promote crop diversification.

Crop losses to pests: Bird damage to the sorghum crop and high post-harvest losses due to insect pests in storage, also reduce crop production.

5.4.5.2 Flood recession agriculture

The Omo River rises during the rainy season and overflows its banks to flood the land on the plains bordering the river, permitting crops to be grown on the residual soil moisture after the floods recede. Further upstream where the valley slopes are too steep to allow large scale flooding, areas of recession crops are grown on the riverbanks, especially where silt has been deposited at bends in the river.

No less than nine ethnic groups practice at least some flood retreat cultivation (See Figure 5.16) and flood recession cropping is important in all four Weredas; Hamer, Salamago, Nyangatom, and Dasenech, from the
Omo River, roughly between latitudes 4.45ºN to 6.00ºN from the latitude of Hana (HQ of Salamago Wereda) to Lake Turkana, some 150 km in a straight line, and more than double that distance in terms of the river length. Extensive flood recession cropping, as opposed to limited river bank cultivation, starts as the topography levels out, around latitude 5.15ºN, some 70km north of Lake Turkana, around Kara Korocho in Hamer Wereda, which is equivalent to some 200km of river length.

Most recession cropping in Salamago Wereda is along riverbanks, since there are no extensive areas of flat land, as found further south. In Hamer Wereda the main area of recession cultivation is found around Kara Korocho and Lake Dipa (Dipa Hayk), practiced by the Kara people. In Nyangatom Wereda flood recession cropping predominates southwards of Kangaten, and in low lying marshy areas, further from the river, which flood in years of particularly high floods. Dasenech Wereda has the largest area of recession cropping, mainly south of Omorate and they are reported to grow flood recession crops in the islands of the Omo river delta. Flooding on this very flat plain can extend several kilometres either side of the river.

The growing season for recession crops is dictated by the timing of the annual floods rather than rainfall, which is insufficient at 300-500 mm/annum. The floods usually peak between July and September, receding after 4 weeks or so to allow planting from August to October. The growing season is only 2-3 months and harvest of the main grain sorghum crop takes place from November to January, with green maize harvested earlier than sorghum. Maize left to mature at lower altitudes tends to suffer from depleted soil moisture and high temperatures, producing small-shrivelled cobs as a result.

Taking the cropped area to be around 12,000 ha, food production from flood recession cropping would be some 5,000 tonnes annually. With 20,000 households (100,000 people) this would provide 250 kg of food per household per year, which in theory would be enough for a family of five for about 6 months (200-300gm/person/day).

The factors limiting recession crop production are summarised as follows:

Unreliable floods: The annual river floods may be excessive in some years, causing human and livestock losses and too little at other times, limiting the area of crops that can be planted.

Short growing season: The amount of water retained in the soil after flooding is usually only enough for a growing season of 2-3 months, which limits the choice of crops and varieties, to early maturing types, which have a lower yield potential. It also restricts the farmer to growing one crop per year.

Low Yields: Sorghum dominates the cropping pattern in recession farming, mainly because of its drought tolerance and its ability to produce a mature grain crop with a short growing season. However the yield potential is 30 to 40% of the better maize varieties, which could be grown if sufficient water was available for a longer period.

Crop losses to pests: Bird damage to the sorghum crop and high post-harvest losses to insect pests in storage, also reduce crop production. The white seeded sorghum which is favoured by the people on the fertile plains is not bitter like the red sorghum and more palatable to birds as well as humans. Storing sorghum heads on platforms, in grass-wrapped bundles provides no protection against insects like weevil and this damage is easily observed in such stores.
Figure 5.16: Location of Recessions Agriculture Sites along the Lower Omo River
Photo 5.8: Typical Recession/ River Bank Cultivation Site at the Lower Omo

Photo 5.9: Recession Cultivation Site at Nyangatom - Sorghum Field
5.4.5.3 Irrigated agriculture

Irrigation farms and schemes are found mainly in the lower reaches of the Omo River, because the banks of the river upstream are generally too high to permit efficient pumping. According to the Omo-Gibe River Basin Development Master Plan Study of 1995, there are 1,350 ha under irrigation in the Weredas of Hamer and Dasenech, although during the field investigation for this study there was an evidence only 150-200 ha in operation.

Most are small farms growing high value crops like vegetables and fruits, particularly bananas, using either diesel pumps or windmills to extract water from the river. There are also a few small, state-owned demonstration and training farms with supervised tenant plots. There are no large commercial irrigated farms but the (defunct) 10,000 ha State Farm near Omorate (Omo Higher Farm), which was established by the “Ethio-Korea Joint Agricultural Development Venture Project” some years ago to grow cotton, has recently been acquired by some investors and is apparently being developed to grow oil palm.

The present level of irrigation development is really quite minimal. The damage caused by annual flooding, low river levels in the dry season (too low for pumping), and limited market development are probably some of the reasons, but another may simply be the traditional, nomadic, pastoralist way of life of the people.

In Dasenech Wereda, windmills are popular for irrigating high value crops such as bananas and vegetables. They are the result of an NGO project and Wereda officials estimated that some 20-30ha are irrigated by windmills. Many of these were seen from Delegnum Kebele, southwards through the delta, on the banks of the main river as well as the islands, although precise numbers were not available. Some are also used for grain milling, supplied under the same project.

In Nyangatom Wereda officials reported that there is one private farm using a diesel pump to irrigate 2-3 ha. In the Kara area of Hamer Wereda, the Ministry of Agriculture operates an irrigation demonstration/training area of 15ha, growing maize, sorghum, beans, tomatoes, cabbage and onions, as well as bananas.

The list of existing and potential small scale irrigation developments in the lower Omo area is given in Table 5.47 (see Figure 5.17 and Photos 5.11 to 5.14).
### Table 5.47: Existing and potential small scale irrigation scheme in the Lower Omo area

<table>
<thead>
<tr>
<th>Wereda</th>
<th>Small scale Irrigation Schemes</th>
<th>Large Scale Irrigation Schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Existing</td>
<td>Potential</td>
</tr>
<tr>
<td>Dasenech</td>
<td>267</td>
<td>6,000</td>
</tr>
<tr>
<td>Selamago</td>
<td>-</td>
<td>1,000</td>
</tr>
<tr>
<td>Hamer</td>
<td>250</td>
<td>3,000</td>
</tr>
<tr>
<td>Nyangatom</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>667</td>
<td>10,100</td>
</tr>
</tbody>
</table>

Source: Respective wereda Agricultural and Rural Development Offices

Existing irrigation schemes: There is an estimated 667 ha of existing small-scale irrigable area in the lower Omo. The main crops grown under irrigation are principally vegetables and fruits. Some stable cereals crops such as maize and sorghum are also cultivated using supplementary irrigation each beneficiaries will have some 0.25 ha. Therefore, the total beneficiaries from 667 ha of existing small-scale irrigation scheme are about 2,670 households.

Omo higher farm is found in the Lower Omo (originally called the Tringole state farm) and was established by the Ethio-Korea Joint Agriculture Development Venture project. At full development, it was planned to irrigate an estimated 10,000 ha with cotton, lifting water from the Omo River by electric pumps powered by diesel generators.

![Photo 5.11: Small scale irrigation Site at Lobet 2 Dasenech wereda](image)

![Photo 5.12: Small scale pumped irrigation Site](image)
Figure 5.17: Locations of Existing and Potential Irrigation Sites along the Lower Omo River
5.4.5.4 The Importance of Omo River for the Lakes along it

Ox-bow lakes such as Lake Dipa in Karo Koroch kebele, Lake Shoshe in Karo Lebuk kebele and Lake Wala of the Hammer wereda, are those lakes found along the Omo River that are used by the Karo people for flood retreat cultivation, small scale irrigation, fishery, and dry season grazing.

The annual flooding of Omo River between July and September replenishes Lake Dipa. When the lake level recedes the local communities start to plant crops like sorghum and maize two to three times a year. According to the study conducted previously, the water in Dipa Hayk has the capacity to irrigate up to 5,000 ha of land.

In addition to the recession cultivation and grazing resources, as per the information obtained from the local community, Dipa Hayk has a good potential for fishery and can also support an important commercial fishery. The Karo tribe are located around Lake Dipa. They rely upon fish for their subsistence and supplement their diet with grains through recession cultivation around the Lake and the Omo River. Fishing has increased the income of these people and improved the nutritional quality (protein food supply of the community).
5.4.6 Livestock

5.4.6.1 Livestock Resources

The arid and semi-arid parts of the lower Omo is inhabited by different groups of pastoralists and agro-pastoralists. Livestock are normally reared by the pastoralists for subsistence. The main products of livestock in this system are milk, meat, blood, cash and transport. Livestock also serve as security against natural and manmade calamities and to pay dowries. Cash from livestock sales is used to purchase grain to supplement their energy-deficient diet of milk and milk products.

According to the information obtained from the south Omo zone Agricultural and Rural Development offices, goat are the principal livestock species followed by cattle, sheep, poultry, and equines (See Table 5.48).

Table 5.48: Livestock Population by Wereda in the Lower Omo Area

<table>
<thead>
<tr>
<th>Sr.No</th>
<th>Wereda</th>
<th>Cattle</th>
<th>Sheep</th>
<th>Goat</th>
<th>Camel</th>
<th>Equine</th>
<th>Poultry</th>
<th>Beekeeping</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dasenech</td>
<td>219,380</td>
<td>105,405</td>
<td>206,185</td>
<td>256</td>
<td>14,144</td>
<td>5,231</td>
<td>5,000</td>
</tr>
<tr>
<td>2</td>
<td>Nyangatom</td>
<td>51,806</td>
<td>48,260</td>
<td>55,100</td>
<td>70</td>
<td>6,343</td>
<td>3,694</td>
<td>1,000</td>
</tr>
<tr>
<td>3</td>
<td>Selamago</td>
<td>66,000</td>
<td>18,000</td>
<td>20,500</td>
<td>-</td>
<td>5,000</td>
<td>54,000</td>
<td>27,500</td>
</tr>
<tr>
<td>4</td>
<td>Hamer</td>
<td>110,696</td>
<td>84,186</td>
<td>167,670</td>
<td>24</td>
<td>12,126</td>
<td>8,955</td>
<td>90,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>447,882</td>
<td>255,851</td>
<td>449,455</td>
<td>350</td>
<td>37,613</td>
<td>71,880</td>
<td>123,500</td>
</tr>
</tbody>
</table>

Source: South Omo Zone Agricultural and Rural development Office

Herd and flock distribution in the area is governed by the availability of feed and water. Consequently, livestock graze close to the river (on the floodplain) in the dry season and in the wet season disperse away from watering points.
5.4.6.2 Livestock Feed Resources

Livestock obtain their feed almost entirely from grazing and browsing. From the standpoint of the type of range, the south Omo range has been classified into five zones. Three of them, namely Mursi-Bodi Rangelands, Hamer-Dasenech Rangelands, and Mago-Omo Park Rangelands are of major importance to the ethnic communities around the Omo River and Lake Turkana. However, there are an estimated 83,000ha of arable land from which some aftermath and crop residue is obtainable for livestock feeding.

The Mursi Bodi Range is characterized by good grass and browse vegetation especially following the rainy season. Soil fertility and abundance of water from Hanna, Mago, and Omo River are favourable characteristics of the rangelands. The Mago-Omo Park Rangeland, as its name indicates, is mostly occupied by the two large national parks, where the wildlife and the inhabitants, Benna, Karro and the Bodi people co-exist. The range has good water supply from Mago and the Omo Rivers. It has a good vegetation cover and provides sufficient animal feed supply.

The Hammer-Dasenech Rangeland (Lower Omo Valley) is the south most part of the overall rangelands system. Potential grazing resources that are used especially by Dasenech are those nine islands found along the Omo River (See Photo 5.17). According to the wereda experts, when the Omo River floods/inundates these islands the grazing resources is palatable and good for pastoralists along the Omo river valley especially for the Dasenech and Hamer people.

In the long dry season, which extends up to February, there are feed and water shortages. Feed scarcity is evident at watering points which attracts livestock during the dry season and these areas are normally overgrazed. Areas farther away from the water sources can only be utilized when water is available in the wet season. Low and erratic rainfall makes these lowlands extremely prone to recurring droughts which causes both heavy livestock mortality and human famine.
5.4.7 Fishery

Fish occur in all major rivers and tributaries throughout the Omo River (See Figure 5.18), although numbers and species types would fluctuate during the wet and dry seasons, particularly in the smaller tributaries. Fish resources are fairly evenly distributed along the Omo River course and the riverine fish species at Omo rate are mainly Nile perch, two types of catfish, elephant fish (Mormyrus spp), Distichodus and barbs (Bagrus spp). Catfish reportedly dominate the catches. Tiger fish (Hydrocynus vittatus) were reportedly caught at most locations along the Omo River. 80% of the fish caught at Lake Turkana is Zilapia and the remainder is catfish (Clarias spp), elephant fish (Heteroutus niloticus) Nile perch and Distichodus (Distichodus niloticus).

It is reported that the catch rates and fish sizes indicate under-exploited fish populations. No riverine fish is exported out of the lower Omo. The main problem for developing fishing in the middle reaches of the Omo system is the lack of an appropriate infrastructure.
The Bacha people are found on the Omo River in the vicinity of Hana and they rely almost exclusively upon fish for their existence. They supplement this diet with grains through rudimentary cultivation along the river banks during the wet season. They occasionally sell dried fish on the local markets in order to buy items such as clothes or utensils. The Dasenech people are found at Bubua on the northern shore of Lake Turkana and they also rely exclusively upon fish for their subsistence.

In addition to these two ethnic groups, there are few “full-time” fishermen operating on the Omo River around Omo Rate. There is a small surplus catch which is sold locally in Omo Rate, but the availability of fresh fish in the town is sporadic and fish eating is not widely accepted.

All other people in the lower part of the Omo are agropastoralist or pastoralist cattle herders. These people do not catch or eat fish and consider fishing and those who engage in it as inferior and primitive.

Commercial fishing activity was initiated by Ethiopian Fish Production and Marketing Enterprise and by the Region Pastoral Area Development Coordination Commission within the Lower Omo River including the part of Lake Turkana, which lies within Ethiopia. The Commission established an association having 100 members from the pastoral community and The Ethiopian Fish Production and Marketing Enterprise organized around 15 individual for commercial fishing activities around Lake Turkana. One Investor and the Ethiopian Fish Production and Marketing Enterprise collect production from those Fishery associations and send to the central Market. On the contrary, the fishing that does occur along the Omo River by various ethnic groups is limited to basic subsistence fishing.
Figure 5.18: Locations of Fishing Sites along the Lower Omo River
5.4.8 National Parks and other Protected Areas

The SNNPRS, which the conservation and sustainable use of the wildlife of the region is vested upon, is among the most active regions of the country to protect wildlife and habitat. The Region has established 5 National Parks and some reserves and controlled hunting areas, out of which the following are found downstream of the Gibe III scheme: Omo, Mago, Mazie and Chabara Chorchora National Parks (see Figure 5.19) and two of these are gazetted. Some of the resources of these national parks and the status they are now in is stated below.

Omo National Park

The National Park is found in the lower Omo valley on the west bank of the Omo River. Much of the Park is around 800m asl but the southern part by the river drops to 450 mm as (SNNPRS, 2000).

The total area of the park being 4,068 km² and the altitude ranges between 440-1183 m asl. It is located at N6°10’, E35°50”. The park encompasses extensive grassland interspersed with various stand of wood land species, bush and riverine vegetation.

The park is established to conserve the rich wildlife of the area and develop the area for tourism.

The total number of mammals recorded to date is 75 mammals. The most notable species are the Eland, Elephant, Tiang, Lelwel’s Hartebeeste, Buffalo, Lesser Kudu, Lion, De Brazza’s Monkey and Giraffe. There are reptiles fauna represented by various species of snakes, Lizards, Geckos, Agamas and Tortoise (Hillman, 1993). The total number of birds so far recorded for the park is about 320 species of birds.

Although considerable gains have been attained in the conservation of the species and the habitat since the park established, still threats such as deterioration of habitat, poaching and competition for grazing between the park animals and domestic animals of the adjacent community exist.

According to the information obtained from both Omo and Mago National Park officials, currently there is an effort to start community tourism through boat transport from Lake Turkana via Omo gorge to the upstream National parks (Omo and Mago National parks). Community tourism is hoped to help encourage the tourist to visit the various ethnic groups along the Omo River.

Mago National Park

Mago National Park is located on the northern end of small branch of the Great Rift Valley called the Omo Trough. It has an area of 2162 km². The gently undulating valley floor at 450 m asl, makes the major part of the Park. The vegetation of the Park can be described as riverine forest along the rivers Mago and Neri, acacia savanna, open grassland and small patches of low land forest in the other locations of the park.

So far 74 mammal species are recorded. The most common ones are Lelwel Harebeest, Tiang, Lesser Kudu, Gerenuk, Anubis Baboons. Topi, Buffalo, Cheetah Leopard, Lion, Elephant etc.

Records for the park show 257 species of birds, out of which 201 species are resident, 4 are endemic, 12 are intra African migrants and 18 are palearctic migrants (Yirmed, 1996)

The threats are the same as Omo National Park and includes: deterioration of habitat, poaching and competition for grazing between the park animals and domestic animals of the adjacent community exist
Figure 5.19: Locations of National Parks and Other Protected Sites along the Omo River
Mazie National Park
The park got its name from the Mazie River which is one of the tributaries of the Omo River. It is found in Goo-Goo Zone, Gofa area Kucha wereda. It covers about 210km$^2$ and the altitude varies from 800-2000 m a.s.l. located at N6°30’ 37°40E. It is one of the four gazetted National Park of Ethiopia (Mohammed, Kahsay 2006).

The park is characterized by two types of habitats the grassland with Combretum and Balanites woodland and in the riverine areas that are covered by forests, the vegetation is composed of Acacia and Ficus species. In general the land cover is included in open combretum- Termindia woodland.

Wild animal species recorded are Swayne’s Hartebeeste, Buffalo, Reed buck, Oribi, water buck, Lion, Leopard, Primates such as Anubis Baboon, Colobus (Balck and white). In general some 29 species of mammals and over 100 species of birds has been recorded in the area.

Chabera Chorchora
The Park has been established from areas that are from Konta special wereda and from two weredas of (Esera and Tocha) of the Dawro administrative zone. It is situated between latitudes 06°39’N and 07°09’N longitudes 36°32’E and 36°45’E. It covers an area of 1,215 km$^2$ in the central Omo basin that ranges from 600 to 2,000 m asl (SNNPRS, 2000)

The area has high diversity of vegetation cover which varies from grass species of Pennisteum, Andropogen, Hyperhemia and Themeda, woody species of Comberatum and Termindia and multi-storied structure of tree species. The dominant trees include Ficus spp, Juniperus procera podocarpus flactus, Erythcrena brucei, Tamarindus indica and Prunus africana. In the Park so far about 37 larger mammals has been recorded. This includes Elephants, African Buffalo, Waterbuck, Greater Kudu, Common Bushbuck, Lion, Leopard, Serval cat, Warthog, Giant Foresthog Jackals, Black and white colobus monkey among others.

A considerable number of birds not less than Omo-Mago National Parks exist in the park. Proper recording has not yet been conducted.

In the SNNRS, apart from the National Park described above, there are parks, wildlife Reserves and controlled hunting areas. The conservation measures the region is taking show that the region is highly concerned to its natural resource.
6 PROJECT BENEFITS

A new hydroelectric plant along the Gibe River represents a relevant step towards the country modernization. It will produces advantages for the country in terms of working opportunities, global economic growth, environment improvement, development in roads construction and communications, growth of new social activities along the main new roads, better health conditions correlated to the social growth.

Like Gibe I and Gibe II projects, hydro plants contribute to the national grid and assist in meeting country’s demand for electrical energy which is an essential part of economic development. Similar projects, as Gibe III, allow to the country not only the mitigation of the expenses (in foreign currency) for fuels but also the complete closure of the running thermal plants with relevant economical and environmental benefits.

The surplus of produced energy can be exported to the neighbouring countries with economical and environmental benefits for all the region similarly related to the reduction of the energy produced with fossil fuels.

Other benefits related to the power plant construction are represented by the satisfaction of regional water needs and the control of Omo river annual flows. This control will allow an agricultural development free from the water flow level variations during the rainy season.

Positive effects generating from Gibe III hydroelectric project on physical, biological and socio-economical environment have been pointed out in the following paragraphs.

6.1 Power generation

The Gibe III hydroelectric power plant is designed to supply 1870 MW of electrical power and 6400 GWh of energy per year to Ethiopia’s interconnected system. When it is implemented, electrification of the areas in the vicinity of the power plant will be possible. This rural electrification project will stimulate the development of the area.

The project will also contribute to reduce the need for fuel wood that is the main energy source in Ethiopia. Almost the 95% of the Ethiopian energy needs (mainly used for cooking) are covered by biomass, mostly in the form of fuel wood and charcoal and almost all of it for cooking.

The extraction of wood has led to large-scale deforestation. A century ago around 40% of the country was covered with forest, while now it is only a small percentage of its territory. Deforestation leads to increased soil erosion, changes in natural habitat and, in consequence, loss of bio-diversity. As deforestation takes place, the distance between settlements and nearest forest increases, making it more and more cumbersome and time consuming to go and collect fuel wood. This is a gender issue, as this work is generally done by women. The increased erosion washes away the best soils, causing a reduction of soil fertility, and silting up streams and reservoirs. Also runoff will become faster, aggravating downstream floods and reducing the groundwater table. The widespread use of fuel wood is one of the foremost problems in Ethiopia.

The project, together with the Gibe II, Beles and Tekeze hydropower under construction, will allow the closure of the thermal plants with the relevant economical and environmental (i.e. greenhouse gas emissions reduction) benefits.
6.2 Avoidance of CO₂ emissions

The energy production process of an hydroelectric power plant doesn’t generate harmful emissions in the atmosphere because it is based on the use of such a renewable energy source as the water.

The Gibe III hydroelectric power plant permits to satisfy the energy requirement avoiding the use of fossil combustibles, that are limitedly available in the underground and that, when burned, produce pollutant emissions, particularly CO₂, for the atmosphere.

Generally hydropower offsets thermal or other types of generation. Besides replacing capacity and energy, the use of hydropower also leads to a reduction of thermal plant emission (CO₂), which is the most important Green House Gas contributor. The cost of one tone of saved CO₂ to date is about US$ 4 to 5 according to GEF, but is expected to rise considerably in the future. Although it is too early now, it is possible that when the project will be operating there will be international trading of CO₂ certificates, and the project could become a direct beneficiary.

Voting in support of hydroelectric power generation and provision of enough funds for the development of hydroelectric power schemes by financing organizations may contribute for the reduction of green house gas emission globally.

6.3 Prospects to Export Power

The project, together with the other hydropower plants under construction, will greatly increase the generation capacity of the country and will also allow the export of the surplus of electricity to the nearby countries (including Djibouti, Kenya, Sudan and Uganda) with relevant economical and environmental benefits for the whole region.

6.4 Effective Utilization of the Country’s Water Resource

Effective and efficient utilization of countries water resource for the socio-economic development of the country will be one of the benefits. It is believed that through the production of electric power the economy of the country will grow. Availability of sufficient energy would encourage the development of other sectors such as industry and agriculture.

6.5 Improvements in Local Access

In terms of roads and settlements Gibe III Project will require some efforts. New permanent roads will be constructed in the project area to provide vehicle access to the sites of the project components.

Under this Project two new roads will be constructed one on the right bank (R1) and one on the left bank (L1). Road R1 and L1 have a total length of 34 km.

All these roads are temporary and open only for construction purposes, anyhow they will greatly improve transport and thereby trade links from the project area to Sodo and other major demand centres in the country. Transportation companies, hotels, small factories and other outlets providing goods and services will take advantage by the project, the purchase of goods and services will generate income, and contribute to salaries and employment during power plant construction. Some of the small entrepreneurs without aspirations of long term economic growth probably will move in other zones after power plant construction, but a large portion of the commercial growth will remain.
The project includes also the relocation of part of the Chida-Sodo road from Bele town to Lala area because both the existing bridge on the Chida Sodo road, crossing the river Omo at a low level, and the L1 road will be submerged by the reservoir. The foreseen “relocation road” will be opened for construction purposes and will therefore become available for public use while completing the impounding of the reservoir. This permanent link will have a total length of about 80 km, starting at a small village called Yalo nearby Lala on the right bank, passing through the foreseen Omo bridge which crosses the river slightly d/s of the dam and ending about 4 km west of Bele on the left bank.

6.6 Job Opportunity

In the area, the main economic benefit will be the temporary, but considerable, labour opportunities for the local population during construction phase.

Comparison with other projects of broadly similar type and magnitude, suggests that the total workforce on construction contract comprising the overall project is likely to be more than 3,000 persons at peak time. In view of the nature of the works, much of which will be plant-intensive rather than labour-intensive, the contractors' requirements are likely to be mainly for skilled and semi-skilled workers, with around 20-30% of the total manpower requirement being for unskilled workers. Unskilled workers will be recruited locally, which will result in the creation of the equivalent of 600-900 full-time jobs on contract for around 4 years.

The creation of regular wage employment in the rural parts of project area is important, even though it will be on a relatively small scale, at relatively good rates of pay and for a limited period, since there are currently few other opportunities available.

The presence of the workforce, who is likely to be relatively cash-rich compared with the majority of the rural population, will undoubtedly encourage individuals to set up stalls to supply food and other consumables at worksites. Businesses in the local towns will also benefit financially through supplying goods and services to the workforce when they are on leave, as well as through the contractors purchasing some of the food requirements of the base camps.

Although labour recruitment is a matter for the contractor, who has the right to determine whom they shall and shall not employ, he should be formally encouraged to hire locally wherever possible, in order to maximize the benefit distribution and social acceptability of the project. Therefore, the contractor will use his best endeavour to maximize local hire of labour, in so far as this is compatible with his skill requirements, and to maximize local procurement of supplies.

Therefore, the production of more hydropower would allow the expansion of power-requiring industries and factories in the surrounding urban areas creating more permanent job opportunities for the displaced and other people in the area.

6.7 Gender Issues

Women as well as men will benefit from the employment opportunities and from the access road related facilities. Women often run shops and bars in the area and obviously they will benefit from the increased business opportunities that will be derived from the project.
During the construction period, there will likely be more women engaged in income generating activities, running restaurants and bars, or selling local products to construction camp workers. These activities will benefit mainly women who are very often the sole supporters of their families.

Therefore, it is recommended for the contractor to use his best endeavours to maximise local hire of labour and give priority to women, in so far as this is compatible with his skill requirements, and to maximise local procurement of supplies.

6.8 Fishery development

The project aims to construct approximately 230m high dam on the Omo River thereby creating a reservoir with a total storage of about 12,500 Mm³ and a surface area of about 200 km².

This is a large artificial lake that provides different environmental and ecological niches for diverse fish species, requiring habitats with varying depth from shallow littoral zone to deep demersal and pelagic areas. A number of fish species now inhabiting the river are expected to adapt to the lentic environment of the reservoir that will be created.

Many of the fish species are also present in the southern Rift Valley Lakes of Chamo and Abaya and it would be expected that these and related species present in the Omo River could adapt to the new reservoir to support an important commercial fishery industry that could be created in the future reservoir fishery. The reservoir fishery is much more productive than the riverine fishery (which is not utilized at the moment) and this increases the income of the people and improves the nutritional quality (protein food supply) of the community.

Commercial fishing would also be allowed downstream the dam including in the river delta, based on the regulation of the flow that will also make the river navigable all year round. Fishing facilities would all be protected from the floods annual devastation, which poses serious financial obstacles to the development of fisheries in the lower valley of the Omo River.

Positive effects on fishing activities would be extended to the Turkana Lake shores, as the worrying deficit trend in the hydrological balance of the lake would be significantly mitigated if not reversed. In fact, huge amounts of water are lost by evaporation in the floodplains where uncontrolled water logging inevitably occurs, due to the extremely high temperatures and frequent drought crisis. Much less surface would be exposed to cause evaporation in the reservoir, and climatic conditions there are anyway unlikely to cause comparable losses. The contribution to restore the original hydrology of the entire Turkana basin is undeniable, and would have as such a clear significance in any international negotiation on equitable sharing of transboundary water resources. The underground water table would benefit from continuous recharge from the river, a major improvement from the flash-floods almost useless in this respect, with positive implications in terms of water supply during the long dry season.

6.9 Regulation of the River Flow for Irrigation

According to the expectations of the weredas’ officials, with the construction of the dam and creation of the reservoir the Omo River will come closer to the nearby settlements and the people will have the opportunity to use the river water for small scale irrigation development.
The expansion of irrigation farms would increase crop production per unit area and compensate for the loss of land for the displaced community whose farmland areas have been covered under the reservoir. This contributes to higher income and increased food security to the community. The easy availability of water for domestic use for the surrounding rural community is also another benefit to expect from the impoundment.

6.10 Flood Protection

The presence of Gibe III reservoir will provide flood protection (will reduce floods both in peak and in frequency) to downstream areas. As a result, the damage due to floods like loss of crops, dwellings and the suffering and possibly death of affected people will reduce. With this regulation, areas prone to frequent flooding can be used for agricultural purposes.

Besides the above, major benefits would be induced by the regulation of the river flow in the downstream lower Omo River valley in terms of public health (reduction of water logging that would facilitate the control of malaria, tripanosomiasis and other water-borne diseases), safety and infrastructure protection from floods (the 2006’ floods have caused in the area hundreds people and thousand animals dead besides 15,000 displaced population, with an estimate of over 17 million US$ of works needed to rehabilitate Health, Education, Shelter, Water and Sanitation, Agriculture, Livestock, Fishing, Roads and Telecommunication facilities washed away), permanent availability of water with stable water levels allowing for development of commercial irrigated agriculture, settled livestock, fishing and tourism, as well as reliable water-supply and sanitation facilities and all-weather road network throughout the year.

6.11 Tourism Activities

Tourism activities will be probably like an economic improvement in the socio economic environment such as the dam will be as an attraction. The reservoir offers potential for eco-tourism, environmental education, etc. for bird watching and sport fishing.

The Omo River is famous for white water rafting starting from the Gibe Bridge on the way to Jima. Another tourism attraction would be probably connected to lake and river navigability respectively upstream and downstream of the dam. The regulated flow will make the water flow dependable for white water rafting and will maintain Omo’s biggest rapids for the adventurous rafter during low flow season.

Transport by boat is not common in the region but it could be quite attractive in the river especially in the lower Omo all the way to Lake Turkana in Kenya. This is considered like an interesting tourism activities by the National Park Authorities, related to foreign or local people spare time.

6.12 River Navigation

Besides its leisure time use, the possibility of a water route could also involve new commercial relationship between villages and inhabited zones currently separated from great distance or difficult connections, eventually permitting the improvement of the economical life of the interested Weredas. This will be a shorter and most likely cheaper route for export of agricultural product and livestock in the region.

6.13 Beneficial Impacts on Wildlife resource

The creation of reservoir and islands will be a very comfortable place for a considerable number of water birds. Resident as well as migrant birds will have a good chance to use the site. The Hippopotamus and
crocodile will enjoy the creation of new habitat (increase in the water level and volume). The water volume and depth may make them swim easily, cool themselves, and makes them less accessible to their enemies mainly human.
7 IMPACT ASSESSMENT AND MITIGATION ACTIONS

7.1 General

In order to assess the potential environmental impacts caused by the construction and operation of Gibe III scheme have been identified considering:

Physical, biological, socio-economic environmental data obtained from direct field observations;

Information gathered from the available scientific publications and information derived by the study of similar projects; and

the activities that may produce impact, evaluated in the description of the Gibe III Hydroelectric Project.

Adverse impacts of project construction and operation and the mitigation and benefit enhancement measures are discussed below, where also a specific section about downstream effects is presented. Beside potential effects on environment due to the project, mitigation actions, representing the ways to reduce the impacts on a specified target, allowing finding out ways to guarantee basic health and safety requirements, are introduced.

7.2 Impacts on Physical Environment

7.2.1 Climate

Hydropower plants and relevant reservoirs may have significant impacts on global and local climate.

7.2.1.1 Global Climate Effects

The present knowledge on the positive or negative effects on global climate changes related to large reservoirs has not yet reached a detailed conclusion.

In general terms, according to the International Hydropower Association (IHA), we can say that hydropower has a very low or even positive impact on climate change because reservoirs sequester large amounts of carbon.

The important question is whether reservoirs are important sinks for anthropogenic carbon. IHA uses an estimate indicating that reservoirs sequester 2.5% of global CO₂ emissions. For several reasons this estimate gives a misleading indication of the climate impact of reservoirs.

In some cases reservoirs will only be temporary sinks for carbon due to measures to mitigate reservoir sedimentation and dam decommissioning. Where reservoirs are permanent sinks their ability to sequester carbon will end once their storage capacity is filled with sediments. However because of the very large reservoir capacity when compared to the sediment transport volumes this risk can be considered very low.

7.2.1.2 Greenhouse Gases Emissions

The major greenhouse gases are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). These gases are emitted from both natural systems and from anthropogenic sources.
Carbon dioxide from the burning of fossil fuels is the largest single source of greenhouse gas emissions from human activities. The supply and use of fossil fuels accounts for about 80 percent of mankind’s carbon dioxide (CO₂) emissions, one fifth of the methane (CH₄), and a significant quantity of nitrous oxide (N₂O). It also produces nitrogen oxides (NOx), hydrocarbons (HCs), and carbon monoxide (CO), which, though not greenhouse gases themselves, influence chemical cycles in the atmosphere that creates or destroy other greenhouse gases, such as tropospheric ozone. Meanwhile, fuel-related releases of sulphate aerosols are temporarily masking part of the warming effect of greenhouse gases.

Hydropower is a very efficient way to produce electricity, in terms of greenhouse gases (GHGs), showing emission factors between one and two orders of magnitude lower than the thermal alternatives. Nevertheless, hydroelectric dams can produce significant amounts of carbon dioxide and methane. Carbon emissions vary from dam to dam. Emissions of GHG are related to the decomposition of flooded “soft” organic matter.

*The Production of Carbon Dioxide and Methane in the Reservoir Environment*

Methane and Carbon dioxide are the two major greenhouse gases (GHG’s) associated with hydroelectric dams. Both affect the global climate, but methane is significantly more powerful than carbon dioxide in terms of its efficiency in trapping heat. However, methane is shorter lived in the atmosphere, possibly decreasing its influence on global warming.

The source of the carbon dioxide and methane in reservoirs is rotting and decaying vegetation. When land is flooded to create a reservoir, the vegetation dies and is no longer able to absorb carbon dioxide from the atmosphere via photosynthesis. Instead, those plants decay and the stored organic carbon is converted into methane and carbon dioxide.

This conversion of the stored organic carbon into methane and carbon dioxide occurs by two distinct mechanisms depending on the oxygen level of the water:

In an oxic environment, more toward the surface of the reservoir, aerobic decomposition of organic matter produces carbon dioxide and methane.

In an anoxic environment, methanogenesis produces carbon dioxide and methane. Methanogenesis is the pathway in which the products carbon dioxide and methane are produced by a biological process involving methanogen bacteria.

In either case, methane and carbon dioxide are the product of the decomposition of vegetation in the reservoir environment.

Once methane and carbon dioxide are produced, they are not immediately released into the atmosphere. The gases are soluble in the water of the reservoir until a chemical event occurs that causes the gases to be released. There are several ways by which this release can occur, depending on the characteristics of the reservoir. The gases can be released from the surface of the reservoir by rapid diffusion directly into the atmosphere, or, the gas can form bubbles at the bottom of the reservoir and rise to the surface. These events are random and unpredictable, however, making them very difficult to predict and quantify. In addition, there is no consistent proportionality between the amount of bubbling and the amount of diffusion from a particular reservoir, making it even more difficult to measure.
Nevertheless, diffusion and bubbling are two important mechanisms by which carbon dioxide and methane are emitted into the atmosphere.

Bubbling, diffusion and above water decomposition are not the only ways by which GHG’s are emitted from reservoirs. Research shows that a major pathway for GHG emissions is diffusion as a result of reservoir water moving through the turbines of a dam.

This occurs because the turbines create a sudden change in water pressure and temperature, which reduces the solubility of gaseous methane and carbon dioxide in water. Consequently, the majority of the methane and carbon dioxide present in the water, prior to moving through the dam, is released into the atmosphere within a few seconds of the water emerging from the turbines.

**Factors that Influence the Amount of Methane and Carbon Dioxide Emitted**

There are a variety of factors that influence the amount of methane and carbon dioxide emitted from a reservoir.

The most important factor seems to be the climate of the surrounding environment. Reservoirs in tropical environments have been found to have significantly larger emissions than reservoirs in boreal and temperate climates. One possible reason for this is that the annual water temperature is much higher in tropical climates. This means that the rate of decomposition is faster, leading to higher carbon dioxide and methane flux in the water (see below figures from “Tremblay, A., Varfalvy, L., Roehm, C. & Garneau, M. (eds.) (2004) Greenhouse Gas Emissions: Fluxes and Processes. Environmental Science Series, 732 pp. Berlin:Springer-Verlag”).
Measuring Emissions: Net vs. Gross Emissions

One thing that appears extremely important in emissions assessments is to differentiate between net and gross emissions:

Gross emissions are only those emissions that are measured at the reservoir surface (or from the turbines).

Net emissions take into account the gases emitted from the reservoir as well as the amount of gases that would have been absorbed by any sinks in the land, and the amount of gases that would have been released from the land before it was flooded.

The formula for calculating net GHG emissions from a reservoir is:

\[
\text{Net reservoir emissions} = \text{Emissions from reservoir and discharged water} + \text{Pre-dam greenhouse gas sinks lost due to dam and reservoir creation} - \text{Pre-dam sources of greenhouse gas lost}
\]

The concept of net emissions relies on knowledge of the ecosystem to be flooded and its role in the carbon cycle. For example, prior to the creation of a reservoir, the land to be flooded most likely contains both sinks and sources of GHG’s, including methane and CO\(_2\):

- A carbon sink is an area that takes in or “sequesters” more carbon than it releases.
• A carbon source is an area that releases more carbon into the atmosphere than it absorbs.
Sources and sinks of carbon dioxide are crucial to maintaining the carbon cycle of the global environment.
Consequently, a reservoirs overall contribution to global climate change could increase or decrease depending on the type of ecosystem flooded.

**Gross emission from Gibe III Hydropower plant**
The GIBE III project shows the main following characteristics:
- Surface: 20,599 ha
- Volume: 15,245 Mm³
- Water resident time: 6 months
- Energy produced annually: 6,400 GWh
- Flooded area per unit of energy produced annually: 3,22 ha

The evaluations are leads following the GOOD PRACTICE GUIDANCE FOR LAND USE, LAND-USE CHANGE AND FORESTRY (LULUCF) from Intergovernmental Panel on Climate Change (IPCC). The Tier 1 is adopted.

The Tier 1 approach provides a simplified approach to estimating greenhouse gas emissions from reservoirs using default emission data and highly aggregated area data. Unless otherwise indicated the area used in Tier 1 calculations is the flooded total surface area, which includes any areas covered with water before the flooding, because area data minus these previously flooded areas are generally not available.

It is important to consider that the gross emissions overestimate the responsibility of the hydro reservoirs

**CO₂ emissions**
The method to estimate the carbon stock change in aboveground living biomass due to land conversion to flooded land assumes that all aboveground biomass is converted into CO₂ in the first year following the conversion. In actuality, the part of the above-ground biomass that is left on site before flooding will decompose more slowly. Decay of soil carbon will also contribute to the emissions and a Tier 1 method for these CO₂ emissions is

\[ CO₂ \text{ emissions}_{\text{WW flood}} = P \cdot E(\text{CO}_2)_{\text{diff}} \cdot A_{\text{flood, total surface}} \]

Where:
- \( CO₂ \text{ emissions}_{\text{WW flood}} \) = total CO₂ emissions from flooded lands, Gg CO₂ yr⁻¹
- \( P \) = period, days (usually 365 for annual inventory estimates)
- \( E(\text{CO}_2)_{\text{diff}} \) = averaged daily diffusive emissions, Gg CO₂ ha⁻¹ day⁻¹
- \( A_{\text{flood, total surface}} \) = total flooded surface area, including flooded land, flooded lake and flooded river surface area, ha

The CO₂ estimation method is simple – the only emission pathway that is estimated under Tier 1 is diffusion emission during ice-free and ice-cover periods. CO₂ bubble emissions are not significant. The default
assumption is that the CO2 emissions would be limited to approximately 10 years after the flooding took place.

For GIBE III Dam

\[ \text{CO}_2 \text{ emissions}_{\text{WW flood}} = 365 \times 11.65 \times 20,599 = 87,592 \text{ t} \]

**CH4 emissions**

The Tier 1 method for estimating CH4 emissions from flooded lands includes the diffusion and bubble pathways:

\[ \text{CH}_4 \text{ emissions}_{\text{WW flood}} = P \times E(\text{CH}_4)_{\text{diff}} \times A_{\text{flood, total surface}} + P \times E(\text{CH}_4)_{\text{bubble}} \times A_{\text{flood, total surface}} \]

Where:

- \( \text{CH}_4 \text{ emissions}_{\text{WW flood}} \) = total CH4 emissions from flooded land, Gg CH4 yr-1
- \( P \) = period, days (usually 365 for annual inventory estimates)
- \( E(\text{CH}_4)_{\text{diff}} \) = averaged daily diffusive emissions, Gg CH4 ha-1 day-1
- \( E(\text{CH}_4)_{\text{bubble}} \) = averaged bubbles emissions, Gg CH4 ha-1 day-1
- \( A_{\text{flood, total surface}} \) = total flooded surface area, including flooded land, flooded lake and flooded river surface area, ha

For GIBE III Dam

\[ \text{CH}_4 \text{ emissions}_{\text{WW flood}} = 365 \times 0.31 \times 20,599 + 365 \times 1.9 \times 20,599 = 16,616 \text{ t} \]

In case of the Gibe III, in order to consider the initial forest flooded, and considering that the vegetable mass will be decomposed between 20 and 50 years, we can estimate a gross CH4 flux from 0.6 to 0.2, respectively, g/m2/d.

This roughly estimation of flux is conservative because it is not considered the storage capacity of the lake and the bacteria oxidation activity.

**Conclusions**

Estimated GHG emissions from GIBE III HPP are lower or comparable to the very large majority of the hydropower schemes and natural lakes.
Reservoirs  | Production (TWh) | Inounded surface (Km²) | Émissions (MtCO₂eq. an⁻¹/TWh an⁻¹)
--- | --- | --- | ---
GIBE III HPP  | 0.64 | 206 | 0.014
Complexe La Grande  | 82 | 13000 | 0.05 (±0.02)
Churchill/Nelson  | 14 | 1400 | 0.02 (±0.01)
Complexe Manic  | 20 | 2645 | 0.04 (±0.02)
Sainte-Marguerite**  | 2.77 | 253 | 0.02 (±0.01)
Churchills falls  | 10 | 6705 | 0.2 (±0.1)
Tucurui  | 18 | 2450 | 0.2 (±0.05)
Sera de Mesa  | 10 | 1100 | 0.2 (±0.05)
Petit-Saut  | 0.56 | 310 | 2 (±1.25)
Curuá-Una  | 0.10 | 72 | 3 (±1.6)
Balbina  | 0.97 | 3147 | 14 (±7)

Concerning CO₂ emissions a comparison can be lead with a thermoelectric power plant:

<table>
<thead>
<tr>
<th>Plant</th>
<th>CO₂ emission t/y</th>
<th>Ratio t/GWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIBE III HPP</td>
<td>87,592</td>
<td>13.69</td>
</tr>
<tr>
<td>Average thermal power plant park</td>
<td>4,478,420</td>
<td>699.75</td>
</tr>
<tr>
<td>Combine cycle thermal plant</td>
<td>2,710,682</td>
<td>423.54</td>
</tr>
<tr>
<td>Carbon thermal plant</td>
<td>5,762,880</td>
<td>900.45</td>
</tr>
</tbody>
</table>

Concerning CH₄ emission a comparison can be lead with other existing lakes:

<table>
<thead>
<tr>
<th>Lake</th>
<th>CH₄ Flux g/m²/d</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatum Lake (Panama)</td>
<td>0.3 - 2</td>
<td>Holger W. Jannasch - Limnology and Oceanography, Vol. 20, No. 5 (Sep., 1975), pp. 860-864</td>
</tr>
</tbody>
</table>

Moreover the GIBE III Power density is equal to 9 W/m² very close to the limit of 10 W/m², figure which UNESCO considers GHG emission negligible.

Furthermore recent researches show that methane emission from wet cultivation, particularly rice, are higher in continually flooded systems, and they can be reduced significantly through changes in irrigation and fertilizer use: recent experiments suggest that draining a field at specific times during the crop cycle can reduce methane emissions dramatically without decreasing rice yields.

The downstream water control, consequent to the GIBE III presence, will allows a different better way to irrigate crops.
Finally it can be considered that Hydroelectric power plant process allows to avoid the emissions of SO$_2$, NO$_x$, dusts, and wastes usually related to thermal plant.

### 7.2.1.3 Local Climate Issues

Large bodies of water influence the climate of their surroundings, especially the temperature and the humidity. The most notable effects are cooling in summer, warming in winter and reduction of the daily temperature variations. In the case of Gibe III reservoir some effects on temperature and humidity can be expected. Nevertheless lakes exhibit a beneficial effect on the local micro-climate.

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 certain 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 in $5 \text{ m}^3/\text{s}$. This value represents 1.1 per cent of the long-period mean annual flow rate and for this reason it is possible to consider the evaporation losses negligible.

The construction of a reservoir with a surface area of approximately 190 km$^2$ can cause microclimatic changes over an average area of some km (1-5 km) from the edge of the reservoir.

In some cases minor climatic changes can occur up to a distances 70-80 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.

Due to the fact that the climate variations on the reservoir could not be easily valuable in a short time, no compensation measures shall be considered.

### 7.2.2 Geothermal activity

There are no confirmed occurrences of geothermal activity in dam area.

The project does not foresee deep excavations; there are no reasons to think about isolated hot spots in excess of gradient temperature because the fault areas are exposed and now covered by a quite thick amount of natural soil.

### 7.2.3 Seismology

The project area is more than 100 km far from the major Ethiopia seismic centres, located in the rift valley. Due to the far from the generation area of earthquakes that could happen, tectonical events would have small
effects and therefore nearly negligible impact on the project area. Anyway in case of an important earthquake in term of magnitude, it’s important to define two different scenarios:

- the construction phase, when the basin is not completely full of water, the lake wouldn’t have significant impacts, due to the basin extension upstream the dam, even if banks fall down into the lake, and
- the working phase, when the basin upstream the dam is full, an eventual fall down of the banks into the lake could occur waves to any direction, included towards the dam. However due to the very large capacity of the reservoir this impact would be practically negligible too.

In both conditions the structures, and particularly the dam, would not suffer significant damages being designed for the Maximum Design Earthquake (50 yr return period earthquake) and checked also for the maximum credible earthquake.

Also the water movement in the lake upstream the dam could generate micro-earthquakes, with minor effects on the banks and on the dam; even if the effects could be considered not so important, the expected RIS (reservoir induced seismic phenomena), that is changes in natural seismicity, is potentially relevant due the amount of water. The area involved is very large and could involve also the top of the plateau.

The RIS is not easily valuable towards people living in the area of the new lake, because lake level, when this is full capacity, could reach areas where there are people living. The buffer zone is to take into particular account and is considerable the most critical for RIS.

Another element to take in account is the erosion of the reservoir bank due to the continuous wave motion. Since this one, on the base of the lithological features, more or less wide portions of the reservoir flanks could be involved in surface landslides phenomena.

No relevant differences highlights about the dam features (RCC or BFRD). In fact both dams would have to be able to tolerate the expected seismic stress in order to respect the safety factor.

### 7.2.4 Hydrogeology

At the present, the hydrogeological characterization at the dam Site is based on over 9000 meters of boreholes, on site geological survey, on aerophotogrammetric and satellite interpretation. The analysis of the continental deposits cores checked for the dozen of boreholes crossing the whole basalt formation and reaching the contact basalt / trachyte, indicates only local presence of conglomerates and paleosoil. The formations do not show features characterizing underground flowing lines.

The already installed piezometers at the dam site provide evidence of a confined aquifer. While the bottom depth of the body aquifer is till now unknown, however the measured water discharge in the boreholes are very modest giving no evidence of relevant groundwater circulation when compared with the Omo river flow.

About the relationships between aquifer and reservoir, as observed from reconstruction of the piezometric surface at the dam site, during construction phase groundwater flows from the aquifer to the Omo River; after the filling, during working phase, the opposite process takes place and the reservoir begins to feed the aquifer.
In the dam site, even if faults have been relieved, there are no occurrences of springs that could be captured by the dam works; this means that people on the plateau won’t have problems about water catchments from their wells.

At the reservoir scale, seepage from the Gibe III reservoir towards other catchments can be excluded for topographic reasons; no valley bottoms at an altitude lower than the reservoir exist within 100 Km at least. The structural pattern observed in the study area (no large scale interconnection) allows to exclude the risk that significant infiltration of water from the reservoir may occur along fault zones. A preferential filtration direction can be inferred parallel to the N20°E set, i.e. to the main river course, further reducing the possibility of consistent water loss away from the reservoir area.

About the underground water circulation, the wide reservoir extension and the limited accessibility, make not easy acquired the necessary detailed level of data in order to have a detailed evaluation of the impact project. A better accuracy is related to the Dam Site, where the campaign of site investigation, still in progress, has defined the relationships between Omo river and groundwater table, together with an artesian aquifer in the deep trachytic body.

During construction works, a well capture could happen. In this case, it will be necessary to verify the well integrity above the dam site, and eventually to drill other wells for the populations living above the dam site area.

### 7.2.5 Slope stability

The slopes are covered by a thin instable surface of soils, whose stability is not always guaranteed. During the construction phase before filling the basin (removal vegetation and cover) any required removal will be carefully carried out, to prevent erosion caused by machinery.

Since these unstable soil conditions, reservoir sides will be investigated to prevent relevant rock falls (for the bedrock) or slumping of the cover material.

After excavation stages geo mechanical characteristics will be duly investigated by geologists and eventual permanent treatment will be immediately applied.

For the final slopes of the excavated areas, all the following measures will be considered by the designer and clearly indicated in the construction drawings:

- Rock bolting of the slopes surface. Type of rock bolts (expansion shell, grouted dowels, etc.) and the length of the rock bolts will be defined according to the rock conditions on the spot.
- Application of shotcrete in different thickness
- Application of shotcrete reinforced with welded wire
- Adequate berms with suitable width and spacing (distance in elevation between the berms)
- Drainage system protecting the area of the slope from the running rainwater with stone pitching. The sloped ditches shall be provided with energy dissipaters to avoid fast erosion by the water flow speed
- Identification of the dry retaining structures (gabion walls) at the toe of the slopes.

For the final slopes of disposal areas, in order to mitigate the environment impacts, mitigation measures will be defined as follows:
• Identification of the disposal areas considering the environment. Minimization of the impact related to the flora
• Definition of proper final slopes according to the nature of the materials to be disposed
• Identification and definition of the drainage works to protect the area from the running rainwater
• Identification and definition of any retaining structure ( gabion walls, concrete retaining walls) at the toe of the slopes to avoid landslides.

During the working phase the whole monitoring system (i.e. piezometers, inclinometers, extensometer and so on) prepared for the ordinary dam control, will be maintained operative and in perfect efficiency. Along the reservoir banks, is better to plan periodical controls to verify the possible triggering of banks movements (eventually of wide dimensions) due to the filling and partial emptying of the reservoir.

7.2.6 Hydrology and Water quality

7.2.6.1 Hydrology

Gibe III is planned to have a reservoir which is very large and the project will regulate the downstream Omo flow at that location markedly increasing the low flows and decreasing the high flows in the river reaches further downstream.

During the construction phase, the diversion tunnels allow the full passage of the incoming flows. Downstream the distance between the dam and the outlet is very short (less than 800 m) and although during operation the river bed in this stretch will remain dry the construction of the project and the change in the hydrologic regime of the river will not affect fishery and other valuable aquatic flora and fauna.

However, when the plant is not operating the environmental flow shall be released downstream by means of one of the several outlet works available. During the first reservoir filling, the two outlet devices will discharge the release required for environmental uses and for impounding control operations. During reservoir filling, it is also recommended to release the environmental flow.

Construction stage of RCC dam will be extremely safe and doesn’t present any potential risk in case of exceptional flood.

7.2.6.2 Water Quality

Water storage in reservoirs induces physical, chemical and biological changes in the stored water all of which affect water quality. The chemical composition of water within a reservoir can be significantly different to that of the inflows. The size of the dam, its location in the river system, its geographical location with respect to altitude and latitude, the storage detention time of the water and the source(s) of the water all influence the way that storage detention modifies water quality.

Major biologically induced changes occur within thermally stratified reservoirs. In the surface layer, phytoplankton often proliferate and release oxygen thereby maintaining concentrations at near saturation levels for most of the year.

Upon dam closure, the lentic system establishes itself rapidly as the reservoir fills. Thereafter, a microbial population explosion occurs, releasing nutrients from the newly submerged organic matter. This stimulates an equally rapid development of the phytoplankton, which harnesses solar energy. The enrichment of
reservoir water by large amounts of nitrogen and phosphorous, as a result of the decay and mineralization of organic matter flooded by the lake, commonly leads to a multiplication of blue-green Algae.

The most important control upon the pattern of primary production within a reservoir is the retention time of the inflow in relation to the sedimentation of inorganic and organic matter. The suspended materials directly affect light penetration and the generation time needed for full development of algal populations (Wetzel, 1973). Short retention times are often associated with high turbulence (and hence turbidity), a mixed water body and a lack of thermal stratification. Phytoplankton requires a minimum retention time to allow development so the quantity of lake plankton tends to be inversely proportional to the speed of water-flow. If rates of water movement through a reservoir exceed a few millimetres per second, little plankton will develop (Hynes, 1970).

Eutrophication is the process of accumulation of reservoir nutrients and the resultant changes that occur to the trophic state and biological productivity of the reservoir. There are three principal categories:

- oligotrophic - poor nutrient content and low biological productivity;
- mesotrophic - intermediate nutrient content and average biological productivity;
- eutrophic - high nutrient concentrations and high biological productivity.

Eutrophication is an ecosystem response to increasing nutrient availability. The response not only involves increased autochthonous primary productivity, but also all other aspects of lake ecosystems, biotic and abiotic, autotrophic and heterotrophic, autochthonous and allochthonous. Trophic level energy exchange operates at a transfer efficiency of approximately 10-15%. Ecological efficiencies are low because the denominator of the efficiency ratio (predator/prey) contains much organic matter (nonpredatory losses) not assimilated by predators. But this low efficiency does not reflect true ecosystem energetic efficiency (predatory/prey-nonpredatory losses). Nonpredatory losses from all trophic levels enter the detrital system supporting a large biomass of heterotrophic microflora.

Initially the inundation of a reservoir results in a substantial increase in nutrient and mineral levels, primarily due to the decomposition of newly submerged biomass and release from sediments. This can lead to beneficial impacts such as higher biological productivity and/or negative impacts such as the proliferation of algae and aquatic plants, and reduced water quality (including taste and odour problems and depletion of oxygen).

The impact of submerged biomass upon nutrient levels tends to dominate during the early years of the reservoir's lifetime but in the long term, as the nutrients from this source are utilised and stabilisation occurs, the contribution of inflowing water becomes more important and represents the only cause of eutrophication.

Nutrients enter the reservoir from inflowing rivers, from groundwater and from the reservoir bottom. The quantities of available phosphorus and nitrogen nutrients are the principal limiting factors in the eutrophication process. These nutrients enter the reservoir from the decomposition of submerged organic matter and from inflowing waters. Fertiliser, detergents and other wastes associated with agricultural, urban and industrial activities are key sources contributing to the nutrient levels in inflowing rivers.

The contribution of nutrients and minerals from the decomposition of submerged biomass is difficult to determine precisely, since it is dependent on many factors. Evidently the quantity of biomass submerged is important. This can vary considerably: for example a wet tropical forest may contain 300 - 900 t/ha of biomass whereas temperate forest rarely exceeds 400 t/ha. A useful indicator as to the potential
consequences of the flooded biomass (and of water quality in general) is the ratio of the surface area flooded (indicating the volume of biomass) and the annual flow discharged (indicating the dilution potential).

Regarding the GIBE III HPP, on the basis of the land cover assessment carried out as part of this study, it is estimated that the Gibe III reservoir will submerge an estimated 17,158 ha of deciduous woodland and 1,839 ha of riparian vegetation.

Although the vegetation is more of woodland, a conservative estimate of the biomass indicates that 211,043 m$^3$ is woodland biomass and 194,015 m$^3$ of forest biomass would be inundated by the water at full supply level, with a really low ratio of less then 10t/ha.

The annual volume of water used and released downstream is about 11,750 Mm$^3$ that is in the range of the average annual runoffs, about 13,800 Mm$^3$: so, the annual recharge of the reservoir is important.

Consequently the impact of the submerged biomass, due to the low biomass/area ratio and to the rapid turnover time of the water in the reservoir, on the water quality of the reservoir, can be considered non significant.

7.2.6.3 Water Pollution

Construction activities may impact water quality and the major sources of construction-related impacts on water quality will be from erosion of disturbed areas required for the construction activities (construction sites, concrete batch plants, material storage areas, vehicle maintenance areas, spoil disposal areas), from wastewater discharge at the construction camps, and from contaminated water (oil, grease, petrochemicals, cement, chemicals). All cement-contaminated wastewater from cleaning or mixing is considered toxic, and should be prevented from entering any watercourse without proper treatment.

All construction related activates should not pollute water ways, in accordance with applicable standards. Therefore, the contractor is required to carryout construction activities as much as possible by methods that will prevent entrance or accidental spillage of pollutants and wastes into flowing and dry water courses and groundwater resources.

7.2.7 Landscape

The impact on landscape due to the project will be significant: a total modification of the middle Omo valley characteristics is expected.

The main potential adverse impacts on landscape will be related to the construction works:

- the dam (231 m high and 580 m long);
- the 40 km long temporary access roads. Both roads R1 and L1 will be constructed in steep slopes areas, therefore the main potential adverse impact associated with the construction of the access roads will be slope stability, landscape and soil erosion;
- the 80 km long permanent relocation road;
- the quarry sites and the borrow areas;
- the camps;
- the excavated disposal areas;
- the Power House;
- the substation.
Some attention must be paid to reduce the visibility of the project works.

The impacts will be reduced, minimized and/or mitigated by properly managing construction activities (roads, camps, etc...) and recovering abandoned construction areas such as quarry sites or controlling (during waste disposal activities) and recuperating (at the end of dumping the excavated material) the waste disposal areas. The excavated materials must be properly disposed in order to prevent their instability, and should be vegetated for reducing on one side the erosion by wind and rain and on the other side to reduce the visibility of the disposal area. The construction roads no more necessary and not useful to local population and will be dismantled at the end of the works.

The visual impact of the dam and of the reservoir, it is not negligible.

The dam represents a big barrier along the present river course and the existing valley landscape. However its visual impact can be considered slightly negative, considering that its visibility upstream it is of minor magnitude.

The construction of the BF rockfill dam would determine the excavation of a large amount of material (about 22 millions of m³) and the opening of numerous quarries and also some disposal areas, while the selected RCC dam will involve much less material (about 6 million m³) and less excavation areas, producing a minor impact on landscape setting.

The reservoir will have a big landscape impact. The presence of a basin along the Omo valley will completely change its visual characteristics.

This impact can be considered on one hand negative because it will create a man-made scenery in a presently natural landscape; on the other hand something positive, because a lake can be considered a new beautiful panorama, that can be seen from the surrounding highlands, increasing landscape attractiveness.

### 7.3 Impacts on Biological Environment

#### 7.3.1 Forest and Natural Vegetation

There will be impacts on the natural vegetation during the construction phase of the Gibe III scheme and these impacts will be either direct impacts related to the physical clearance, or disturbance and/or indirect impacts resulting from increased population and improved access. The major unavoidable direct impacts which results from implementation of this scheme is the flooding and clearing of natural vegetation for the operation of quarry and borrow areas, construction of access roads, construction of temporary camp sites, operators dwelling, etc.

On the basis of the land cover assessment carried out as part of this study, it is estimated that the Gibe III reservoir will submerge an estimated 17,158 ha of deciduous woodland and 1,839 ha of riparian vegetation. The vegetation that will be impacted as compared to the available resources in the affected Weredas is indicated in Table 7.1. This loss would not bring about marked differences in the carrying capacity as it represents only 5.0% and 1.0% of the available woodland and riparian vegetation in the affected woredas respectively.
Table 7.1: Loss of Natural Vegetation

<table>
<thead>
<tr>
<th>Land Cover</th>
<th>Area in Impacted Wederas [ha]</th>
<th>Area lost due to the project [ha]</th>
<th>Percentage loss to the project [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riverine vegetation</td>
<td>176,720</td>
<td>1,839</td>
<td>1.04</td>
</tr>
<tr>
<td>Deciduous woodland</td>
<td>341,075</td>
<td>17,158</td>
<td>5.03</td>
</tr>
</tbody>
</table>

Although the vegetation is more of woodland, a conservative estimate of the biomass indicates that 211,043 m³ is woodland biomass and 194,015 m³ of forest biomass would be inundated by the water at full supply level. Although this volume seems attractive, there is no wood product, which can be used for commercial purpose. However, denser, taller and relatively straight trees are found around edge of the riverbank and valley bottoms.

A terrestrial vegetation survey that was done in the course of the field investigations confirmed that there are no designated or protected areas of terrestrial ecological interest that will be affected by the proposed construction activities. Comparison of the species list of the woodland and the riparian and the surrounding vegetation with the list of endangered and endemic plant species of Ethiopia (Ensermu et al., 1992) does not indicate any endangered species in the area.

To mitigate the potential impacts of flooding on the vegetation resources and the associated impacts on reservoir water quality, a combination of the following two measures are recommended:

1. **Harvesting by enterprises or individuals:** It is recommended to encourage enterprises or individuals living in the surrounding area harvest the biomass through salvage logging and promotion of firewood collection and/or charcoal collection by the people well before the reservoir filling begins.

   The informal discussion made with the local people suggested that although a considerable amount of the biomass would be submerged; salvaging the biomass for use would be very costly in terms of labour considering the availability of wood in the vicinity for relatively cheaper price. Besides, the wood is not useful other than for fuel since the tree species in the area are not among those preferred for lumbering. The availability of abundant eucalyptus biomass both in Wolayita and Waka area makes the first option (harvesting) non-profitable because of the inaccessibility of most parts of the reservoir area and as the result of the steep slope which would make extraction and transportation of the biomass very difficult.

   However, if not regulated, harvesting may exert a very salient impact on the surrounding. The community may continue to harvest the vegetation outside the target area and it would be required to adopt protection measures to the surrounding of the future reservoir area from the long term effect of encouraging the people to use the vegetation in their own way. Therefore, it will be important to implement a strict regulation and policing to stop harvesting and protect the rest of the hill slopes ones the vegetation which will be inundated are fully harvested and/or flooded. Therefore, EEPCO/EMU should inform the SNNP Regional State about the project and arrange special policing to protect illegal timber extraction outside the future reservoir area.

2. **Flooding:** The proposed plan to harvest as much as possible the available vegetation resources will reduce the level of this risk and the conditions will stabilize in due course. However, the remaining vegetation could be left to be submerged and decompose as it stands. This option would have a relatively
minor temporary effect on the quality of the water (see section 7.2.6.2) since the decomposition of the biomass will contribute to the organic matter content and therefore will create anoxic conditions in the reservoir.

There is also a real possibility of the workforce engaging in illegal timber extraction to the detriment of the environment if adequate controls are not applied. Policing of the forest from a conservation viewpoint is probably ineffective as a result of manpower and other constraints.

To minimise the destruction of trees and natural vegetation and replace for the loss due to construction activities outside the future reservoir area, it is recommended to:

- adhere to principles of environmental conservation during the construction period in order to avoid excessive destruction of vegetation,
- prepare a plan to remove mature trees in the construction area (i.e. access road, construction camp sites, quarry areas, etc.) so as to obtain optimal benefits from harvested timber,
- prepare a plan to transplant endemic trees wherever they appear in construction areas,
- avoid damping construction spoils in cliffs and dry river beds where rare and endemic plants are available,
- compensate in cash for the loss of privately-owned mature trees,
- rehabilitate the area to an acceptable condition by planting indigenous trees in the abandoned sites after preparing the sites for establishment of plants. This will involve establishment of nurseries to prepare the necessary amount of seedlings in the area near a water source. This restoration presents an opportunity for environmental enhancement. Restoration and enhancement proposals should be discussed and agreed with the Kebele Council.
- make the contractor responsible for any fire accident caused by his activities within construction activities sites,
- make the contractor responsible for the conduct of his workforce in relation to environmental protection matters and to specifically prohibit unnecessary felling of trees.

### 7.3.2 Wildlife and other Terrestrial Fauna

Although the presence of wildlife within the project area is reported and confirmed by the local communities, the area harbours only limited number of wildlife which justifies the minimum opportunity cost loss suffered by the dam construction and creation of reservoir.

Currently, there are no endangered or rare species in the reservoir area. There are also no species with restrictive habitat preferences. No adverse impacts in respect of sensitive wildlife habitat and wildlife reserves.

However, although minor this flooding and construction activities not only shrink the wildlife habitat and feeding area, it will also disturb the wildlife which were using the forest for shelter, breeding and feeding. These and other potential impacts of the Gibe III scheme on wildlife resources and their habitats have been identified and include the following:

1) The reservoir will require the flooding and/or clearance of natural vegetation and although minor this will shrink the wildlife habitat and feeding area. This loss would not bring about marked differences in the available habitat for the limited wildlife. Therefore, there are ample sites on both (up or down
stream) locations of the river for the animals that move, provided a satisfactory protection is made by the regional government or the project. These sites can be a sanctuary for the animals that tend to occupy them.

2) Although minor, it is inevitable that the flooding will disturb and deprive the few wildlife inhabiting the area and their existing habitat and they will be pushed to the proposed buffer area. Hence, animals (especially the browsing animals) search for a new suitable habitat for feed source, shelter, breeding, egg laying and hatching sites. This may make the wildlife vulnerable to poachers, when they leave their usual dwelling and hiding sites.

3) Not all the valley land is topographically uniform; therefore the inundation at some sites may also cause fragmentation of habitat and disrupt the movement of some animals.

4) It is mentioned already that the steep cliffs of the gorge and the riverine forest along the river are important for several groups of birds such as herons and egrets, king fishers, barbets, chats and thrushes, wood peckers, pigeons, shrikes, warblers and flycatchers, etc. As the reservoir level increases some of their existing habitats will be flooded. However, because of the availability of wide areas in the River Basin (upstream and downstream of this project site) in which these birds are found, it is unlikely that the project will significantly affect the survivorship and well-being of these species.

5) As reported by settlers at Sorowereda specifically at Gortancho and Asawincho kebeles there were lions which have been turned to man-eating which extensive search have been made by experts from the Department of wildlife of ministry of Agriculture and Rural Development. Although the experts have found none, they speculated the existence of four such lions. This was later found to be true, and as a protection measure it was possible to hunt two of the lion legally (Kahsay and Chere 2007). Furthermore these authors have indicated that hunting was permitted only to get rid of these lions otherwise no hunting is allowed in the area.

Although the local communities from the kebeles located close to the reservoir have expressed their concern that the incidents of wild animals’ attack on humans and domestic animals may increase due to flooding their habitat there is no risk to human and wildlife conflict in the area. This is because during the survey it was observed that due to a very high risk of malaria and trypanosomiasis humans and livestock do not inhabit the area close to the future reservoir. However, a wildlife emergency response team has been proposed to deal with any such unforeseen risks.

The following mitigation measures are recommended to offset these adverse impacts posed by the project:

- **Establish Buffer Zone:** During our survey we were able to observe that because of the risk of Malaria and Trypanosomiasis humans and livestock do not inhabit most of the hill-slope of terraces III and IV (altitude below 1,300 m a.s.l). Therefore, it is recommended to establish a buffer zone on an estimated 50,000 ha of land in the area between altitudes 900 and 1,100 m a.s.l (See Figure 7.1) and EEPCO to initiate a discussion with the Regional Governments to secure a protection zone status to the buffer zone. The buffer area will serve as a refuge for the wildlife to move to the area downstream or upstream of the reservoir. It will also support the bio-diversity conservation and enhance the biological value of the area. Given time there will be the reestablishment of the riparian zone on the edges of the reservoir from the woodland vegetation at the initial stage since the species composition of the woodland vegetation and riparian vegetation are more or less similar except differences in size. As the reservoir water level increases relatively slowly, wildlife (animals) that will be affected will have time to adapt themselves to the new habitat and move to the dry place.
Those animals which afford to remain within the newly created condition will occupy the habitat. Those that are not comfortable with the modified situation will use the corridor as temporary refuge and later may move up stream or down stream along the river. However, it will be required to identify and protect corridors that may lead the wildlife to the potential alternative habitats (upstream or downstream). It is also recommended to erect easily recognizable permanent marks such as concrete poles at appropriate intervals to mark the buffer zone.

- **Establish a Rescue Team**: When the reservoir fills, the animals will be displaced and can be vulnerable to poachers when they move upwards. They may also be drowned or stranded in the islands formed when higher sites are encircled by water. These necessitate some kind of human intervention to save the wildlife. In this respect, it is recommended to establish a rescue team. A rescue team trained by wildlife specialists will have the duty to identify areas that can be safe from the inundation so that animals are assisted to move to safer areas before the inundation takes place. When assisted by the rescue team, the wildlife will have ample opportunity to find their most preferred route to the nearest refugia. During Construction and reservoir filling, it is recommended to assign competent personnel in charge of the team who is knowledgeable with the existing regulations and policy for wildlife of the regions and federal government who can assist for protection of wildlife and their habitat. He will organize and co-ordinate the management of the threats, through well organized patrolling plan. He would also involve relevant institutions such as the police and Kebele guards to deal with problems such as those posed by harnessing wildlife by the movement of people and vehicles.

- **Organise Awareness Creation Campaign**: Rural people usually have limited knowledge about wildlife and their importance. As a result, their cooperation for their conservation may be minimal. Therefore, for the protection of the wildlife resources it is recommended to conduct a well coordinated community awareness creation program. The awareness creations will contribute to the protection of wildlife resources from most human induced problems. This awareness creation program should be organised in all villages adjacent to the reservoir and to the authorities responsible for the different kebeles. Apart from village level awareness creation, the Contractor for the project should also be encourage for on-job awareness creation training so that the construction workers refrain as much as possible from adversely affecting wild animals by avoiding unnecessary deforestation and creation of noise and by locating construction camps as much as possible away from wildlife concentration sites.

- **Improve Enforcement Measures along the Buffer Area**: During the impoundment of the reservoir, animals will move upward from sites they were enjoying for a long time and will be exposed to human disturbance. Unless this is coupled by an organized patrol, the existence of the animal will be at risk. Therefore, this requires the increase in enforcement measures and can be done by assigning game guards along the buffer area at regular intervals. The game guards will carry out patrolling and need to concentrate on such kind of work for example, the abolishing of the use of firearm in the area and the establishment of new settlements etc.

- **Strengthening the existing Protected area along the Omo River Basin**: The Omo, Mago, Mazie and Chabera-Chorchora national parks which are explained earlier are located downstream of the dam (See Figure 5.18) and therefore, it is recommended to strengthen these parks. They all harbour at least some or all species of the animals and birds of the project area and these sites are eventually potential refuge for some of these animals in the project area.
• Establish Cooperation with the Regional Government: From experience, we know that the history of wildlife conservation of the SNNP State is relatively among the best in the country. This fact can be witnessed by: i) Strong protection measure implemented to protect the formerly established protected areas like Omo and Mago National Parks. These parks are better protected than other national park in the country; ii) the establishment of additional national parks such as Mazie and Chabera – Chorchora. Therefore, the project should capitalize on the above fact and strengthen its cooperation with the region to protect the wildlife in the project area.

In addition to the above, the following mitigation measures are recommended to offset the adverse impacts posed by the construction of the project:-.

• Prepare a rescue plan to take the necessary action before the reservoir filling takes place;
• Make camps in areas away from wildlife sites and reduce the number of camp-sites if possible by constructing in a single area;
• Implement special and strong regulation and enforcement measures against hunting wildlife that move in search of alternative shelters;
• Make the contractor responsible for the conduct of his workforce in relation to environmental protection matters and to specifically prohibit unnecessary felling of trees, killing of any wildlife, etc.
• Periodic monitoring of habitat integrity of the Gibe III River area to check that these wildlife and birds are safe and secure; and
• Provisions of waste disposal facilities (for both human and construction wastes) to prevent transmission of disease to wildlife.
Figure 7.1: Locations of the Proposed Buffer Area
7.3.3 Aquatic Ecology

The potential impact of construction of the Gibe III dam and creation of the reservoir on the aquatic ecology include the following:

The change from a lotic to a standing reservoir system will result in an altered aquatic food web involving change of dominant functional groups (e.g. plankton become more important at the expense of benthos, riffle-loving groups such as Simulium will be replaced by stagnant water loving forms) and the establishment of disease vectors such as mosquitoes and snails in such systems.

Plankton and benthic-feeding fish may increase at the expense of others. For example, plankton feeders such as Alestes sp (Characidae) may dominate in the reservoir, as this species is already present in the Gibe and Omo rivers. Similarly, insect feeders such as Clupeids may increase and dominate the fishery, as the flooded vegetation allows for proliferation of macro-invertebrates. Such scenarios have happened in other tropical impoundments. The deep gorges and the rich riparian vegetation that will be flooded appear to be ideal for such ecological developments.

No floating species was detected in the River. However, there are instances where reservoirs and lakes in Ethiopia have been shown to form favourable habitats for the excessive development of noxious aquatic weeds. Explosive growth of certain plant species are known to have devastating hydrological (evapotranspiration loss) ecological (fish kills, anoxia, shading, etc) and navigational problems. It may also seriously threaten the effective use of the reservoir. In addition, these weeds offer ideal habitat for disease vectors. Therefore, the creation of reservoir conditions may result in dramatic expansion of plants, particularly along the margins, which in turn can create these unfavourable conditions for use of the reservoir.

The following mitigation measures are recommended to offset the adverse impacts posed on aquatic ecology:

- **Harvesting**: In case of observed growth of macrophytes and aquatic weeds harvesting could be an effective method to control the problem. This technique is best applicable during the early infestation period.
- **Chemical control**: applying chemicals to the water is also one of the effective methods to control undesirable growth of aquatic plants. There are several herbicides, which combat macrophyte and weed growth. Nevertheless this option should only be used as ultimate solution to fight severe infestation.
- **Biological control (Biomanipulation)**: Fish is also used to control algae, macrophytes, zooplankton, phytoplankton and aquatic weeds in the reservoirs. However, applying this technique will require extreme caution due to the required introduction of exotic species in the reservoirs.

During reservoir filling, the change of the flow regime will have significant impact on the aquatic ecology below Gibe III reservoir. Although there is no regulation in Ethiopia defining required minimum flow in the rivers, a minimum flow immediately downstream of the dam would have to be maintained naturally to meet the ecological requirements (to maintain a river as a suitable habitat for aquatic species) of the river downstream. From the ecological point of view, the minimum flow in the normal dry season is critical. During reservoir filling, it is also recommended to release the compensation flow equivalent to the base flow. This flow preserves the natural regime during the dry season, and because it will be regulated, it has the added environmental benefit of reducing the incidence of extreme low monthly average flows which have
been experienced in the past, and which may be damaging to the river ecology. During operation shutdown, water should also be released to benefit the fish stock and aquatic ecology below the dam site.

7.3.4 Fishery Resources

Dam construction across rivers is known to affect fish biodiversity by modifying the upstream and downstream aquatic environments. As the dam interrupts the continuous flow of the water it would disconnect or reduce the floodplain area in the lower reaches of the river below the dam. Thus it would have impact not only on the fish biodiversity but also on the fish stocks and fisheries in the process. In the upstream area above the dam it creates large reservoir, thus creating a lentic environment for the riverine fish species.

The reservoir is quite large and filling will normally take up about 6 to 8 months, depending on the calendar month the filling starts.

The key potential impacts associated with implementation of the Gibe III scheme are summarised below:

- As reports indicate many of the fish species present in Omo River would adapt to the lentic environmental condition created in the reservoir and therefore the impact on the fish stock in the upstream of the Gibe III dam is less significant. However, it is also possible, as it has been observed in other areas, that a decline in the number of fish species and their populations could occur on account of changed ecological conditions especially silt deposition at the bottom and the stratification of water column in the reservoir. Change in fish population is common phenomena expected during the early stage of reservoir development (Crul and Roest, 1995). This could be detected in the follow up monitoring.

- The riverine fish species in the main stream seasonally migrate up and down and sideways to the floodplains. The adverse impact of the dam on these downstream fish species would be due to the reduced flow rather than disruption of migratory route. As a result of the modified flow, the feeding and spawning grounds shrink and therefore there would be possible reduction in fish number.

- The dam is located far upstream on the River Omo beyond the limit of the spawning grounds of the migratory fish species from the Lake Turkana. However, the reduction in water and possible loss of flood pulse could adversely impact the spawning activities unless appropriate mitigation measure is implemented.

- Endemic fish species of the lake will be adversely affected by the project as their spawning and feeding grounds are located along the lakeshore of Turkana and the river delta areas.

- There are no fish species listed as threatened or endangered in any of the study reports of the River Omo basin fish fauna study that could be affected by the proposed Gibe III scheme.

To offset these potential impacts posed by the project on the fishery resources the following mitigation measures are recommended:

- During reservoir filling, the change of the flow regime will have significant impact on the riverine fishery below Gibe III reservoir. Therefore, during reservoir filling it is recommended to release a compensation flow equivalent to the base flow. This flow preserves the natural regime during the dry season, and because it will be regulated, it has the added environmental benefit of reducing the incidence of extreme low monthly average flows which have been experienced in the past, and
which may be damaging to the river ecology. During operation shutdown, water should also be released to benefit the fish stock below the dam site;

- The riverine fishery has not been considered for commercial fishing development to gain economic benefit up to now. However, with the reservoir fishery, the situation would be different. It is expected that many commercially valuable fish species like Nile perch, Lates niloticus, the Bagrus, Tilapia, Clarias, Barbus, and other large fisher species that are currently in the riverine system would adopt and flourish in the reservoir. This would create the opportunity to develop a commercial fishing industry that would support the local community economically and nutritionally. Once the reservoir system is stabilised, with regard to its productivity, further study should be undertaken on the possibility and/or the need for stocking more fish species that could fill up open niches to enhance productivity of the reservoir without negative impact on the existing fish fauna.
- Based on the outcome of the monitoring activities, the flow rhythm (of water to be released from the dam) be regulated and synchronised with the biological rhythm of the fish species to enhance or sustain the regular spawning activity of these migratory downstream fishes; and
- Protect the brooding stock from being exposed to heavy fishing pressure as they aggregate at the river mouth and become more vulnerable to fishing.

7.3.5 National Parks and other Protected Areas

Based on the review of available national and regional conservation area maps issued by the Federal Government of Ethiopia and other competent authorities, the Consultant has confirmed that: the project area is neither contiguous with, nor in close proximity with any of these nationally protected areas like National Parks, Wildlife Resources, and Controlled Hunting Areas. Therefore no direct mitigation measures are necessary.

The government has classified 58 of the most important high forest areas as Regional Forest Areas (RFA) in the country. However, none of these RFAs are directly influenced by the Gibe III reservoir.

There are many birds in the project area. However, none of the nationally designated Important Bird Areas are found anywhere near the project area. Therefore no direct mitigation measures are necessary.

As discussed above, it is recommended to establish a buffer zone around the future reservoir area for the wildlife displaced during reservoir filling. This buffer Area will also support the bio-diversity conservation as it would enhance the biological value of the area.

7.4 Impacts on Socio-Economical Environment

7.4.1 Agriculture

Realization of the proposed Gibe III Scheme (including EEPCO’s permanent camp and the Chida-Sodo Road Realignment) will impact an estimated 138.7 ha of cultivated land belonging to five PAs in two Weredas (See Table 7.2). This principal construction impact arises from the land-take requirements for the reservoir (70.4 ha) and construction of other facilities associated with Gibe III hydropower scheme. To accommodate the future operators dwelling, and the Chida-Sodo realignment an estimated 14.38 ha and 54.18 ha of farmland will also be affected respectively. This agricultural land is under annual cropping, most of which is for family subsistence, with a relatively small surplus being available for sale or trading. The resettlement/compensation strategies have been presented in the Resettlement Action Plan report.
Table 7.2: Households and Land Affected by Project Component and Wereda

<table>
<thead>
<tr>
<th>Wereda</th>
<th>Project Components</th>
<th>Total</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Main Road</td>
<td>Reservoir</td>
<td>EEPCO Camp</td>
</tr>
<tr>
<td>Kindo Didaye</td>
<td>67</td>
<td>51</td>
<td>47</td>
</tr>
<tr>
<td>Kindo Koyisha</td>
<td>69</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loma</td>
<td>114</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>All Weredas</td>
<td>250</td>
<td>58</td>
<td>47</td>
</tr>
<tr>
<td>Percent</td>
<td>70.4</td>
<td>16.3</td>
<td>13.3</td>
</tr>
<tr>
<td>Woreda</td>
<td>Kindo Didaye</td>
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<td></td>
<td>Kindo Koyisha</td>
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<td>-</td>
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<tr>
<td></td>
<td>Loma</td>
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<td>47.50</td>
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<tr>
<td></td>
<td>All Weredas</td>
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<td>Percent</td>
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<td>51.63</td>
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<td>Farmland</td>
<td>Kindo Didaye</td>
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<td></td>
<td>Kindo Koyisha</td>
<td>19.14</td>
<td>-</td>
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<td></td>
<td>Loma</td>
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<td>28.00</td>
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<tr>
<td></td>
<td>All Weredas</td>
<td>54.18</td>
<td>70.14</td>
</tr>
<tr>
<td>Percent</td>
<td>39.06</td>
<td>50.57</td>
<td>10.37</td>
</tr>
</tbody>
</table>

Photo 7.1: Partial View of Existing Farmland in the Reservoir Area

7.4.2 Housing and Settlements

According to information obtained during the survey, in spite of the fact that the size of the project area is large which affects 67 PAs in eleven weredas, no households will lose their residential houses to the reservoir. This is mainly because settlements are mostly on highland and far away from the Omo River and the future reservoir.
However, only an estimated 47 households will lose their residential houses and other assets (i.e. perennial and annual crops and trees) around the homesteads due to the land requirement for the construction on EEPCO’s permanent camp and the road (See Table 7.3 and Photo 7.2).

The resettlement/compensation strategies for the loss of housing and other related structures have been presented in the Resettlement Action Plan report.

### Table 7.3: Number of Residential Houses Affected by Project Component

<table>
<thead>
<tr>
<th>Houses by Type of Roof Material</th>
<th>Project Components</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Road</td>
<td>EEPCO Camp</td>
</tr>
<tr>
<td>Number of Households</td>
<td>16</td>
<td>29</td>
</tr>
<tr>
<td>Houses with CIS Roof</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>Houses with Grass Roof</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>29</td>
</tr>
<tr>
<td>Percent</td>
<td>38.3</td>
<td>61.7</td>
</tr>
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</table>

### Photo 7.2: Partial view of the Proposed Site for EEPCo’s Future Permanent Camp Site

#### 7.4.3 Tribal People

There are no ethnic minorities or tribal people whose traditional lifestyles could become compromised through the development of the proposed Gibe III scheme. Therefore, no indigenous development plan will be required.

#### 7.4.4 Livestock Resources

**Loss of Grazing Land**

As discussed above, there is very little farming and grazing activity in the reservoir area due to a less favourable rainfall and the Tsetse fly infestation and the consequent occurrence of cattle disease, trypanosomiasis. The steepness of the slope on either side of the valley appears to be another important
factor which has discouraged the use of the valley for agricultural and grazing purposes. However, in times of feed shortage during the dry months of the year, livestock are taken to the lower altitude closer to the Omo River where water and pasture is available and with the risk of Tsetse infestation. In these areas farmers move their cattle only in times of the lowest risk into this area. With the beginning of the rain, when the occurrence of trypanosomiasis increases, farmers take back their livestock from the rivers to their permanent villages.

The construction of the dam and creation of the reservoir is expected to flood an estimated 17,158 ha (see Table 5.30) of woodland grassland (See Photo 7.3). This loss would not bring about marked differences in the carrying capacity for cattle as it represents only 5.0% of the available woodland grassland vegetation in the affected weredas. The total land area affected by the reservoir is only 7.5% of the affected PA areas and its impact per PA is shown in Table 7.4.

![Photo 7.3: Recommended EEPCo’s Permanent Camp Site](image)

Although the loss of grazing land will not bring about marked difference in the carrying capacity for cattle, to offset these potential impacts posed by the project on the livestock feed resources and health it is recommended to implement the following compensation measures:

Feed Resources Improvement: It is recommended to improve the feed resources in replacement of the flooded grazing resources by integrating improved forages and proper range management practices in the proposed buffer area. The improved forages include annual species of vetch and oats and from perennial species sesbania, leucenea and elephant grass. In addition, maintenance and planting of indigenous fodder species common to the area will be encouraged. The total amount of money required to compensate for the loss of grazing land by improving the buffer area to serve as grazing land is estimated at Birr 8 million. This includes cost of purchase, raising and management of annual and perennial improved forages and indigenous fodder species around major settlement areas within the affected PAs. This is a one time cost that will be incurred during the first year of the implementation phase. No other cost will be required thereafter, since
multiplication can be done using both cuttings and collection of seeds. The type of inputs required after the introduction of the improved forages would be proper range management and feeding practices.

Strengthening the Veterinary Service: The other important aspect that needs due consideration would be the strengthening of livestock health services. The eleven weredas of the study areas are heavily infested with trypanosomiasis, internal and external parasites. At present, taking the livestock resources into account, the animal health services rendered in the project area are not adequate. Provision of dependable veterinary service will improve the health condition and increase productivity including the traction output of the oxen. Therefore, in order to provide better veterinary service to the local the community the veterinary service should be strengthened at each Wereda level. The required inputs include infrastructure (construction of at least one veterinary clinic in each affected Wereda), facilities, veterinary equipment and drugs. Essential veterinary drugs will be supplied on revolving fund basis. The Clinics will be centrally located and will give veterinary services to Project Affected PAs, so that farmers do not necessarily have to travel long distances to Wereda clinics. Alternatively, the existing Wereda clinics will be supplied with necessary veterinary equipment and drugs.
<table>
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<tr>
<th>Zone</th>
<th>Wereda</th>
<th>Affected PA</th>
<th>PA Area (ha)</th>
<th>Affected area (ha)</th>
<th>% affected</th>
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<td>Kindo Didaye</td>
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<td></td>
<td>Zaro</td>
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<td></td>
<td>Patata</td>
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<td>Gocho</td>
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<td><strong>20.2</strong></td>
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</tr>
</tbody>
</table>

Table 7.4: List of Affected Pas by the Gibe III Reservoir
### 7.4.5 Agro-pastoralists Population

Several agro-pastoralists belonging to Hadiya community move from place to place along the banks of the Omo River in search of grazing for their livestock. The movement or transhumance of pastoralists is a rational and efficient response to the exploitation of arid environments. These agro-pastoralist groups move seasonally to make the best use of available resources. Movement with the livestock occur from the high
altitudes to the low altitudes during the dry season and from the low altitudes to the high altitudes in the wet seasons when there is pastor available in the highlands and water in the dry rivers.

The agro-pastoralists mostly move in Omo Sheleko, Kacha Bira, Boloso Sore and Kindo Koyisha weredas in search of grazing resources for their livestock. They usually construct temporary residential houses for their short stay (for about three months).

The loss of grazing land to flooding in these areas used by the agro-pastoralists communities will not bring about marked differences in the carrying capacity at present and also no gradual deterioration and undesirable effects could be observed in the future. This loss will not compromise the traditional lifestyle of these community and will not also push them into a more distant and marginal land. However, these communities will benefit from the recommended buffer area (integrated with feed resources) development plan.

**Bridge Across the Gibe River to Serve the Agro-pastoralists Community**

Along the Gibe, Gojeb and Omo River, established river crossings used by the agro-pastoral communities will be submerged by the long stretch of the Gibe III reservoir. To compensate for the loss of traditional crossing points it is recommended to construct a bridge across their major crossing point across the Gibe River.

EEPCO is responsible to reinstate the cattle crossing at least at one location between Buryo Lenge and Ambe Lenge PAs of the Soro Wereda by financing the construction of a bridge across the Gibe River. The cost of construction is estimated at Birr 15 Million and this includes the cost of access road to the bridge site.

**7.4.6 Public Health**

Damming and regulating rivers for hydroelectric project schemes can result in the tropics and sub-tropics in higher frequencies of water related diseases within the human population. The Project will likely increase the number of breeding sites for vectors through the creation of a reservoir. Current diseases and their vectors that have been identified as important for the project area include: malaria, schistosomiasis, etc.

The potential public health impacts from various disease vectors species are, at this point not considered to be a major factor affecting the implementation of the project. However, for the control of these vector borne diseases and other communicable diseases it is recommended to adopt the following mitigation measures:

- Environmental management by eliminating sources and habitat management against eggs, larvae and pupae, chemical methods (i.e. insecticides) and biological methods (i.e. using insect growth regulator such as fish or bacteria toxic to mosquito larvae);
- Snails grow well on plants and cannot thrive without them and therefore, removing the aquatic vegetation is a simpler way to control snails;
- After the implementation of the project, it is recommended to strengthen the existing health institutions in each affected weredas and start a surveillance program for mosquito breeding areas, the occurrence of schistosomiasis, onchocerciasis and trypanosomiasis vector suitable habitats.

Most people in the project area are not aware of what causes vector borne diseases like malaria and shistosomiasis or how they get it. Through the regional and wereda health programme, the Project will support local health institutions in continuing the existing education of the population in prevention/control of malaria and other vector borne diseases. This education programme will also include disseminating
information on the prevention of schistosomiasis. Such support and reinforcement of local medical facilities in providing preventive measures has been found to be lacking in schemes elsewhere in the country, and is now considered an essential prerequisite to international funding.

**Impacts During Construction**

Construction is inherently a relatively dangerous industry, and has a number of adverse impacts on public health and safety unless appropriate mitigation measures are undertaken. Particular concerns include the risk of increasing the incidence of social and communicable diseases due to the influx of migrant construction workers, the risk to the workers themselves of contracting malaria, the risk of injury from traffic accidents and blasting activities.

Of the potential adverse social and health impacts, some of the most serious are the transmission of sexually transmitted diseases including HIV/AIDS. Due to the immigration of workforce to the project area, this risk is expected to increase from time to time.

Many persons will influx to the project area in search of job opportunities, and these migrant workforces may bring non-endemic diseases to the project area. This may aggravate the health situations of the communities of the project area.

In the project areas, which already have relatively poor resources in terms of medical services, the presence of contractor's workforce can impose additional strains, reducing their effectiveness as far as the local population is concerned. It is also reasonable to expect that the contractor should exercise a duty of care towards his workforce in relation to injuries sustained at work.

To mitigate the potential health risks to the construction workers the following measures are recommended:

- Require the Contractor to provide a quality health services to the construction employee’s by establishing appropriate health facility with subsidiary treatment posts at the local camp and first aid posts at each construction sites;
- Medical screening and treatment of workers coming from outside the project area;
- Utilisation of preventive and curative measures to reduce transmission of communicable diseases between the work force and the local population;
- Organise awareness campaign on sexually transmitted diseases and their prevention methods for the construction works. Workers will be sensitized to the risks, particularly of HIV/AIDS;
- The provision of a safe water supply, good drainage and appropriate sewage and waste disposal and treatment facilities on the site;
- Sanitation and hygiene education to the workforce and the community;
- Institute anti-malaria measures following current accepted practice at campsites and facilities established for the early diagnosis and treatment of patients with the disease;
- An active surveillance network to facilitate the detection of fever cases. The efficiency of the surveillance system and the timely examination of blood slides/films and treatment are the crucial components of malaria control programme;
- Require the Contractor to provide to construction camp buildings mosquito proof facilities;
- The prime means of controlling malaria in construction camps is the use of bed nets. Levels of human infection have dropped dramatically since impregnated bed-nets (IBN) were introduced. Therefore, provide as much as possible pyrethroid-treated mosquito nets;
• Grade borrow pits after use to avoid ponding and mosquito breeding;
• Remove discarded items that could contain water and keep storm water drains and borrow pits free of water and vegetation; and
• Use insecticide control as a last resort method, and only after studies indicate primary locations of mosquitoes.

Although not a contractual obligation, the Contractor’s Project Staff Health Program shall also provide some assistance to the nearby communities for emergency matters at no cost if spare resources become intermittently available. Availability of this health services to local communities is not required to be guaranteed.

7.4.7 Infrastructure and Severance of Access

The long stretch of Gibe III reservoir formation on the Gibe, Gojeb and Omo Rivers, will impact upon some social service facilities and infrastructures. These include submergence of chid-soda road section and the Omo Bridge and several river crossings. As a result, people residing on both sides of the reservoir will be separated from each other. These impacts are briefly discussed below:

**Submergence of Chida – Sodo Road Section and Omo Bridge**

Due to the creation of the Gibe III reservoir the Chida – Sodo road and the Omo Bridge (See Photo 7.4) will be submerged. The road is an all weather road that connects the deep rural village population of the region with the main Addis – Sodo – Arba Minch highway. The road is located in the densely populated areas and has a political, social and economic significance. This is an important trade route for the rural population and serves a number of villages and is the only road access to serve the community to get agricultural inputs and to sale their products to the market.

![Photo 7.4: View of the Omo Bridge](image-url)
As compensation action, a new bridge across the Omo River will be built downstream of the Gibe III dam. After reservoir impounding, the permanent link between the Omo River left and right banks will be possible utilising the new road (on the right bank plateau) to the dam site, passage over the downstream toe of the dam and a new road on the left plateau from the dam site to the existing road (or to Kindo Halale) will be constructed.

**Submergence of footpath crossings on the Omo River**

Along the long stretch of the Gibe III reservoir there are an estimated nine river crossings (See Figure 7.1). These crossings are mainly used when the river flow is low for transporting goods to market places and serve a significant portion of deep rural community belonging to Dawro, Wolayita, Hadiya, Kembata, Tembaro and Oromo ethnic groups. These people attend weekly markets and visit their relatives by crossing the Omo River using these trails.

The interruption of these crossings will significantly affect the social interactions and the socio-economic values of the people living on both sides of the river. The population density on the left bank is relatively higher and the area is food insecure than the western part of the region where there is food surplus. Therefore, it was observed that the community in the Eastern part of the Gibe III reservoir crossed the river more often to purchase agricultural products. There is also no other well developed alternative road infrastructure available that could be used to alleviate the problem. Therefore, the impact is considered to be very significant.

As mitigation action, it is recommended to establish a boat service at the affected nine locations (See Figure 7.2) to provide service to transport people their goods and livestock’s. The unit cost for the establishment of boat service is estimated at 1 million Birr/station. This includes cost of purchase boats and related accessories. In addition, considering the high fluctuation of the water level in the reservoir (upto 90 m) appropriately designed and constructed 9+9 wharfs will be required. This is a one time cost that will be incurred during the first year of the implementation phase and no other cost will be required thereafter, since co-operatives could be organized to operate and maintain the boats as they provide services by charging passengers. The people who are currently providing the service to cross the rivers could be organised further to provide similar service in a better way. Therefore, the total amount of money required to establish the boat service to compensate for the flooding of river crossing points is estimated at 9 million birr.

### 7.4.8 Impacts on Other Social Service Facilities and Economic Activities

Visits made to the project area and discussions held with key informants indicated that Gibe III reservoir will have no effect on social service facilities like public buildings, schools, health centres, water supply facilities, electric and telephone lines and religious institutions (churches and mosques). Therefore, no mitigation measures will be required.

**Loss of Hot spring**

One of the potential impacts to the local communities will be the loss of hot springs (located closer to the Rivers) to flooding. According to the interviewed community members, the hot springs are considered as holy water and people usually go to these springs to take bath (See Photo 7.5) expecting to be cured from different kinds of diseases such as skin and stomach diseases. Of the affected hot springs some are located at Asawicho PA in Soro wereda, Belela PA in Omo Sheleko wereda, Bombe PA in Boloso Sore wereda and in Gena Bossa wereda. This impact is unavoidable due to the nature and location of the resource and no direct
mitigation is possible. However, it is recommended to locate and develop new hot spring sites (if there are any) and improve or provide access roads. This would be done in consultation with the affected communities and their leaders.

![Hot Spring Site Located in the Reservoir Area](image)

**Photo 7.5:** Hot Spring Site Located in the Reservoir Area

**Loss of “Horra”/Salty Water Pond**

According to the information from Gena Bossa Wereda Office, a salty water pond known as “Horra” is located within the proposed reservoir area (near the Omo River). The cattle drink from this salt water and farmers do not buy salt for their cattle because they have this “Horra” around. However, with implementation of the Gibe III reservoir this salty water pond will be affected. The impact to the local population is the unavoidable impact due to the nature and location of the resources.

**Loss of “Bolle”**

Bole is a kind of soil material used for fattening cattle and this resource (located at Ole kebele of Soro Wereda) will be submerged by the future reservoir. The impact is unavoidable due to the nature and location of the resources.

**Impacts on some Economic Advantages**

Although relatively minor, the inundation of the area by the reservoir will bring adverse impacts on the livelihood of the local people who collect forest product for home consumption and market in different ways (See Table 7.5).

<table>
<thead>
<tr>
<th>No</th>
<th>Types of Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fire wood</td>
</tr>
<tr>
<td>2</td>
<td>House construction woods</td>
</tr>
<tr>
<td>3</td>
<td>Grass for house roofing</td>
</tr>
<tr>
<td>4</td>
<td>Forest honey production</td>
</tr>
<tr>
<td>5</td>
<td>Hunting of animals for food consumption</td>
</tr>
<tr>
<td>6</td>
<td>Wild plant fruits and roots for food consumption in worst times</td>
</tr>
<tr>
<td>7</td>
<td>Cultural medicine plants and roots</td>
</tr>
</tbody>
</table>

**Table 7.5:** Loss of Advantages

Although project affected persons are the ones who bear the main impact, as indicated above other households and communities in the project affected PAs will also be affected directly and/or indirectly by the project. In addition to loss of access to natural resources the impacts by the project include among others:
increased human and livestock health hazards,
submergence of river-crossing points which will disrupt communication and exchange between communities on both sides of the river, and
threats and damage to historical and cultural sites.

These effects require commensurate mitigation, compensation and social development measures. Accordingly, it is recommended EEPCo to implement the following social development project as a compensation measures:

- public health interventions,
- improving clean water supply and rural access roads,
- livestock feed resources and veterinary clinics,
- boat services at river crossing points, and
- protection and promotion of historical and cultural resources.

In formulating these social development plans, we have taken into account a number of basic principles including the following:

- The views and concerns of PAPs and local government officials elicited through public consultations,
- National and International policy, legal, and institutional frameworks, guidelines and best practices on compensation, rehabilitation and income restoration, and
- The principle of partnership and coordination in implementation, that is, while EEPCO will take the lead role in terms of funding and coordinating the income restoration and community development measures, implementation will be based on partnership with various government agencies, NGOs, community based organisations and PAPs.
Figure 7.2: Locations of Affected Road Section and River Crossing Sites along the Omo River
7.4.9 Cultural and Historical Sites

Impact on the Walls of King Ijajo and King Halala

The walls of kings of Wolayita and Dawro constructed to protect their people from ground-fighters and war-horses will be partially flooded by the reservoir. In Wolayita Zone, four sites located at Menera kebele of Kindo Koyisha Wereda are at very high risk of flooding. According to the survey results part of the walls of Ijajo, which will be submerged by the reservoir, is less than 2% of the available 67km long wall.

In the Dawro Zone there is a small section of the wall sites that will be submerged by the reservoir. The Walls of Halala will also be affected by the construction of the realigned Chida-Sodo road. Although this loss will only be a relatively small section of the available 170km long walls, it is recommended to avoid this potentially significant impact by preparation of engineering design which avoids (by realigning the road section) acquisition of land occupied by walls of Halala.

As discussed above, the flooding of relatively small section of the King Ijajo and King Halala walls is considered to be minor. Therefore, to appropriately compensate this loss it is recommended to implement the following measures:

- Full and urgent documentation works should be carried out on the very high-risk sites before the sites will be submerge by the reservoir. The documentation should include preparation of site plan and mapping, taking measurement, photograph and description of the sites with their contexts. This has already been initiated by EEPCO and ARCCH and the cost for this research to fully document the historic site is estimated at 1.5 million birr;
- ARCCH will carry out archaeological and historical researches on walls of Ijajo and Halala. Based on this research finding, all responsible bodies together with stakeholders and collaborators will prepare management plans to protect, conserve and manage the sites from manmade and natural hazards (animal, human and developmental);
- Establishment of a view point for the Ijajo kella of Wolayita and the Halala Kella of Dawro sites for tourists. The unit cost for the establishment of these stations is estimated at 1.0 million Birr per station. This includes for the construction of access road to the nearest representative sites and associated services (catering and information desk) to ensure satisfactory standards to the tourists visiting the sites. This is a one time cost that will be incurred during the first year of the implementation phase and no other cost will be required thereafter, since Office of Information and Culture would operate and maintain the site as they provide services by charging domestic and international tourists. Therefore, the total amount of money required to establish these stations is estimated at 2.0 million birr;
- Establishment of the Ijajo kella of Wolayita and the Halala Kella of Dawro as a Heritage Site: Generally, these sites need an urgent attention from the ARCCH, the Information and Culture Bureau of SNNPR and other stakeholders and researchers. ARCCH, as responsible body will immediately initiate the process to register these sites as cultural heritage sites.

7.4.10 Archaeological Sites

The UNESCO World Heritage Site is known for its geological and archaeological importance and is located downstream of the Gibe III dam and reservoir site in the lower valley of the Omo river. Therefore, the
UNESCO World Heritage Site will not be affected by the construction and the subsequent flooding and operation of the Gibe III hydroelectric scheme.

There are no known archaeologically important sites in the reservoir area to hinder the implementation of the Gibe III hydropower project. The probability of encountering undiscovered sites and human remains in the reservoir area is low. Therefore, no recovery plan will be required.

However, it is recommended that the construction contract should make provision for work to be halted and the relevant authorities to be notified, in the event of accidental discovery of archaeological remains.

7.5 Downstream effects

7.5.1 General

These findings of the studies of the benefits and impacts of the project downstream of the dam site are illustrated in detail in the report:

- 300 ENV R AG 003 A Environmental Impact Assessment, Additional study on downstream impact

This chapter briefly recalls the effects on the downstream hydraulic regime following Gibe III dam construction.

7.5.2 Hydraulic regime

The operation of the Gibe III reservoir will regulate the Omo river flows downstream of the dam.

The hydraulic regime at Gibe III site is illustrated in the following Figure 7.3, where the mean monthly flows before and after dam construction is shown.

Basically the dry season (November-May) discharges will be increased while the wet season (June-October) average flows will be reduced.
The reservoir operation will also allow controlling the downstream peak floods, occurring in August/September, including the sudden and critical ones of wet years (increased in peak because of the deforestation of the basin) which often causes critical events as in year 2006.

Average floods are however required both for environmental and human activities (flood retreat/river bank cultivation, fishery, grazing resources, etc.).

Therefore a controlled environmental discharge is envisaged from the reservoir in the period August / September.

This release is intended to limit the downstream flooding to the required extent, in duration and in areas, while reproducing the natural average flooding conditions.

The annual flooding of the river banks of the lower Omo River soaks the land for traditional recession cultivation and dry season grazing, replenishes lakes and swamps on the floodplain and favours fish breeding.

Therefore controlled floods during the rainy season are envisaged to recreate for the time necessary the natural hydrological regime downstream of the plant.

The characteristics of these floods (duration, outflows) are:

- **Period**: September (or last two weeks of August)
- **Flows**: 1,000 – 1,200 m$^3$/sec (at Gibe III)
- **about 1,600 m$^3$/sec** (at lake Turkana)
- **Duration**: 10 days (peak flow)
Flows nearby the Lake Turkana will be therefore similar to the monthly average flows of August/September also during the dry years thus avoiding any critical drought event.

The figures below illustrate the discharges of the Omo River nearby Lake Turkana during an average year and during a particularly dry year (1987).

**Figure 7.4:** Monthly flows at Lake Turkana: average 1964-2001

**Figure 7.5:** Monthly flows at Lake Turkana: dry year 1987 (min flows)
7.5.3 **Downstream flows during construction and first impoundment**

During all the construction phases, the diversion tunnels allow the full passage of the incoming flows. A small “routing effect” for the largest floods, obtained by the cofferdam reservoir flood capacity, immediately allows a reduction in the highest peaks contributing to the protection of the downstream environment.

During the first filling, the two outlet devices will discharge the releases required for environmental uses and for impounding control operations:

- Temporary environmental outlet (No. 2, \( Q = 30\ldots70 \text{ m}^3/\text{sec} \))
- Middle outlet (No. 2, \( Q_{\text{max}} = 800 \text{ m}^3/\text{sec} \))

The temporary ecological outlet is envisaged through the diversion tunnels to allow the releases during the first months of the impounding period.

Then when the reservoir reaches 755 m a.s.l. the middle outlet will allow the release of the environmental controlled flood illustrated in the previous paragraph.

The detailed impounding program must be developed in the Level 2 design phase of the project in order to guarantee that the middle outlets and temporary ecological devices will discharge adequate flows for the downstream environmental requirements.

7.5.4 **Daily Flow Variation Acoustic Warning System**

The first section of the river downstream Gibe III dam will experience consistent fluctuation of water levels within the riverbed in the course of normal (24 hrs) hydroelectric operations. Although, due to local geomorphology, no permanent human settlement/activities are located in areas interested by the fluctuating water levels, this does not mean that humans, especially in the proximity of villages, may not approach the river for different usages or for crossing it.

To this aim, a long-term warning system constituted by sirens will be placed and operated in river sections located in the immediate proximity of nearest villages and around major river crossing to signal in advance occurrence of rising waters in a number of priority spots (provisionally estimated in 50-100 locations) along the Omo river first 200 km downstream Gibe III Dam.

The sirens will advice differently for Large Water Releases (Controlled floodings) and Ordinary Discharges occurring daily as a result of Dam operations by mean of distinct warning signals to the understanding of which the residing population will be trained beforehand.

The Warning Units will be remotely trigged by the Dam Control Station, on a pre-organised time sequence according to the river water speed, possibly coupled with water level gauges systems reacting to rising water levels placed in the immediate proximity of warning units.

Sonic Devices and water level gauges with ultrasonic sensors will be operated by solar panels.

7.5.5 **Sediment transport and water quality**

The northern part of the Gibe III catchment area has several tributaries, with the most relevant ones from the NE (Walga and the Wabe rivers) draining largely cultivated land.
The construction of the dam will determine a reduction in the Omo River total solid transport downstream of the reservoir.

The coarse fraction of the solid transport (i.e. gravel and sand), carried from the upstream catchment, will be trapped into the reservoir.

However in the lower Omo river the sediment yield is substantially made (more than about 70 %) of extremely fine particles (colloids, clay, fine silt), which will remain in suspension during the annual operation of the reservoir.

On the base of the first analyses and on the results of the previous studies in the river basin (Omo river basin Master Plan, Gibe I, Gojeb and Halele Werabesa hydrological studies) it can be assumed that:

- The average total solid transport in the Omo river is composed of a relevant fine fraction (colloids, clay, silt) totalling about 80 % and of a smaller coarser fraction (sand, gravel);
- The existing Gibe I reservoir, which has similar operating conditions to those planned for Gibe III reservoir, indicates that:
  - Average suspended solid transport (colloids, clay, silt) is not substantially reduced by the reservoir trapping effect which regulate discharges during the year;
  - The most relevant mean water quality parameters (phosphorus, nitrogen, COB, BOD, etc) will probably not be greatly varied by the reservoir operation.
- Oligotrophic conditions (i.e. quite clear lake with low biological productivity) are likely to develop in most of the reservoir;
- While the water quality and the mean sediment content will not greatly change because of the reservoir operation, the trapping of the coarser sediments, coupled with the effect of restored hydrological conditions of the Lake Turkana system on the longitudinal slope of the Lower Omo River, may cause erosion at places previously characterised by sedimentation activity.

These local phenomena can be negative for the riparian environment and will need hence to be detected through regular monitoring of the suspected critical locations, and where necessary prevented by means of carefully designed river training works.

### 7.5.6 Agriculture

Under present ‘average’ flood condition, large tracts of floodplain are submerged annually along the lower Omo River and around the river mouth. The annual flooding of the land bordering the Omo River soaks the land for traditional recession cultivation and dry season grazing replenishes lakes and swamps on the floodplain and favours fish breeding.

To satisfy the demand for traditional recession agriculture, dry season grazing and fishery resources, seasonally more water will be released and flooding will be created on the land bordering the Omo River.

One of the immediate benefits of constructing the Gibe-3 dam will be the ability to avoid severe drought periods and to control the large flooding downstream which cause the loss of lives, both human and animal, as well as damage to property and infrastructure. However it is recognised that a complete cessation of the average annual floods would be disastrous for the communities, which practice flood recession agriculture.

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The peak controlled floods releases shall be adjusted during the first years of operations to be adequate in flow and timing to achieve the current natural penetration in the soils and for soil moisture to carry the crops through to maturity while maximising killing of weeds germinated by the water, thereby allowing continuation of current practices.

Construction of the Gibe-3 dam will not have a direct effect on rainfed cropping, which is mainly confined to the higher lands. It might possibly lead to an increase in rainfed cropping, in an effort to compensate for loss of recession crop area, which in turn might result in overuse of the limited amount of arable land available and more susceptibility to soil erosion. Controlled flooding after dam construction, to allow the continuation of flood recession cropping will obviate this potential impact.

The ethnic groups, Dasenech, Karo, Hamer, Mursi, Murle, Mugugi and Nyangatom, all rely on flood recession and river delta crops as well as livestock for their subsistence. The potential loss of flood recession crop area, as well as grazing, would reduce their food supply and could possibly lead to conflicts over grazing areas.

There will be no adverse impact on irrigated agriculture from reduced flooding, only benefits because of the regulated flow in the river, which will ensure adequate water levels at all times of the year.

The planned release from the reservoir intended to artificially induce flooding of both the river banks and floodplains, as well as the provisions for a minimum environmental flow, will mitigate and full compensate all adverse effects.

Nevertheless modern agricultural techniques practices including infrastructure (roads, markets, finance, irrigation, extension, etc.) will have to be promoted so as to ensure food security by the vertical growth in agricultural (crop, livestock and fishery) productivity and improve the income level of the community.

Therefore, in addition to seasonally releasing more water to create flooding on the land bordering the Omo River the following benefit enhancement measures are also recommended:

- There is large area of unutilized land along the floodplain of the Omo which could be used for recession cultivation and/or small scale irrigated crop production if accessibility and the public infrastructure are improved. Therefore, provide assistance to expand cropped area by harnessing under-utilized (or unutilized) land resources by opening up poorly accessible areas along the Omo floodplain through the construction of community feeder roads.
- Experience of irrigation schemes in the lower Omo suggests that small scale river diversion and small scale irrigation have positive effects and is providing a vital contribution to food security and self-sufficiency. Therefore, provide assistance to expand irrigated crop production and water harvesting practices;
- Assist the farmers by introducing improved agricultural practices including supplying locally adopted and high yielding varieties; and
- Creating a suitable settlement environment through development of infrastructure for Dasenech, Karo, Hamer, Mursi, Murle, Mugugi and Nyangatom communities; and
- Since not only economic opportunities (other than traditional and subsistence farming), but also technical and business skills among affected populations are very low, therefore project affected persons should be supported by the project through training, facilitation and capacity building so that they can set up profitable ventures.
The supply of water will never be a constraint on the development of irrigation in the lower Omo: even the unregulated flows of the Omo River will irrigate more land than is likely to be developed. Therefore, construction and operation as the Gibe III scheme will have no effect on downstream irrigation schemes.

7.5.7 Grazing resources

The lower Omo floodplain has a potential advantage on the livestock feed resources, for example Hammer-Dasenech Rangeland system which is predominantly on the alluvial sediments of the Omo River is valuable feed sources. Most of the grazing resources both the grass and shrubs are a good source of livestock feed especially in the period of drought.

Therefore, to satisfy the demand for recession grazing, seasonally more water will be released and flooding would be created on the land bordering the Omo River.

To avoid the loss of floodplain grazing feed resources and its associated impacts on livestock resources, and to enhance the beneficial impacts from seasonally releasing flood water, development packages in the following major livestock improvement areas are recommended:

- To introduce high yielding and locally adoptable forage and feed sources to improve the quantity and quality of grazing resources. This would help to overcome feed shortages during the height of the dry season;
- To improve the feed resources by integrating improved forages and proper range management practices in the area. With the provision of improved forages and improvement of the grazing lands training will be provided for both the farmers and the technical staff in the respective Weredas. The unit cost for the improvement of the grazing land is estimated at 200 Birr/ha. This includes cost of purchase, raising and management of annual and perennial improved forages and indigenous fodder species. This is a one time cost that will be incurred during the first year of the implementation phase. No other cost will be required thereafter, since multiplication can be done using both cuttings and collection of seeds. The type of inputs required after the introduction of the improved forages
would be proper range management and feeding practices. Therefore, the total amount of money required to compensate for the loss of grazing land by improving an estimated 10,000 ha floodplain grazing land is estimated at Birr 2 million;

- To introduce milk processing plant in the weredas located downstream of the Gibe III scheme. This would not only insure that the pastoralist and agro-pastoralist get attractive prices for the milk they supply from farm by adding value, but will also introduce the much needed market oriented diversification in the agricultural system of the area. It could be managed and run by farmers who get specialised trainings;
- To rehabilitate and strengthen the existing veterinary services and establishing new veterinary facilities in the affected weredas. The intervention would include strengthening the service with facilities, equipment, trained staff, drugs, etc. at wereda level;
- To provide training for farmers, development and extension workers at wereda and community level.

7.5.8 Fishery

Under present ‘average’ flood condition, large tracts of floodplain are submerged annually along the Omo River and around the river mouth. These areas are essential for the breeding success of many species of commercial importance and any reduction in the area flooded or the duration of flooding would have consequences on the fishery resources.

It is planned to seasonally release more water to create some floodplain condition and allow those fish species to spawn and maintain the recruitment level. However, the discharge mechanism and operational program (timing and volume of water discharge) should be arranged by considering the impacts on the fish stocks. To enhance the benefit from the planned release to cause flood pulse and avoid any potential impacts on fishery it is recommended to:

- Assist the wereda agriculture and rural development offices to monitor the fishing activity and protect the brooding stock from being exposed to heavy fishing pressure as they aggregate at the river mouth and become more vulnerable to fishing;
- Assist for the introduction and promotion of modern fishing technologies in the area in order to increase productivity and efficient utilization of the fishery resource; and
• Data on fish species composition and fish ecology in this region would be useful for deciding to regulate the flow and synchronise with the biological rhythm of the fish species to enhance or sustain the regular spawning activity of the fishes. Therefore, it is recommended to study the implications of various dam operating policies that might be feasible following the implementation of Gibe III scheme.

7.5.9 National Parks

According to the information obtained from both Omo and Mago National Park officials, currently there is an effort to start community tourism by using boat transport from Lake Turkana via Omo gorge to the upstream National parks (Omo and Mago National parks). Community tourism is expected to help encourage the tourist to visit the different ethnic groups along the Omo River. Therefore, the following measures are recommended:

• Adequate flows are essential for river navigation. Therefore, to avoid the potential impacts on the operation of this service, it is recommended to initiate consultation between the National Parks management team (for the planned community tourism) and the Gibe III plant operators on their operation programme (timing and volume of water to be discharged).
• Seasonally more water will be released and flooding will be created on the land bordering the Omo River. This will create floodplain condition will also improve grazing resource for browsing animals in the park area. This will also help the local community not to encroach the national parks in search of grazing resources because of shortage of feed.

7.5.10 Dipa Hayk Lake

Dipa Hayk is a lake that is used by the Karo community for recession cultivation, grazing resources and fishery. During the month of July to September the Omo River floods and fills the Dipa Hayk. This creates the opportunity for the local community to plant crops around the lake using recession cultivation for their subsistence need and they also fish from this lake. Therefore, to avoid the reduction in flood flow to Dipa Hayk and the associated potential impact to the community in terms of reduced crop harvest gain, fishing and availability of grazing for their livestock:

• it is planned that annual flooding would occur to replenish the Dipa and other nearby lakes for recession cultivation, fishing and grazing resources;
• construct appropriate structure that helps to divert water from the Omo (if required); and
• assist for the introduction and promotion of modern fishing technologies in the area in order to increase productivity and efficient utilization of the fishery resource.

7.6 Impacts Associated with Ancillary Works

7.6.1 Quarries and Borrow Areas

The construction of Gibe III hydropower scheme will require huge quantities of quarry material for various project uses, such as access road, the main dam and diversion dams, spillway, power station, intake structure, tunnels, etc. The principal environmental concern related to opening a quarry site include: visual impact, sedimentation of waterways, dust and noise nuisance, and public safety aspects associated with the storage and use of explosives. However, in this Project Area there is less concern regarding the impacts of quarry
development on locations with sensitive habitat and wildlife resources. There will also be no effects on agricultural lands or to settlements.

The following measures are recommended to be taken for the rehabilitation of the quarry areas: re-establishment of vegetation, restoration of natural water courses, avoidance of flooding of the excavated areas, achievement of stable slopes, and avoidance of features which would otherwise constitute a risk to health and safety or a source of environmental pollution. Quarry faces and excavations be made safe and buildings, plant, equipment and debris and stockpiles of material be removed from the areas.

### 7.6.2 Spoil and Waste Material Disposal Areas

The construction of Gibe III hydropower scheme is expected to generate large quantities of spoil material and these spoils will need to be disposed off. The potential environmental concerns related to the spoil disposal include loss of productive land, grazing land and natural vegetation, interference with natural drainage, increase in erosion and sediment deposition, increase in slope instability and visual alternation of landscapes quality. There is a possibility of soil erosion and adverse aesthetic impact if spoils are not properly placed and rehabilitated.

Spoil disposal activities should be planned to be executed in a manner which minimizes these potential damage to environment and maintains stability during all stages of placement and when the site is in its final form. For disposal of waste soil and rock, both the placement of the materials and the rehabilitation methods are important. Therefore, to mitigate and minimize the impacts of spoil disposal on the local environment the following mitigation measures are recommended:

- Locate spoil disposal sites as much as possible in unproductive land and outside flood conveyance areas with preference being given to backfilling quarry and borrow sites which have been developed by the contracted. However, spoil disposal sites to be located in flood storage areas only in those cases where the studies have determined that the impact is not significant;
- Locate disposal sites in areas of land, which, prior to the commencement of the construction works, were not used for agricultural purposes or designated for agricultural purposes;
- For each disposal site incorporate the most appropriate stabilization techniques;
- Placement and rehabilitation of spoils and waste be executed with sensitivity to topographic and visual aspects and in such a way that the disposal areas enhance rather than detract visual quality of the route. After the completion of construction, most of the disturbed areas will require some re-contouring to encourage natural drainage pattern, improve slope stability, and mimic the original shape of the slope. The amount of grading and re-contouring will depend heavily on the type of disturbance and the quantity of material deposited. Re-contouring will also consider drainage such that water neither pools on the site, nor flows through with sufficient velocity to erode soils and overburden;
- Adopt restoration measures to reinstate the site for its previous use. For this, soil excavated during construction be stockpiled separately and used for landscaping and restoration of work areas. Topsoil stockpiles are deep ripped to provide for moisture retention and re-growth of local trees and bushes.

However, it is also recommended to prepare a site environmental management plan for each proposed spoil disposal sites and this plan should include environmental studies and consultation to assess the potential impacts of each proposed spoil disposal sites and the recommend site specific management measures. The
The findings and results of the above activities are used to prepare a Spoil Disposal and Management Plan as a sub-plan under the Contractor’s Site Environmental Management Plan. The Owner shall review the proposed plan and may require modifications to the proposals. Therefore, in accordance with the comments provided by the Owner, the Contractor shall finalize site selection or design.

### 7.7 Cumulative Impact Assessment

#### 7.7.1 Background

The Omo-Gibe basin is one of the significant surface water resources of Ethiopia. The Gibe cascade project is one of the most attractive potential hydroelectric developments in the country and it has been selected by EEPCO as one of its key hydroelectric development areas.

In subsequent studies various several options were considered for the Gibe river development plan and as a result hydro-projects in series along the main Gibe river in a cascade style were proposed. The general layout of the Gibe cascade plan is shown in Figure 7.6. These four projects are shown in the longitudinal profile in Figure 7.7 from upstream to downstream.

The Gibe III hydroelectric project is a third stage of the Gibe hydroelectric cascade scheme on the Greater Gibe (Omo) River which includes three other schemes. The Gibe III scheme is designed to generate 6,400 GWh of electricity with an installed capacity of 1,870 MW. Table 7.6 shows the list of existing and planned hydropower projects.
This section of the ESIA report briefly presents the cumulative impact assessment result. The objective is to ensure that large-scale and potentially significant cumulative impacts if there are any will not be ignored and will be addressed in the planning, design and operation phases of these projects.

Cumulative impacts are defined in CEQA Guidelines as two or more individual effects that together create a considerable environmental impact or that compound or increase other impacts. “A cumulative impact occurs from the change in the environment, which results from the incremental impact of the project when, added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time” (guidelines 15355 [b]).
Figure 7.6: Overall layout of the Gibe Hydroelectric scheme
Figure 7.7: General Layout of the Gibe Cascade
The cumulative impact analysis considered existing Gibe I HPP, Gibe II and Gibe III which are under construction and the planned Gibe IV projects in the Omo-Gibe system. It is recognised that other project may be developed in the future, but there is not available information and therefore not considered further in this analysis.

7.7.2 Results of Cumulative Impact analysis

As discussed above, an action must meet any of the following three criteria to be included in the cumulative impacts analysis:

- Impact a resource or region potentially impacted by the proposed project;
- Incur an impact within the region of impact or region of influence; and
- Produce this impact during the allotted time frame of the proposed project.

In this cumulative impact assessment actions of projects that are expected to potentially affect similar resources in the region of influence during similar periods or in the “reasonably foreseeable” future are considered in the cumulative impact analysis. The following resource areas with the potential to be impacted by these projects have been considered and the result briefly presented below:

i) Water Resources

Operational simulations of the Omo-Gibe river system were performed as part of the hydrological analysis for Gibe III and the other schemes. In broader terms during plant operation there will be an increase on the river flows during the dry season and reduction of the flows during the rainy season, when the water is retained in these reservoirs. Because of the spatial distance and temporal separation between projects (see Table 7.6) the potential cumulative impact due to the influence of initial reservoir filling is avoided. The impact of these schemes on the water resources is also insignificant in terms of the long term river system. Therefore, these schemes would not be expected to contribute to cumulative impacts to water resources of the Omo-Gibe system.

ii) Water Quality

Water quality issues were addressed as a component of the respective environmental studies. It was reported that impoundment could have adverse effects on water quality as a result of the decay of vegetation and consequent release of nutrients which might lead to anaerobic conditions. However, the planned removal of biomass from the future Gibe III reservoir area will significantly reduce the potential impacts on water quality. Any residual adverse effect on water quality will be confined to the reservoir itself and the river immediately downstream. Therefore, serious water quality impacts are not expected on a cumulative scale.

iii) Fishery Resources

Fishery in the Omo-Gibe Basin include: the riverine fishery and floodplain fishery. The river system supports an abundant population of fish, of various species, which form the basis for a fishing industry. As reports indicate many of the fish species present in the Omo River would adapt to the lentic environmental condition created in the reservoir and therefore the impact on the fish stock in the upstream of these schemes is less significant. These schemes are located far upstream on the River Omo beyond the limit of the spawning grounds of the migratory fish species from the Lake Turkana. There are no fish species listed as threatened or endangered in the River Omo. Overall, the proposed Gibe III mitigation measures during
operation phase (environmental release and artificial flood), combined with mitigation measures associated with the other projects would minimise any cumulative impacts to fishery and other aquatic resources.

iv) Forestry and Natural Vegetation

On the basis of the land cover assessment carried out as part of this study, it is estimated that Gibe III reservoir will submerge an estimated 17,158 ha of deciduous woodland and 1,839 ha of riparian vegetation. The vegetation that will be impacted as compared to the available resources in the affected weredas is only 5.0% and 1.0% of the available woodlands and riparian vegetation respectively. However, there would be no overlap in the area impacted by the cascade schemes. Thus, any cumulative impact to natural vegetation resources associated with Gibe III scheme in combination with existing and other future projects would be minor. To compensate for the loss of woodland and riparian forest it is recommended to develop a buffer area around the future reservoir area. When implemented, the buffer zone around the future reservoir area will also support the bio-diversity conservation as it would enhance the biological value of the area. Therefore, any cumulative impacts would be beneficial.

v) Wildlife and Wildlife Habitat

Although the presence of wildlife within the project area is reported and confirmed by the local communities, the area harbours only limited number of wildlife which justifies the minimum opportunity cost lose suffered by the dam construction and creation of reservoir. Currently, there are no endangered or rare species with restrictive habitat preference around any of these schemes. No adverse impacts in respect of sensitive wildlife habitat and wildlife reserves. Because of the spatial distance between the reservoirs of these projects no cumulative impacts on wildlife resources and their habitat is expected due to the construction and operation of the Gibe III Hydroelectric Project.

vi) Socio-Economic Impacts

One of the most important points to note is that although the Gibe III project is one of the largest hydropower project ever undertaken in the country, the impact from the reservoir in terms of population displacement is very small (47 households). This is because the impounded water will be confined within the gorge of the river far from large population settlement areas. Because of the spatial distance between the Gibe III scheme and the other projects, no cumulative socio-economic impact will result from construction and operation of the proposed Gibe III scheme. When Gibe III is implemented it is expected to create significant economic and social benefits, and will contribute to the attainment of the country’s priority goals and ongoing national and regional efforts to accelerate economic growth and alleviate poverty. Therefore, any cumulative impact would likely be generally beneficial.

vii) Cultural Heritage Sites

Preliminary survey has been carried out for objects and sites of physical cultural resources within the project area. The result of the survey indicated that small section of historical sites known as King Ijajo Kella and Halala Walls are located within the future Gibe III reservoir area. However, no other known protected cultural or historical sites like local religious facilities, local monuments, holy trees etc. were identified.

Although Gibe III scheme will impact very small sections of the Historic Walls of Halala and Ijajo, the other cultural heritage sites available in the region would not be directly impacted by construction or operation of
any of these schemes. Therefore, the Gibe III would not contribute to cumulative impacts on any cultural resources.

**viii) Agriculture and Grazing Resources**

There is very little farming and grazing activity in the Gibe III reservoir area due to less favourable rainfall and Tsetse fly infestation and the consequent occurrence of cattle disease, trypanosomiasis. The steepness of the slope on either side of the valley appears to be another important factor which has discouraged the use of the valley for agricultural and grazing purpose. The loss of land to flooding for Gibe III reservoir would not bring about marked differences in the carrying capacity, for cattle as it represents less than 5% of the available woodland grassland vegetation in the affected weredas. However, the nearby communities will significantly benefit from the recommended buffer area development plan (which is integrated with development of livestock feed resources). Therefore, the potential adverse cumulative impacts to the region’s agriculture and grazing land resources are considered negligible.

### 7.8 Synthesis of Environment Impact Matrix

A table summarizing the results of the impact assessment has been compiled from the technicians, in order to give a comprehensive evaluation of positive and negative impacts caused by the new plant.

The table contains the synthesis of the aspect listed below:

- Physical environment
- Geothermal activity
- Seismology
- Hydrology
- Hydrogeology
- Water quality
- Climate
- Landscape
- Natural Environment
- National Parks and protected areas
- Ecologically sensitive areas
- Priority forest areas
- Wildlife and wildlife corridor
- Fishery resources
- Wetland ecosystem
- Aquatic ecosystem
- Aquatic weeds
- Eutrophication
- Socio-Economical Environment
- Property residence
- Agricultural land
- Grazing land
- Disease ecology
• Traditional community
• Employment community
• Cultural Heritage Sites and monuments
• Local services
• Migrant workers and local population

The analysis of each one of the aspect above, has been done in the impact assessment report. The table is useful to collect and summarize the data to make data better understandable and comparable.

The assessment has been carried out through technical meetings among the assessment team experts.
### Table 7.7: Synthesis of Environment Impact Matrix

<table>
<thead>
<tr>
<th>Environment Component</th>
<th>Physical Component</th>
<th>Construction Stage Activity Component</th>
<th>Operation Stage Activity Component</th>
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<td>Reservoir</td>
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<tr>
<td>Climate:</td>
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<tr>
<td>Climate:</td>
<td>Local</td>
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</tbody>
</table>

**Positive Impact:**

- A = Very Important
- B = More Important
- C = Important
- D = Fair Important
- E = Less Important

**No Impact:**

- 0

**Negative Impact:**

- 1 = Very important
- 2 = More important
- 3 = Important
- 4 = Fair important
- 5 = Less important

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8 PUBLIC CONSULTATION AND DISCLOSURE

8.1 Objective of Public Consultations

The FDRE Constitution contains a number of articles that are relevant to environmental matters in connection with development projects, as well as to the environment in general. In relation to public consultation, Article 92 of Chapter 10 (which sets out national policy principles and objectives), includes the following on public consultation:

“….. people have the right to full consultation and to the expression of their views in the planning and implementation of environmental policies and projects that affect them directly”

The Environmental Policy of Ethiopia (EPE) recognises the need for an ESIA to address social, socio-economic, political and cultural impacts, in addition to physical and biological impacts, and for public consultation to be integrated within ESIA procedures.

Public consultation plays a key role in enabling the public to participate in the planning of project that affects the people directly. As of the beginning of this project, there have been several public/stakeholders consultation and participation briefings and meetings, which have taken place at the local, regional and federal levels.

The public consultation process has been carried out based on the following objectives:

- To identify potential negative and positive impacts of the project as well as the associated appropriate remedial measures that could be identified through the participation of the people;
- To include the attitudes of the community and the officials that will be affected by the project so that their views and proposals in the formulation of mitigation and benefit enhancement measures; and
- To increase public awareness and understanding of the project and its acceptance.

8.2 Consultation Methodologies

In order to assess knowledge, perception and attitude of the communities about the proposed Gibe III project and its potential impacts, several meetings and discussion were held with a number of community members and their leaders from various regional sector offices. A number of household individuals were consulted privately so that the people were given a chance to express their views freely.

The groups that are chosen for the consultative meetings were selected with great care on the basis of the location of the project so that their views could represent the entire attitudes of the community as well as the officials in which the project is located. The sampling groups of the people are taken from the communities residing in various villages and kebeles, weredas, zones, Federal Offices and NGO’s. The people that can best represent the ideas of the people were selected from the directly affected people and from the administration offices that administer the project areas.

Consecutive field trips were taken to these reservoir and the downstream areas in order to collect the views and attitudes of the concerned bodies found with in and around the project areas. The field trips to the reservoir and the downstream places were conducted in the year 2006 and 2007 respectively.

The consultative meetings were undertaken by the team of experts comprising of economists, sociologists, environmentalists and surveyors having relevant work experience and qualifications in the field.
Appropriate guidelines and related studies were referred before the launching of the consultative meetings and on this basis, the points of discussions were formulated to facilitate the discussion towards the desired output.

The consultative meetings were done through an official language of Amharic. However, the community and individual based discussions were conducted through an interpreter of the consultative members that can speak the language.

The main results on public consultations process are described in the present chapter, while in the Annex 4 the complete public consultation report, further demonstrated by the help of different pictures that are taken from the area in order to illustrate the presentations clearly, is illustrated.

8.3 Identifying Stakeholders
Following scoping of issues and review of findings, the following stakeholders were identified for consultation:

- Government officials at Federal, Regional, Zonal, Wereda and Kebele level
- Communities and people directly affected by the project
- NGO operating in the project area.

The focus community and individual groups, development agents, experts, government and NGO institutions have given their opinions, shared experiences and discussed critical issues. During this consultation process, a number of project implementation related issues were identified by the stakeholders and these are presented in this report.

8.4 Results of Dam and Reservoir Area Consultation

8.4.1 Consultations with Community Focused Groups
In spite of the fact that there were no official engagements made to present the project to those groups previously, there were some people who had some limited knowledge of and mixed expectation from the project. For instance, while some members of the community expressed their worries about displacement and loss of livelihood due to the project, others voted for the project for they believed that that is the sacrifices they had to pay to realize national development goals in general and creation of new employment opportunities in particular. Generally speaking, the attitude of the community towards the proposed project was positive.

The findings and recommendations of the local communities are presented as follows:

Positive impacts
The people expect that the implementation of the project will bring positive changes to their life. They also expect additional income as the result of the opening of more job opportunities. More specifically they expect improved access and construction of bridge on the Omo River, and employment opportunity from the project. Small scale irrigation will be developed and this will contribute to higher income and increased food security to the community. When the Gibe III dam is built, electrification of the areas in the vicinity of the power plant will be possible. This rural electrification project will stimulate the development of the area.
Negative Impacts

The result of the discussion revealed that the project will affect the population’s social, economic and cultural relations that existed between the left and right bank of the river. The anticipated negative impacts of the project are summarized below.

- The most important adverse impacts perceived by the respondents were loss of dwellings, farmland and fuelwood, and flowering plants that are useful for the production of honey.
- The movements of the pastoralist in search of grazing land will be affected and this can affect the basic livelihood of the pastoralist communities.
- The flooding of the forest resources may expose them to wildlife attacks and this can threaten them and their domestic animals.
- The project will flood the natural spring and holy water used for healing. In addition to this, the mineral soil (Bole soil) which is used for cattle feed will also be flooded by the reservoir.
- The project will result in the disruption of social, economic, cultural and trade relation between the people of Soro and Dawro, Omo Sheleko wereda and Dawro, Soro and Omonada, Omo Sheleko and other people residing on the opposite side of the river, Boloso Soro and other people reside in the opposite side, Boloso Soro wereda and Dawro people.

8.4.2 Views of Individual Households

The discussions made with individuals shows that the project will have both the negative and the positive impacts and the most important ones are presented below.

Positive Impacts

The individual consultations show that the people associated the project with poverty reduction program through an introduction of different interventions. The people may get access to development, improved water facilities, electricity and also construction of clinic and school as well as manufacturing industries may take place. Irrigation could be developed and job opportunities could be created.

Negative impacts

- The implementation of the project will lead to the displacement of the people living within the reservoir area and this will result in the loss of income and other associated problems.
- The project will cause the disruptions of social, economic and cultural relation between the people residing on both banks of the river.
- The project will be a cause for the destruction of spring water found within the project area.
- There will be a loss of beehives, farming and grazing lands of the area and the absence of forests will lead to the migration and death of wild life. The people could also be attacked by wild animals.
- The implementation of the project will interrupt the existing foot paths and this makes communication among the people residing at different places difficult.
- The prevalence and the spread of malaria could be worsened.

8.4.3 Consultations with Local Officials

Discussions were held with wereda administrations and several issues were raised during the consultative meetings and the brief summery is presented below.
Positive Impacts
The lists of the anticipated positive impacts include:

- Construction of new accessible roads that can commonly be used by the project and the local communities. Roads could be constructed that goes to the river and the people are expected to be one of the beneficiaries of these roads.
- There are many jobless people within the weredas and the project is expected to create job opportunities for these people.
- The reservoir will be a good source of fish resources and this can improve the food security of the people. However, the people need to be trained how to conduct modern fishing activities so that they can satisfy their own needs and supply to other consumers found outside their areas.
- Irrigation could be developed along the river Omo.
- The people may get access to electricity since the project may supply electric power to the rural and urban towns located around the Project area.
- The development of electric power will benefit the country at large and additional foreign exchange could be earned as the result of the development of this hydroelectric power project.
- The project could lead to the establishment of different factories into the area.

Negative Impacts
According to the local Officials, the project is expected to bring the following negative socio-economic and environmental impacts:

- People will be displaced from their residential areas.
- The farming and grazing lands will be inundated by the reservoir and this will cause the loss of income to the local communities.
- Currently, the people get different kinds of forest products for the purpose of house construction and fuel wood requirements and the implementation of the project may deprive them from these privileges.
- Honey production which is taking place on the natural forests grown along the river will be affected and therefore the benefit of the people arising from this activity will be lost.
- The project may interrupt the social and trade relations between the people residing on the both banks of the river.
- Submerges of the Omo Bridge and the Chida – Sodo road, and if not replaced will cause major socio-economic problems for the people of Wolayita zone and the wereda as well.
- The project may lead to migration of the wildlife inhabiting the area.
- The prevalence of malaria and cattle diseases may be worsened and other communicable diseases may be introduced into the area by imported construction workers.
- Mineral water and hot springs will be flooded.

Proposed Mitigation Measures
The wereda officials have forwarded the following different remedial measures to reduce or avoid some of the negative impacts of the project listed above.

Land allocation should be adapted to those people who will lose their lands.
• Provision of compensations for those people and institutions that will be affected by the project.
• Contribute to improve the health service in the area.
• Construct two bridges that connect the people of Wolayita and Dawro are proposed at two different places i.e. one bridge located on the main road and the other one near to the dam site. In addition to these bridges, other accessible roads that connect the remaining communities living in both banks of the river should be constructed at different places so that the affected people could retain their social interactions and also maintain their income from trade relations.
• Implementation of hand pump small scale irrigation schemes will enable the farming community to produce more from a small area of land and the people will benefit from the introduction of such irrigation schemes.
• Introduction of modern fishing mechanisms.
• Introduction of Improved cattle feed.
• Introduce boat transportation.

8.5 Results of Downstream Areas Consultation

The downstream part of the project is entirely located within SNNP Regional State. Implementation of the Project will affect a total of four woredas located within, South Omo zone. Consultation meetings were held with representatives of the ethnic groups resented in the project area and also with the wereda and zonal administration offices.

The view of zonal office was taken from the Agriculture and Rural Development office of South Omo zone. Among the four woredas that will be affected by the project, three of them are included in the sampling of the consultative meetings and this large size sampling provided an exhaustive list of the impacts of the project and their mitigation measures. In the downstream parts of the project, a total of 7 ethnic groups are consulted.

8.5.1 Views of Local Administrations

Positive Impacts
The project makes significant contribution to the development of the country and it will enable the areas to have access for electricity.

Negative Impacts
The project will affect socio-economic and environment of the wereda and particularly livelihood of the ethnic groups residing on the floodplain of the river. A substantial decline in the production of crop and fishing will be encountered and this may result in serious shortage of food and other related problems, shortage of grazing land and livestock feed are the expected to be negatively affected by the project.

Proposed Mitigation Measures
The expansions of small scale irrigation which can be operated by diesel or wind pump as well as creating an artificial lake to sustain and improve fish production can restore the income that could be lost due to the implementation of the project.
8.5.2 Views of the Community

Positive Impacts
The project could accelerate the expansion of small scale irrigation developments in to the area. This development will improve the standard of living of the local community.

Negative Impacts
A reduction in the flow of the Omo River will exacerbate the socio economic life and livelihood problems of all of the communities depending mainly on farming and cattle raising. The project will affect major economic activities such as crop production and fishing. A decrease in the flow of the river will also bring about a reduction in the size of recession cultivation and crop production, as well as decline in fishing activities. Lack of grazing lands will lead to serious shortage of livestock feed and other related problems. Shortage of livestock feed is a critical problem for all of the communities residing along the river due to the fact that many of the people own large number of livestock population.

Proposed Mitigation Measures
Developing small scale irrigation schemes that could be operated by diesel pump generators, the construction of wind mill and the introduction of modern method of fishing are proposed to be applied as mitigation measures of the negative impacts of the project.

Consultation conducted with Community at Gibe III Reservoir

Photo 8.1: Ose kebele community discussion

Photo 8.2: Belila kebele community discussion
Consultation conducted with Authorities at Gibe III Reservoir

Photo 8.3: Consultation with Wolayita zone, Kindo Koyisha Wereda Council

Photo 8.4: Consultation with Dawro zone Administration Office

Consultation conducted with communities at Gibe III downstream

Photo 8.5: Community Consultative Discussions with the Rate and Brokonoch People

Photo 8.6: Community Consultative Discussions with the Karadus kebele People

Photo 8.7: Consultation with Individual at Kangatom village
Consultation conducted with Authorities at Gibe III downstream

Photo 8.8: Consultation with South Omo Zone, Dasenech Wereda Council

Photo 8.9: Consultation with South Omo Zone, Hammer Wereda Council

8.6 Consultation for National Parks and Protected Areas

8.6.1 Views of the Ministry of Agriculture and Rural Development

The Wildlife Conservation Department of the Ministry of Agriculture and Rural Development (MoARD/WCD) which is the responsible governmental body for the Omo and Mago national parks was requested to forward its comments towards the potential negative impacts of the project upon the parks and the surrounding areas. These parks are situated on the right and left banks of the Omo River downstream of the hydropower project.

According to the office, there is no wildlife that is entirely dependent on grass grown on floodplain. The livestock and wild animals have abundant grazing lands outside the river courses and therefore they will not be affected by the project.

There will also be no any significant effect upon the aquatic life in the National Park areas.

Currently, a “community tourism” is initiated and this is taking tourists from Lake Turkana to the upstream of the Omo River through small hand operated as well as motorized boats. By this package a tourist will visit the national parks as well as the indigenous people of the area. Therefore, the fluctuating water levels caused by operation of the plant (reduction in discharge when no energy is generated from the power station and the increased discharge as the power station begins to operate) may affect the operation of this programme.

8.6.2 Views of the Office of National Parks and CHA

The Omo and Mago National Park and Murule Controlled Hunting Area (CHA) are found within the downstream of the Gibe III scheme. The potential impact of the project on these protected areas was assessed through consultations with the officials from the two parks and the CHA. As an introduction, the study team made brief presentation about the general features of the project. According to the information obtained from them, currently the parks have started community tourism program by means of boat transport from Lake Turkana via Omo gorge to the upstream of the parks. The officials’ perceive that the high fluctuation in the river flow may hinder boat transportation and could be a cause for the interruption of the program. Therefore, the operation of the hydropower scheme could have a significant negative impact on the program.
The wildlife around the Park and CHA, have ample grazing land resources and therefore, the implementation of the Gibe III hydropower project will have no significant impact on the wildlife feeding sites.

8.7 Consultation for Historical Sites

The Gibe III Hydroelectric project, will affect historical places found within the reservoir area. Therefore, in order to assess the potential impacts of the project on these sites, consultation and a rapid field assessment was made jointly with the experts and officials from the Federal Authority for Research and Conservation of Cultural Heritage (ARCCH), Information and Culture Bureau of SNNPR, Zonal and Wereda Administration councils. The summary of consultation is presented below.

8.7.1 Consultation with ARCCH and Information and Culture Bureau

Two Historical places i.e. King Halala wall of the Dawro Zone and king Ijajo Kella of the Wolayita zone will be partially submerged by the implementation of the project. Therefore, in order to verify the possible impacts and to recommend the mitigation measures, the consultation was initiated with the ARCCH and Information and Culture Bureau of SNNPR. As part of the consultation process, a field trip was arranged and conducted along the Omo River, in Wolayita and Dawro Zones from January 28 to February 4, 2007. During this consultation it was confirmed that the project will partially flood the existing historic walls.

Therefore, the team has forwarded the following recommendation:

- Immediate registration of the Ijajo kella of Wolayita and the Halala Kella of Dawro as cultural heritage by ARCCH.
- Full documentation works should be carried out on the very high-risk sites. Further archaeological survey should be conducted in and around Dawro localities, which are parts of the risk zones. After a full record and documentation of those affected section of the wall, it is possible to flood the cultural remains/historical walls and allow the project to go-ahead.
- The walls of Ijajo and Halala urgently need the attentions of the ARCCH, the Information and Culture Bureau of SNNPR, Wolayita and Dawro Zones' Information and Culture Bureau, stakeholders and researchers.
- In depth archaeological and Paleontolgical survey shall be conducted along the northern part of the Omo Valley between Wolayita to the east and Dawro to the west. This survey will help to collect prehistoric artefacts, hominid, fauna and flora fossils before these materials will be out of context by the alteration of the landscape due to the formation of the reservoir.
- The administration of the Wolayita and Dawro Zone and its responsible offices should protect the wall of Ijajo from manmade and natural hazards.
- Based on the results of scientific researches all responsible bodies together with stakeholders and collaborators should prepare management plans to protect, conserve and manage the remaining sites.
- The concerned bodies should also encourage local and foreign researchers who are interested to study the walls of Ijajo and Halala in particular and the cultures of Wolayita and Dawro in general.
- Above all, higher educational and research institutions should encourage their students to do archaeological and historical researches in Wolayita and Dawro Zones in particular and in southern Ethiopia on the whole.
8.7.2 Consultation with Zonal and Wereda Authorities

Consultation was conducted with the Dawro zone council, Gena Bossa and Loma wereda of the Dawro zone and Kindo Koyisha wereda of the Wolayita zone administration council on the issues related to the impacts of the project on the historic walls.

Local officials expressed their fear regarding the flooding of the walls. However, after consultation and a joint field visit to some of these sites it was confirmed that only a relatively small portion of the wall will be flooded.

Therefore, from the consultation process the following were proposed:

- Both Ijajo kella of Wolayita and the Halala Kella of Dawro should be registered immediately as cultural heritage;
- Full documentation works should be carried out on the very high-risk sites before the sites will be flooded;
- Further information should be collected and detailed study should be conducted to enrich the information regarding the impact of the project on both historical walls;
- For those portions of the wall which will not be submerged by the reservoir, the administration of Dawro and Wolayita Zone and its responsible offices should protect the wall of Halala and Jiao from manmade and natural hazards (animal, human and developmental).

8.8 Consultation with NGOs and Other Organisations

Currently Farm Africa, Ethiopian Pastoralist Area Research and Development Association (EPARDA), Catholic Church and Refuge Trust are those Non Governmental Organization’s which are actively involved in the social and development activities within the community in the Lower Omo area.

These organizations are engaged in the activities of various socio-economic development sectors like the health, education, water supply, livestock disease, conflict resolution, food security, natural resource and agriculture.

According to them, the implementation of Gibe III project will have an impact for the community residing along the lower Omo River on crop production, fish and livestock grazing. Therefore, development of small scale irrigation, forage development, demonstration plots for crop and forage, and fish marketing are some of the activities that will mitigate these impacts. During implementation of these measures, adopting such activities which are currently practiced by other organization has a paramount importance and helps to implement the interventions effectively.

8.9 Public Disclosure

It should be emphasized from the outset that the Gibe III hydroelectric project involves a multitude of stakeholders ranging from project affected persons and communities to the project developer, regional and federal governments through to financiers, environmentalists NGOs, etc. Needless to argue that infrastructure projects such as Gibe III usually attract the attention of various stakeholders and hence are often prone to criticism. This is especially true in today’s highly globalized world. It is not the type and the number of criticisms made to an infrastructure project that is important. Rather, more important is the way how such criticisms, both constructive or otherwise, are handled or entertained and taken care of.
Depending on the interests of the parties, all arguments in favour or against large infrastructure projects have several dimensions including constructive and destructive, national and international, personal and institutional, local and global. In other words, arguments and criticisms on mega projects such as Gibe III Hydroelectric project may range from a narrow business or other interests to the more genuine and broader social, economic and environmental ones. Be that as it may, entertaining the views of all parties from all sides, angles and perspectives is naturally in the best interest of the project. In summary, it is crucially important for the project to encourage views and comments from all players and address them properly and adequately regardless of their sources, types and motives.

Constructive comments about the project are straightforward and are relatively easy to deal with. Equally important, if not more, are the views of those who might stand against the realization of the project. The underlying factors for view holder to take such a stand may vary widely. But, one thing is common, lack of sufficient information about the project including the nature and scale of its positive and negative impacts at different levels. If view holders are misinformed or are unable to obtain correct information, then they are forced to form their opinions on wrong premises such as rumours. This, in turn, leads to counterproductive arguments. Therefore, it is the responsibility of the project to provide all stakeholders at all levels to provide them with accurate and up-to-date information about its plans and operations.

Methods and modalities for public disclosure can take different forms depending on who and what is intended to be achieved. The bottom line, however, is the participation of all key players at all levels local, regional, national as well as international. Based on the nature and scale of the project, the following methods will be adopted the public disclosure exercise.

A) National Consultative Workshop:
Upon completion of preparation of ESIA, ESMP and RAP reports, the project will organize a national consultative workshop to bring all key players together to express their views and concerns on the project and its impact and discuss the contents of these reports and contribute to their finalization. To host the consultative workshop successfully, the project office will accomplish the following:

- Make reports and related documents available;
- Send a Team of professionals to PAPs and local officials in the project area to explain contents of these reports and solicit their views and concerns in the whole project process;
- Organize a national consultative meeting, collect views and comments and present the findings;
- Develop project promotional materials (flyers, posters or small publication) and distribute it the wider public;
- Prepare an expert panel of discussion; and
- Finalize these reports and make them available.

B) Permanent Project Web Site:
The project will design, host and maintain a project web site throughout the life of the project. This electronic medium will serve as a permanent promotion, information and public relations forum for the project making it easier to reach out both national and international stakeholders and address their concerns in addition to equipping them with accurate and up-to-date information about the project and its progress. As and when required, the project web site could draw on resources and experiences from EEPCO. The project web site, as an electronic medium, is a crucial communication and information medium serving the project
and its stakeholders as their respiratory organ, (the lung) through which they both can breath in and out, exchange views, experiences and information on matters related to the project. The project will complete the following tasks to make the web site up and running:

- Design and host an interactive and dynamic project web site.
- Populate the web site with project and other relevant information classified as ‘public domain’, as necessary.
- Keep the web site as dynamic, lively and interesting as possible and maintain it throughout the life of the project.
9 ENVIRONMENTAL COMPARISON

9.1 Forewords
In March 2001 the Ethiopian Power System Expansion Master Plan was published by EEPCo.
In this work several different power generation options are considered and a comparison between all is made with the same ESIA methodology.
At the end a ranking of the options considered is done.
In order to understand the environmental impact assessment of the project in relationship with other hydroelectric projects in Ethiopia in the following pages a comparison between Gibe III and the other hydroelectric projects considered in the EPSEM will be done.

9.2 Ranking methodology
In the EPSEM seven criteria were selected in order to rank the different schemes in terms of their environmental impact:

- Land lost;
- People affected;
- Access;
- Cultural heritage;
- Downstream effects;
- Aquatic ecosystems.

For each criterion a scoring system was developed to give it the relevant value.
The score for each scheme was normalized by using a weighting system for the criteria.

9.2.1 Land lost
Land, especially arable and/or grazing land is a scarce commodity in Ethiopia where the largest part of the population is dependent on agriculture and on cattle. Furthermore, as the population is mostly dependent on firewood as a source of energy, the remaining forests are of high value. For this reason the weights reported in the following Table 9.1 were given to the criterion:

<table>
<thead>
<tr>
<th>Table 9.1: Land lost weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss in land</td>
</tr>
<tr>
<td>Forest</td>
</tr>
<tr>
<td>Agricultural land</td>
</tr>
</tbody>
</table>

In the different cases the impact of the land lost was scored as reported in the following Table 9.2.
9.2.2 People affected

In hydroelectric projects the resettlement of people represents one of the major impacts. There are not many opportunities for people to find employment and more people are affected by the project more difficult it becomes to assimilate them in the surrounding communities. For this reason a weight of 35 has be given to the criterion and the impact will be scored as described in the following Table 9.3.

<table>
<thead>
<tr>
<th>Score</th>
<th>People affected (n°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;500</td>
</tr>
<tr>
<td>2</td>
<td>500-1.000</td>
</tr>
<tr>
<td>3</td>
<td>1.000-5.000</td>
</tr>
<tr>
<td>4</td>
<td>5.000-10.000</td>
</tr>
<tr>
<td>5</td>
<td>&gt;10.000</td>
</tr>
</tbody>
</table>

9.2.3 Access

Most people in the rural areas walk to the neighbouring villages or to markets, while donkeys and/or horses are used to convey their products. A large water body may therefore completely cut them off from the markets and communities on the other side, which previously could be reached. For this reason a weight of 15 will be given to the criterion and the impact will be scored as described in the following Table 9.4.

<table>
<thead>
<tr>
<th>Score</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
</tr>
</tbody>
</table>

9.2.4 Cultural heritage

Cultural impacts may be associated with the loss of churches, mosques, historical monuments, archaeological sites and cultural heritage areas. A weight of 10 will be given to the criterion and the impact will be scored as described in the following Table 9.5.

<table>
<thead>
<tr>
<th>Score</th>
<th>Loss of monuments, etc… (n°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>0 - 2</td>
</tr>
<tr>
<td>2</td>
<td>2 - 5</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 5</td>
</tr>
</tbody>
</table>
9.2.5 Downstream effects

Inundation of the river crossings, loss of scenic river areas such as rapids and waterfalls, access to the water, variations of flow during the day due to peak electricity demands are only some of the possible downstream effect that will be considered. A weight of 10 will be given to this criterion and the impact will be scored as described in the following Table 9.6.

<table>
<thead>
<tr>
<th>Score</th>
<th>Downstream effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
</tr>
</tbody>
</table>

9.2.6 Aquatic ecosystems

A weight of 10 will be given to this criterion and the impact will be scored as described in the following Table 9.7.

<table>
<thead>
<tr>
<th>Score</th>
<th>Expected Ecosystem modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
</tr>
<tr>
<td>3</td>
<td>High</td>
</tr>
</tbody>
</table>

9.2.7 The Scheme Impact Score

The weighting and the score range for the seven criteria that were selected in order to rank the different schemes in terms of their environmental impact is summarized in the following Table 9.8.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>Score Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land lost:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>5</td>
<td>1-5</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>15</td>
<td>1-5</td>
</tr>
<tr>
<td>People affected</td>
<td>35</td>
<td>1-5</td>
</tr>
<tr>
<td>Access</td>
<td>15</td>
<td>0-3</td>
</tr>
<tr>
<td>Cultural</td>
<td>10</td>
<td>0-3</td>
</tr>
<tr>
<td>Downstream effects</td>
<td>10</td>
<td>0-3</td>
</tr>
<tr>
<td>Aquatic ecosystems</td>
<td>10</td>
<td>0-3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

The maximum score will amount to 100; a higher score means a higher impact.

The score for each scheme will be calculated as follows:

\[
SIS = \sum \frac{C_w * C_s}{Mps}
\]
where:

- SIS is the Scheme Impact Score;
- Cw is the Criterion weight;
- Cs is the Criterion score;
- Mps is the Maximum possible criterion score

### 9.3 The Impact of Gibe III

As described in Chapter 7 the Gibe III is likely to have important impacts on the main environmental issues as summarized in the following Table and its final environmental impact score is reported in Table 9.10.

**Table 9.9: Impacts of the Gibe III HPP**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>&gt; 3,000</td>
</tr>
<tr>
<td>Agricultural land (cultivated and grazing)</td>
<td>84+17,158</td>
</tr>
<tr>
<td>People affected (n°)</td>
<td>329(^{22})</td>
</tr>
<tr>
<td>Access</td>
<td>Medium(^{22})</td>
</tr>
<tr>
<td>Cultural (n° of monuments lost)</td>
<td>1</td>
</tr>
<tr>
<td>Downstream effects</td>
<td>Medium</td>
</tr>
<tr>
<td>Aquatic ecosystems</td>
<td>Medium</td>
</tr>
</tbody>
</table>

**Table 9.10: Impact Score of the Gibe III HPP**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weight</th>
<th>Score Range</th>
<th>Score</th>
<th>Weighted score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land lost: Forest</td>
<td>5</td>
<td>1-5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Agricultural land</td>
<td>15</td>
<td>1-5</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>People affected: Agricultural land</td>
<td>35</td>
<td>1-5</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Access</td>
<td>15</td>
<td>0-3</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Cultural</td>
<td>5</td>
<td>0-3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Downstream effects</td>
<td>10</td>
<td>0-3</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Aquatic ecosystems</td>
<td>15</td>
<td>0-3</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
<td></td>
<td>53</td>
<td></td>
</tr>
</tbody>
</table>

A comparison between the Gibe III scheme, the GGIIHEP and the schemes discussed in the EPSEMP is reported in the following Table 9.11.

---

\(^{22}\) The n° of affected households reported is 47, the total affected people are estimated considering 7 persons per household.

\(^{23}\) Considering mitigation and compensation represented by reallocation of the Chida-Sodo road and the provided boat service.
Table 9.11: Impact Scores of different schemes considered in EPSEMP, of GG II HEP and Gibe III

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Land lost</th>
<th>People affected</th>
<th>Access</th>
<th>Cultural</th>
<th>Downstream</th>
<th>Aquatic Systems</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beles</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Geba 1 and 2</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>41</td>
</tr>
<tr>
<td>Halele-Werabesa</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>Baro 1 and 2</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>Aleltu East</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>55</td>
</tr>
<tr>
<td>Aleltu West</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>55</td>
</tr>
<tr>
<td>Chemoga-Yeda</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>75</td>
</tr>
<tr>
<td>Genale 2 and 3</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>85</td>
</tr>
<tr>
<td>Gilgel Gibe II</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>GIBE III</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>53</td>
</tr>
</tbody>
</table>

As shown in the above table Gibe III scheme, compared to all the hydroelectric schemes reported in the EPSEMP, has a medium-high score mainly due to the area considered as grazing and it is related to downstream and aquatic ecosystem effects that may be significant.

In the following Table 9.12 a relationship between the installed capacity (in terms of MW) and the score (calculated according to EPSEMP methodology) of the considered hydroelectric schemes is evaluated calculating the relevant ratio.

Table 9.12: Installed Capacity/Impact Scores of different schemes considered in EPSEMP, of GG II HEP and Gibe III

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Score</th>
<th>Installed Capacity (MW)</th>
<th>Ratio Installed Capacity/Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beles</td>
<td>12</td>
<td>460</td>
<td>38.33</td>
</tr>
<tr>
<td>Geba 1 and 2</td>
<td>41</td>
<td>254</td>
<td>6.20</td>
</tr>
<tr>
<td>Halele-Werabesa</td>
<td>49</td>
<td>374</td>
<td>7.63</td>
</tr>
<tr>
<td>Baro 1 and 2</td>
<td>50</td>
<td>669</td>
<td>13.38</td>
</tr>
<tr>
<td>Aleltu East</td>
<td>55</td>
<td>214</td>
<td>3.89</td>
</tr>
<tr>
<td>Aleltu West</td>
<td>55</td>
<td>186</td>
<td>3.38</td>
</tr>
<tr>
<td>Chemoga-Yeda</td>
<td>75</td>
<td>440</td>
<td>5.87</td>
</tr>
<tr>
<td>Genale 2 and 3</td>
<td>85</td>
<td>338</td>
<td>3.98</td>
</tr>
<tr>
<td>Gilgel Gibe II</td>
<td>9</td>
<td>420</td>
<td>46.67</td>
</tr>
<tr>
<td>GIBE III</td>
<td>53</td>
<td>1870</td>
<td>35.28</td>
</tr>
</tbody>
</table>

The above table shows the relationship of the installed energy with the Environmental Score of each scheme and demonstrate that the most attractive plant is Gilgel Gibe II, followed by Beles and Gibe III.

It is to be noticed that the hydropower plants have been implemented, by EEPCo, in accordance with the above Environmental Impact Score.
10 ENVIRONMENTAL MANAGEMENT PLAN

10.1 General Considerations
In order to be effective, environmental management must be fully integrated with the overall project management effort at all levels, which itself should be aimed at providing a high level of quality control, leading to a project which has been properly designed, constructed working properly and efficiently throughout its life.

An Environmental and Social Management Plan has been prepared and presented in a separate report. This chapter summarise the recommended plan.

10.2 Pre-Construction Phase
Prior to contractor mobilization and the commencement of construction, environmental management will be concerned with the following principal groups of activities (See Table 10.1):

- Ensuring that all government and funding agency requirements and procedures relating to ESIA are complied with.
- Implementation of land and property acquisition procedures including the payment of compensation.
- Ensuring that the project designs and specifications incorporate appropriate measures to minimise negative impacts and to enhance beneficial impacts.
- Ensuring that the appropriate environmental protection clauses have been included in the contract documents to allow control of actions by the contractor which are potentially damaging to the environment.

The above activities will have to be carried out as part of the preparation of contract documents for the project.

EEPCo is responsible for submitting the ESIA to Environmental Impact statement (ESIA Report) and other competent authorities for evaluation and issuing clearance according to the national procedures.

10.3 Construction Phase
Most of the project environmental management activities will be carried out during the construction phase, since this is when most impacts can be expected to arise. Management will very largely be concerned with controlling impacts which may result from the actions of the Contractor, through enforcement of the construction contract clauses related to protection of the environment as a whole and of the components within it. In this respect, it is important to recognize that successful mitigation of construction impacts can only be achieved if the environmental protection measures, as set out in the construction contract, are properly enforced.

The overall/primary responsibility for construction supervision and contract management, and therefore for environmental management during construction, will lie with the Engineer. The Resident Engineer (RE) will have executive responsibility for ensuring that all site environmental management and monitoring aspects are dealt with promptly and properly. The site supervision staff will be responsible for environmental management and monitoring, and their role in the management chain is crucial if effective impact control is to be achieved.
The RE will be responsible for establishing procedures and mechanisms for effective environmental management and monitoring and will ensure that these are fully incorporated in, and integrated with, the overall construction supervision and monitoring framework. This aspect will cover matters such as the development of checklists of key points which will be monitored on a routine basis during construction and reporting mechanisms for ensuring that appropriate remedial action is taken, should monitoring reveal that this is necessary.

Particular attention will be paid to establishing procedures whereby emergency action can be taken by site staff in the event of actions which may cause immediate and significant environmental damage, for example problems associated with contamination of land, groundwater or surface water through inappropriate handling of contaminating substances.

It is recommended that an Environmental Inspector (EI) be appointed as a member of the construction and also supervision team. The Environmental Specialist would be responsible for reviewing and commenting on environmental aspects of work plans prepared by the Contractor during the mobilization period, as well as in developing site environmental management procedures etc. in collaboration with the RE. During the construction period, the EI would provide advice and assistance to the RE, as and when required, on all aspects of environmental management. He would also be responsible for periodic overviews of environmental monitoring during the construction period and would report directly to the Engineer.

As a Project Developer, EEPCo has the responsibility to be involved with the construction supervision team to see the implementation of this Environmental Management Plan. Therefore, EEPCo must establish a Project level Environmental Management Unit and assign a responsible person to coordinate the environmental management activities.

**10.4 Post-Construction/Operation Phase**

Continued enjoyment of the benefits arising from implementation of the project will only be achieved if effective environmental management is carried out in a timely manner. Table 10.1 sets out, in summary form, the environmental management measures to be taken with regard to controlling the potential impacts which might occur during the pre-construction, construction and operational phases of the Project. The Table also indicates the institutional arrangement (who is responsible for taking the recommended actions) for the execution of the mitigation, management and monitoring plan. However, EEPCo, as a Project Developer of this project, has the overall responsibility for the coordination and implementation of this Environmental Management Plan. EEPCo is responsible to coordinate environmental management and monitoring activities and preparation of regular status reports.
Table 10.1: Environmental Management Framework

<table>
<thead>
<tr>
<th>Action</th>
<th>Responsible body</th>
<th>Comments</th>
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<tbody>
<tr>
<td><strong>Pre-construction phase:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review and submission of ESIA documentation to EPA for evaluation.</td>
<td>EEPCO/Project Developer</td>
<td>All reviews and revisions should be on time, so that an environmental permit can be issued.</td>
</tr>
<tr>
<td>Detailed drawings showing project land acquisition requirements submitted to EEPCO</td>
<td>EPC Contractor</td>
<td>Must be submitted as early as possible to allow that EEPCO has sufficient time for completion of all land acquisition related matters (including implementation of resettlement and compensation).</td>
</tr>
<tr>
<td>Land and property expropriation surveys, assessment, payment of compensation and implementation of RAP to start.</td>
<td>EEPCO and local govt. bodies</td>
<td>Land/property expropriation process and full implementation of RAP must be completed on time, so that the contractor has unimpeded access to the site.</td>
</tr>
<tr>
<td><strong>Construction phase:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of site environmental checklists, reporting procedures etc.</td>
<td>Supervision Consultants’ RE and Environmental Specialist</td>
<td>Must be completed before main construction works commence.</td>
</tr>
<tr>
<td>Review of contractor's plans, method statements etc.</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Review of environmental management plan</td>
<td>Owner’s Engineer and Environmental Specialist</td>
<td>To take place approximately 6 months into the main construction period.</td>
</tr>
<tr>
<td>Site clearance inspection and certification on completion of the works</td>
<td>As above</td>
<td>Carried out on a rolling basis as each major section of work is completed.</td>
</tr>
<tr>
<td><strong>Operation phase:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buffer Area Development and Watershed Management</td>
<td>EEPCO with Wereda and Zonal Level Offices of Agriculture</td>
<td>Regularly check the effectiveness of the recommended and implemented watershed management interventions</td>
</tr>
</tbody>
</table>
11 ENVIRONMENTAL MONITORING PLAN

11.1 General Considerations

Environmental monitoring is an essential tool in relation to environmental management as it provides the basis for rational management decisions regarding impact control. Monitoring should be performed during all stages of the project (namely: construction, commissioning, and operation) to ensure that the impacts are no greater than predicted, and to verify the impact predictions. The monitoring program will indicate where changes to procedures or operations are required, in order to reduce impacts on the environment or local population.

The monitoring program for the present project will be undertaken to meet the following objectives:

- to monitor the environmental conditions of the Omo River and the reservoir as impacted by the Gibe III Hydropower Project;
- to check on whether mitigation and benefit enhancement measures have actually been adopted, and are proving effective in practice;
- to provide a means whereby any impacts which were subject to uncertainty at the time of preparation of the ESIA, or which were unforeseen, can be identified, and to provide a basis for formulating appropriate additional impact control measures;
- to provide information on the actual nature and extent of key impacts and the effectiveness of mitigation and benefit enhancement measures which, through a feedback mechanism, can improve the planning and execution of future, similar projects.

There are two basic forms of monitoring:

- Compliance monitoring, which checks whether prescribed actions have been carried out, usually by means of inspection or enquiries;
- Effects monitoring which records the consequences of activities on one or more environmental components, and usually involves physical measurement of selected parameters or the execution of surveys to establish the nature and extent of induced changes.

It is recommended to carry out both Compliance and Effects monitoring. However, during construction compliance monitoring will play a big role in checking whether recommended impact mitigation and management plans have been carried out or not. This is because most impact controls take the form of measures incorporated in project designs and contract documents, and the extent to which recommendations on these matters, as set out in the ESIA, are complied with, plays a major part in determining the overall environmental performance of the project.

11.2 Construction Phase

Environmental monitoring during the construction phase will comprise two principal groups of activities:

- review of the contractor’s plans, method statements, temporary works designs, and arrangements so as to ensure that environmental protection measures specified in the contract documents are adopted, and that the contractor’s proposals provide an acceptable level of impact control
- systematic observation on a day-to-day basis of all site activities and the contractor’s offsite facilities including quarry and borrow areas, as a check that the contract requirements relating to
environmental matters are in fact being complied with, and that no impacts foreseen and unforeseen are occurring.

The majority of monitoring will comprise visual observations, carried out at the same time as the engineering monitoring activities. Therefore, check monitoring also be carried out on an intermittent basis by the Environmental Inspector.

Site inspections will take place with emphasis on early identification of any environmental problems and the initiation of suitable remedial action. Where remedial actions have been required on the part of the Contractor, further checks will need to be made to ensure that these are actually being implemented to the agreed schedule and in the required form. Each part of the site where construction is taking place needs to be formally inspected from an environmental viewpoint on a regular basis.

The RE will decide on the appropriate course of action to be taken in cases where unsatisfactory reports are received from his field staff regarding environmental matters. In the case of relatively minor matters, advice to the Contractor on the need for remedial action may suffice, but in all serious cases, the RE should either recommend an appropriate course of action to the Engineer, or should issue a formal instruction to the Contractor to take remedial action, depending on the extent of his delegated powers.

In addition to visual observation, it is particularly important that monitoring should also include limited informal questioning of people and local community leaders who live near to the project since they may be aware of matters which are unsatisfactory, but which may not be readily apparent or recognized during normal site inspection visits.

The environmental monitoring plan summarised in Table 11.1 describes the particular resources that will be monitored on a continuing basis through construction and operation of the project and the types of data that will be collected to describe each resource.

Monthly reports prepared by the RE should contain a brief section referring to environmental matters, which summarizes the results of site monitoring, remedial actions which have been initiated, and whether or not the resultant action is having the desired result. The report will also identify any unforeseen environmental problems and will recommend suitable additional actions. Progress meetings with the Contractor will also include a review of environmental aspects.

EEPCo’s EMU has the responsibility to be involved with the construction supervision team to see the implementation of this environmental monitoring plan. The EMU must assign a responsible person to coordinate the environmental monitoring activities on behalf of EEPCo.

11.3 Post-Construction/Operation Phase

Eleven major resource areas have been identified that will be subjects of the Gibe III Hydropower Project’s Environmental Monitoring Programme. The investigations included under each programme are designed to directly evaluate the effects of operation of the Gibe III Hydropower Project on the various resources. Although EEPCo’s EMU will retain administrative and technical direction and management responsibilities for all of the monitoring programmes, as required, certain tasks must be performed by other Agencies.

The principal fields of interest requiring monitoring during operation phase are discussed below.
**Hydrology:** As part of the monitoring process, hydrologic monitoring stations will be established to measure river inflow, stored water volume, volume of water used, downstream river flow, etc. Once the project becomes operational, river hydrology will continue to be monitored to enable adjustment of the operation of the project as required by the uncertainties of the hydrologic regime. Additionally, records of the inflow and outflow from the reservoir will be used in conjunction with water quality data. How the project affects other resources within the Omo River and downstream will also be evaluated. This monitoring primarily will be the responsibility of the Ministry of Water Resources and EMU will coordinate the activities.

**Water Quality Monitoring:** This monitoring program is required to establish the seasonal variation of water quality of the Omo River and its major tributaries (Gibe and Gojeb Rivers) and the reservoir. It will be monitored at a minimum of six locations and these include: on the Gibe and Gojeb Rivers (on both rivers upstream of the reservoir), at three locations along the reservoir and from the outfall. It is recommended that water quality sampling be undertaken at least two times per year in both high and low flow season. It is recommended to subcontract this activity to Addis Ababa University.

**Sediment Monitoring:** Sediment transport in the Gibe, Gojeb and Omo Rivers to address the concern about accumulation of sediment in the reservoir once the dam is completed and the reservoir is impounded. The information will be used to determine the annual volume of sediment transported into the reservoir and if the predicted rate of accumulation is realized after the project becomes operational. This monitoring primarily will be the responsibility of Ministry of Water Resources and EMU will coordinate the activities.

**Aquatic Ecology:** The purpose of this programme is to document how the aquatic community responds to the operation of the Gibe III scheme. Limnological sampling of microflora, micro fauna, aquatic weeds and benthic organisms will be carried out. Periodic inspection of the reservoir and the river in the lower Omo will be carried out. It is recommended to subcontract this activity to Addis Ababa University.

**Fish Stock:** A regular biological sampling of the fish stock, species diversity, abundance and distribution both in the reservoir and the river would be necessary to detect and monitor any changes in the fish stock. Based on the outcome of the monitoring activities, the flow rhythm (of water to be released from the dam) be regulated and synchronised with the biological rhythm of the fish species to enhance or sustain the regular spawning activity of these downstream fishes. It is recommended to monitor the fishing activity and protect the brooding stock from being exposed to heavy fishing pressure as they aggregate at the river mouth and become more vulnerable to fishing.

**Terrestrial Ecology:** The purpose of this programme is to monitor changes in the terrestrial community around the Reservoir and downstream of the Omo River. It is recommended to subcontract this activity to Addis Ababa University.

**Public Health:** The monitoring of public health will focus primarily on the survey and prevalence of vectors in the reservoir and control of malaria, schistosomiasis and other epidemic diseases that may become established in the reservoir area. In addition, periodic survey will be conducted once the reservoir is filled to determine any further remedial measures that may be required to reduce the potential for establishment of mosquito and mollusc population within the reservoir area. It is recommended to jointly carry out this activity with the Ministry of Health or Health Bureau of the Region.

**Social status:** As a part of monitoring activity the social status of the community with regard to health, disease vector, in- and out-migration, the function and performance of the facilities and safeguard measures,
effectiveness of environmental requirements in controlling occupational hazards, waste collection facilities, establishment and function of pit latrines, will be considered during operation phase of the project.

**Compensation and Resettlement:** Changes in economic and social status of compensated and resettled population including livelihood improvement. It is recommended to jointly carryout this activity with EMU and representatives from Regional and Wereda Office.

**Buffer Zone Management:** As part of the environmental management, implementation of Buffer Zone Management programme is recommended. The purpose of this programme will be to monitor the effectiveness of the recommended Buffer Zone management interventions. It is recommended to jointly carryout this activity with the Ministry of Agriculture and Rural Development and Bureau of Agriculture and Rural Development.

**Construction Site Restoration:** This programme will be maintained for only a short duration during the construction period and the cleanup of the construction site. The programme will have the responsibility of ensuring that the construction contractors implement environmental precautions and that the required landscaping and re-vegetation programme are implemented as part of the construction demobilisation process.

### 11.4 Monitoring Framework

Effective monitoring of all stages of the project could be managed through an environmental management team. The principal aim of the environmental management team would be advising the project authorities and local administration about the best practicable means for protecting the environment during all stages of the project’s life span it would provide the project developers and station operation managers with concrete proposals for monitoring the environment, and defined operational procedures for protecting the environment.

The primary responsibility of this monitoring plan is of EEPCo. However, it is recommended that EEPCo involves other Agencies (including EPA) and sub-contractors as required to form the environmental management team.

A public awareness program shall be initiated with emphasis on proper management of soil and forests in the watershed. The goal of education and public awareness is to develop the understanding and active participation of the local community on the program by seeing the direct benefit. It is recommended to provide all facilities (Office and Field) for the EMU staff to promote environmental awareness and protection within the river catchments.

### 11.5 Institutional Strengthening and Training

The proclamation for the Establishment of Environmental Protection Organs No. 295/2002 requires at the Federal level each sectoral ministry to establish in-house Environmental Protection and Management Units to ensure harmony with respect to implementation of the Environmental Proclamations and other environmental protection requirements. This Unit will provide for a lower level inter-sectoral coordination structure.

The establishment of environmental institutions in Ethiopia is still in the early stages of development. Environmental Monitoring Unit (EMU) within EEPCo which is the implementing agency is also a relatively
new office and not well organized. Although EMU currently carry out environmental management and monitoring programs on hydropower projects, the office has serious limitations in undertaking these activities mainly due to the insufficient numbers of trained staff, inadequate budgets, office facilities and equipment.

In view of the key role the power sector is likely to continue to play in the economic development of Ethiopia, there is a need for training to strengthen EMU’s capability in the area of environmental management and monitoring of projects in the water resource sector.

It is recommended to carry out capacity building measures and this appears to be appropriate in relation to the current environmental management and monitoring capabilities within EEPCo and the implementation of several hydropower projects by EEPCo.

Training courses in this field are provided at different institutes and universities; among these are the Environmental Impact Assessment Centre of the University of Manchester (UK) and the Institute for Housing and Urban Development Studies in Rotterdam (the Netherlands). In Nairobi (Kenya), the African Institute of Technology arranges tailored courses in the field of ESIA.
Table 11.1: Environmental Monitoring Framework

<table>
<thead>
<tr>
<th>Action</th>
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<tbody>
<tr>
<td><strong>Construction phase:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of site environmental checklists, reporting procedures etc</td>
<td>RE and EMU</td>
<td>To be completed within six months after the commencement of construction works.</td>
</tr>
<tr>
<td>Review of contractor’s plans, method statements etc</td>
<td>As above</td>
<td>As above</td>
</tr>
<tr>
<td>Commencement of site monitoring</td>
<td>As above</td>
<td>Environmental Inspection by EMU to commence when contractor starts site mobilisation and to continue throughout the construction period.</td>
</tr>
<tr>
<td>Air Quality</td>
<td>As above</td>
<td>Dust levels would be spot-checked near settlements to evaluate effectiveness dust control measures and provide the basis for additional measures (as required).</td>
</tr>
<tr>
<td>Noise and Vibration</td>
<td>As above</td>
<td>Check noise generated by construction activities in the construction areas. Undertake a pre-blast survey of any buildings within 300 m of the blast zone prior to blasting to evaluate structural integrity, potential for damage and provide background for damage claims.</td>
</tr>
<tr>
<td>Water Quality</td>
<td>EMU to subcontract this activity</td>
<td>The pre-construction water quality monitoring program should continue through the construction period at the proposed established sampling sites, with the following modifications: - the monthly sampling regime with its associated list of general water quality parameters should be reduce to quarterly intervals - the metals sampling program should be undertaken once during the construction phase, within 3 to 6 months of the completion of construction activities.</td>
</tr>
<tr>
<td>Natural Terrestrial Environment</td>
<td>As above</td>
<td>Implement 'best management practices' and ensuring that disruption to natural resources is minimized. Maintain casual observations and records of wildlife sightings.</td>
</tr>
<tr>
<td>Communicable Diseases</td>
<td>RE/Contractor/EMU</td>
<td>As part of the construction camp and work force establishment process, awareness creation program should be developed for communicable diseases, including AIDS. Maintain records of work force health and safety status and accidents.</td>
</tr>
<tr>
<td>Waste Disposal</td>
<td>RE/Contractor/EMU</td>
<td>Ensure that waste materials generated during the construction process are disposed of in an appropriate manner.</td>
</tr>
<tr>
<td>Social/Community Monitoring</td>
<td>EMU with local Administration</td>
<td>Evaluate the success of and identify areas for improvement related to resettlement plan. The monitoring program will assess social factors such as: integration of new residents into existing land base and communities; potential conflicts relating to reallocation of land base, etc.</td>
</tr>
<tr>
<td>Review of environmental management and monitoring plan</td>
<td>RE and the Contractor</td>
<td>To take place approximately 6 to 9 months into the main construction period.</td>
</tr>
<tr>
<td>Site clearance inspection and certification on completion of the works</td>
<td>RE</td>
<td>Carried out on a rolling basis as each major section of work is completed.</td>
</tr>
<tr>
<td>Action</td>
<td>Responsible body</td>
<td>Comments</td>
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</tr>
<tr>
<td><strong>Operation phase: The following parameters are to be monitored during the operational phase of the project</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrology</td>
<td>Ministry of Water Resources and EMU</td>
<td>As part of the monitoring process, hydrologic monitoring stations will be established to measure river inflow, stored water volume, volume of water used, etc. Additionally, records of the inflow and outflow from the reservoirs will be used in conjunction with water quality data.</td>
</tr>
<tr>
<td>Sediment</td>
<td>As above</td>
<td>Sediment transport in the Omo River and its major tributaries (Gibe and Gojeb) to address the concern about accumulation of sediment in the reservoirs once the dams are completed and the reservoirs impounded.</td>
</tr>
<tr>
<td>Water Quality</td>
<td>EMU to subcontract this activity</td>
<td>The monthly water quality sampling program should be repeated at the selected sampling locations when reservoir filling is complete. The monthly sampling program should continue for a period of 12 months and metals should be evaluated once every 12 months for a minimum of 5 years after reservoir filling to evaluate and document water quality changes as a result of reservoir ageing and increased application of fertilizer and other agrochemicals within the catchment.</td>
</tr>
<tr>
<td>Aquatic Ecology</td>
<td>EMU to subcontract to Addis Ababa University</td>
<td>In the event that the decision is made to establish a reservoir fishery, a sampling program would be required to assess fish food supplies (planktonic and benthic organisms and forage fish species), reproduction rates, etc. to establish sustainable levels of harvest of the new resource. Limnological sampling of microflora, micro fauna, aquatic weeds and benthic organisms will be carried out.</td>
</tr>
<tr>
<td>Terrestrial Ecology</td>
<td>As above</td>
<td>The purpose of this programme is to monitor changes in the terrestrial community around the reservoirs and downstream of the dam after the project construction is completed.</td>
</tr>
<tr>
<td>Public Health and Water-Related Disease Vectors</td>
<td>EMU and Health Bureau</td>
<td>A program should be established to monitor the proliferation of vectors in the reservoir.</td>
</tr>
<tr>
<td>Reservoir Area Resettlement Support Program</td>
<td>EMU with Regional and local Administrations</td>
<td>A detailed monitoring program would be required to evaluate the success of and resolve conflicts arising from the reservoir area resettlement and support programs. The intent of the program would be to verify that as a minimum the pre-project level of income and livelihood has been re-established and is sustainable after project implementation.</td>
</tr>
<tr>
<td>Buffer Zone Management</td>
<td>EMU with Wereda and Zonal Level Offices of Agriculture</td>
<td>The purpose of this program will be to monitor the effectiveness of the recommended and implemented buffer zone development plan.</td>
</tr>
</tbody>
</table>
12 ENVIRONMENTAL MITIGATION, MANAGEMENT, MONITORING AND TRAINING COSTS

12.1 Implementation Cost of ESMP

The total environmental mitigation, management, monitoring and training costs are summarised in Table 12.1 and amounts to some ETB 445.2 million. This estimate includes the costs for Resettlement Action Plan and downstream mitigations measures. Out of this, approximately ETB 40.5 million will be allocated to cover implementation of the environmental mitigation, management, monitoring programmes described in Chapter 7, 10 and 11 respectively.

It should be noted that no significant increase in construction costs is expected in connection with requiring compliance with environmental protection clauses, since these merely require the contractor to behave in a responsible manner in relation to the environment and in accordance with good construction practice. Costs associated with several environmental mitigation and management plans are integral part of the construction contract (incorporated in unit rates and bill items), and no separate budget is necessary to cover these aspects.

The cost estimate has made adequate provisions for contingencies and it has been considered as a component of the financial requirement of the project.

Brief description of the various cost items are presented below:

1 Environmental Mitigation and Management Cost: Dam and Reservoir

I Buffer area development: This measure is designed to compensate for the loss of natural resources and by developing buffer area and restoring the woodland resources over the steep slopes of the valley through enrichment planting and hillside closure by the user communities for multipurpose uses. The plan also includes creating awareness and initiate community participation in conservation and sustainable utilization of these resources through training. The buffer area development includes compensation for lost grazing area by the community.

II Watershed management: Cost of protecting and rehabilitating forest cover in the Gibe III watershed to assure adequate water discharge with low suspended sediment. It also includes cost of conservation, maintenance and promotion of biological diversity.

III Reservoir fish resources development: To create the opportunity for engagement in commercial fishery. This programme will expand PAPs non-farm income generating opportunity. The cost will cover key inputs and services and these include: access to raw materials and inputs (wooden planks fishing boats and fish collection boat, gill nets, fish box, etc.,) skill training, capacity building, access to credit services, etc. Fisheries development by taking into account present and future fishery potential through study and this include: a regular biological sampling of the fish stock, species diversity, abundance and distribution both in the reservoir and the Omo River.

IV Wildlife conservation initiatives: This is to provide financial assistance for wildlife conservation initiatives around the reservoir and to strengthen national parks and wildlife reserves located downstream of the reservoir.
2 Environmental Mitigation and Management Cost: Downstream Area

I Development of flood recession agriculture: Various interventions are proposed to offset possible negative impacts stemming from possible difficulties in fully implementing designed controlled floods as planned. Together with this measure, more support actions are proposed for recession agriculture and meant to increase productivity and attain self-sufficiency in the lower Omo.

II Irrigated Agriculture: the project would assist the lower Omo population by implementing and promoting small scale irrigation schemes.

III Livestock production: Rangeland development and management, forage improvement and development, improvement of the veterinary services, and improved livestock practices.

IV Fishery development: Expanding and developing the riverine and lake fishery to bring more income and improve the livelihood for the community. This requires inputs in terms of improved technical skill, fishing materials, infrastructure, processing, storage, transport and fish market facilities.

V Socio-economic support programme: Since not only economic opportunities (other than traditional and subsistence farming), but also technical and business skills among the Lower Omo populations are very low. Therefore, they will be supported by the project through training, facilitation and capacity building so that they can set up profitable ventures. In addition to capacity building (at community and Wereda level), the Project would also finance livelihood economy diversification support programme and agriculture in service training for Farmers Training Centre (FTC). Under this programme, cooperatives will be established and capacity building and technical assistance will also be provided.

VI Installation of flow variation acoustic warning system: “alert and danger” posts and acoustic signals shall be provided downstream of the dam to alert/inform about abrupt release of waters to the downstream communities. The cost is estimated to cover 50-100 locations.

VII Food aid during reservoir filling: The food aid is to compensate for the loss of flood recession cropping until such time their source of livelihood has been restored. It will be required during reservoir filling and before the start of controlled flooding.

VIII Establishment of Data Collection and Monitoring Station at Omo Rate: This is a facility from which management, monitoring, technical support and training would be coordinated.

3 Resettlement Action Plan

I Compensation for loss of farmland, houses and other assets: Given their preferences, PAPs will receive cash compensation and/or employment within the project. For loss of productive farmland PAPs will accept cash compensation amounting to forgone benefits of 10 years. Cash compensation for loss of houses and other assets will also be paid to PAPs and this estimate reflects current rebuilding costs.

II Income restoration projects for the PAPs: The income restoration and improvement plan which directly targets PAPs incorporates various component activities including: land-agriculture based strategies (intensification of crop and livestock production through various extension packages), non-farm income restoration strategies (such as small-scale trade, business enterprises, employment opportunities in project construction activities), labour-saving technologies for women (e.g. fuel saving
stoves and grain mills), and special assistance measures for vulnerable groups of PAPs (female-headed households, persons with disability, the elderly, and the poorest of the poor).

III Social-Community Development Project: The communities in the project area will be affected directly and indirectly by the project and these effects require commensurate mitigation, compensation and social development measures. These measures include: public health intervention, improving clean water supply and rural access roads, veterinary clinics and range development and management, etc.

IV Replacement of Affected Infrastructure and Social Services (Reservoir): The associated cost to establish a boat service to replace the affected nine river crossings sites has been estimated and included in the environment cost. Considering the fluctuation of water level of the reservoir (up to 90 m), a permanent infrastructure (wharf) will also be constructed at each boat service site.

V Construction of a bridge across the Gibe: Established river crossing sites (across the Gibe and Omo Rivers) used by the agro-pastoral communities from Hadiya will be submerged. Therefore, to compensate for this loss it is recommended to construct a bridge at one of their major crossing site across the Gibe River and the associated cost has been estimated and included.

VI Cultural Property Protection and Promotion: As a compensation measures for the partial loss of the historical sites known as King Ijajo Kella of Wolayita and King Halala Walls of Dawro, EEPCO will financially assist ARCCH and the Information and Culture Bureau of SNNPR to properly study, document and register these sites as parts of Ethiopian cultural heritage sites. The financial assistance also includes the establishment of view points (at two representative sites) and information centres (with associated services for tourists).

4 Training and Study Tour

Cost of training to strengthen EMU’s capability in the area of environmental management and monitoring and international study tour to hydroelectric plant sites.

In an effort to strengthen institutional capacity and environmental awareness, seminars, workshops and study tours to be organised under this project shall also be open for individuals from concerned ministries and agencies such as Federal MWR, EPA, Oromiya’s office of Environmental protection, Regional Bureau of Agriculture and Rural Development, Regional and We reda level Environment departments, etc. The objectives of the seminar-workshops are to ensure environmental awareness, knowledge and skill for the implementation of this ESMP.

5 Capacity Building and Procurement

Cost to cover the establishment of a fully furnished and equipped monitoring station and a mobile laboratory has been included.

6 Environmental Monitoring

To ensure that monitoring is adequately funded, costs to carryout a comprehensive environmental monitoring plan has been included. This will provide the basis for rational management decisions regarding impact control.

I Baseline Monitoring: A monitoring regime will begin at the earliest convenience to be established against which changes during construction, and on into operation, can be assessed. EEPCO will set-up
an environmental and social monitoring system and establish a databases as well as support system for
data storage and dissemination. Such system will assist for general state of the environment reporting.

II Monitoring during construction: Most of the monitoring will comprise visual observations during site
inspection and will be carried out at the same time as the engineering monitoring activities. However,
factors to be monitored include: air quality, noise, water quality, soil erosion, waste management,
natural vegetation, equipment, fuelling and maintenance, health and safety, cultural and historical
assets, social status, wildlife, etc.

III Monitoring during operation: The principal fields of interest requiring monitoring (in the river and
reservoir) during operation include: hydrology, riparian release, reservoir sedimentation (annual
volume of sediment transported into reservoir), water quality (water quality at dam discharge and at
various points along the reservoir and river), aquatic ecology, fisheries (species, populations. etc.),
wildlife (species, distribution, numbers), public health and disease vectors, safety, compensation and
resettlement, buffer area management, construction site restoration, etc.

7 Environmental Audit

The cost of systematic evaluation of the environmental and social performance of the project will be covered by
the project.

12.2 Funding Mechanism

The total funding needed for identified activities is presented in Table 12.1.

EEPCO is responsible for providing these resources from the national budget for all activities related to the
implementation of environmental mitigation, management, monitoring and training programmes. Therefore,
EEPCO is responsible to set aside marginal benefits from the exploitation of the hydropower development
for financing the long term financial needs of the social and environmental needs of the area such as
environmental mitigation and management, resettlement, social development projects, development and
management of buffer zones and watershed, environmental monitoring, capacity building and training, etc.

With this, EEPCO would demonstrate its commitment to its own environmental policy “to work towards
realizing the objectives of sustainable development and continual improvements in its environmental
performance”. It will also decrease its short- and long-term liabilities and improve its public image by complying
with existing national environmental regulations and ensuring that construction work does not adversely affect
the environment and social community resources.

12.3 Implementation Schedule

An indicative schedule for implementation of the proposed environmental mitigation, management, monitoring,
RAP, Training and study tour, has been prepared and presented in Figure 12.1.
Figure 12.1: Schedule for Implementation of Environmental and Social Mitigation, Management and Monitoring Plan

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### Table 12.1: Summary of estimated environmental mitigation, monitoring, RAP and training cost

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<td>2.1.1</td>
<td>Survey, design and tender document preparation</td>
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<td>Implementation of the irrigation schemes</td>
<td>32,000</td>
<td>8,000</td>
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<td>4,500</td>
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<td>2.2</td>
<td>Livestock production</td>
<td></td>
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<td>Livestock forage production on individual irrigated agriculture holding</td>
<td>4,000</td>
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<td>2.2.2</td>
<td>Irrigated forage development - further in-land along the Omo River (Livestock Enterprises)</td>
<td>12,000</td>
<td>1,000</td>
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<td>2.2.3</td>
<td>Range development and management in the Omo River Delta</td>
<td>6,000</td>
<td>1,000</td>
<td>1,000</td>
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<tr>
<td>2.2.4</td>
<td>Improved livestock practices</td>
<td>8,000</td>
<td>1,000</td>
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</tr>
<tr>
<td>2.3</td>
<td>Fishery development</td>
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<td>500</td>
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</tr>
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<td>2.4</td>
<td>Socio-economic support programme</td>
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<td>Livelihood economy diversification support programme</td>
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<td>Agriculture in service training for Farmers Training Centre (FTC)</td>
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<td>Wereda institution strengthening programme</td>
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<td>6,000</td>
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<td>Facilitate the creation of cooperatives through capacity building and technical assistance</td>
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<td>2.4.5</td>
<td>Community awareness, regular information meetings and conflict prevention and resolution programme</td>
<td>8,500</td>
<td>1,500</td>
<td>2,000</td>
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<td>Install flow variation acoustic warning system (to inform about abrupt realise of waters to the downstream communities)</td>
<td>50,000</td>
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<td>Food aid during reservoir filling (for loss of recession agriculture)</td>
<td>50,000</td>
<td>30,000</td>
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<td>2.7</td>
<td>Establishment of Monitoring Station at Omo Rate</td>
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<td>Operation phase</td>
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<td>3</td>
<td>Environmental Monitoring</td>
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<td>3.1</td>
<td>Baseline Monitoring</td>
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<td>Environmental Monitoring (during construction)</td>
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<td>Water quality monitoring (construction site)</td>
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<td>250</td>
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<td>3.2.2</td>
<td>Public health monitoring (construction area)</td>
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<td>100</td>
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<td>3.2.3</td>
<td>Fishery and aquatic resources monitoring</td>
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<td>300</td>
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<td>3.2.4</td>
<td>Aquatic flora and fauna monitoring</td>
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<td>3.2.5</td>
<td>Wildlife resources and their habitat</td>
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<td>200</td>
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<td>3.2.6</td>
<td>Noise and air quality</td>
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<td>200</td>
<td>200</td>
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<td>3.2.7</td>
<td>Socio-economic monitoring</td>
<td></td>
<td>250</td>
<td>50</td>
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<td>3.3</td>
<td>Environmental Monitoring (During Operation for 2-5 years)</td>
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<td>200</td>
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<td>Hydrological and climatic monitoring (continuous)</td>
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<td>3.3.2</td>
<td>Sediment monitoring (continuous)</td>
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<td>3.3.3</td>
<td>Public health (Reservoir area)</td>
<td></td>
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<td>3.3.4</td>
<td>Water quality (reservoir and downstream)</td>
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<td>100</td>
</tr>
<tr>
<td>3.3.5</td>
<td>Aquatic resources (reservoir and downstream)</td>
<td></td>
<td>500</td>
<td>100</td>
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<tr>
<td>3.3.6</td>
<td>Fishery resources (reservoir and downstream)</td>
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<td>500</td>
<td>100</td>
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<td>3.3.7</td>
<td>Wildlife resources (Buffer area)</td>
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<td>Land use and land cover (Buffer area and lower Omo)</td>
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<td>500</td>
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<td>Biodiversity assessment (Reservoir and Lower Omo)</td>
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<td>Socio-economic monitoring (around the reservoir and downstream areas)</td>
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<td></td>
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<td>Resettlement Action Plan</td>
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<td>Compensation for loss of assets</td>
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<td>Compensation for loss of farmland (annual crops)</td>
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<td>11,800</td>
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<td>Compensation for loss of perennial crops and other trees</td>
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<td>8,187</td>
<td>7,970</td>
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<td>Compensation for houses and other structures</td>
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<td>3,639</td>
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<td>Replacement of Affected Infrastructure and Social Services (Reservoir)</td>
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<td>Establishing boat services at 5 river crossing points</td>
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<td>Construction of rural access roads</td>
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<td>Construction of a bridge across the Gibe (for agro-pastoralist communities)</td>
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<td>Social-Community Development Project</td>
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<tr>
<td>4.3.1</td>
<td>Establishment of clinic for each affected woreda</td>
<td></td>
<td>5,500</td>
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<td>4.3.2</td>
<td>Establishment of veterinary clinic for each affected woreda</td>
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<td>4.3.3</td>
<td>Water supply scheme per affected woreda</td>
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<td>Livestock Feed improvement</td>
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<td>4.3.7</td>
<td>Labour-Saving Technologies for Women</td>
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<td>Special Assistance for Vulnerable Groups</td>
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<td>Estimated Cost (birr)</td>
<td>Year</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Construction phase</td>
<td>Operation phase</td>
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<td>Cultural Property Protection</td>
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<td>Initiate research and documentation about the Historic walls</td>
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<td>Establishment of viewpoints for tourists with information desk and catering</td>
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<td>3,000</td>
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<td>4.5</td>
<td>Evaluation and monitoring</td>
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<td><strong>102,195</strong></td>
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<td>Capacity Building and Procurement</td>
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<td>Laboratory instrument and equipment</td>
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<td>Vehicles</td>
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<td>Office equipment and computers</td>
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<td></td>
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<td>6</td>
<td>Training and Study Tour</td>
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<td>6.1</td>
<td>In-service training and technical assistance</td>
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<td>1,000</td>
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<tr>
<td>6.2</td>
<td>Short-term overseas workshops, site visit and training</td>
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<td>3,500</td>
<td>1,000</td>
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<td>6.3</td>
<td>Agriculture extension team training (around reservoir area)</td>
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<tr>
<td>6.4</td>
<td>Awareness creation</td>
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<td><strong>Sub-total of - 6</strong></td>
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<td><strong>5,100</strong></td>
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<td>7</td>
<td>Environmental audit</td>
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<td><strong>GRAND TOTAL (1+2+3+4+5+6+7)</strong></td>
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<td>8</td>
<td>ADMINISTRATION COST (5%)</td>
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<td>9</td>
<td>CONTINGENCY (10%)</td>
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<td><strong>GRAND TOTAL</strong></td>
<td></td>
<td><strong>445,150</strong></td>
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</tr>
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</table>
13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

The key potentially beneficial impacts associated with implementation of the Gibe III Project are related to the post-construction phase and include: power generation at low CO₂- emission rates (i.e. 90,000 t/y compared with 4,500,000 t/y which an equivalent thermo power plant produces), prospects to export power, rural electrification, regulation of the river flow for irrigation, and local income-generation during construction, etc. The creation of additional water bodies would also have a positive effect by significantly increasing the fishery potential in the reservoir area. Besides the above, major benefits would be induced by the regulation of the river flow in the downstream lower Omo River valley in terms of public health (reduction of water logging that would facilitate the control of malaria, tripanosomiasis and other water-borne diseases).

The presence of Gibe III reservoir will provide flood protection (will reduce floods both in peak and in frequency) to downstream areas. As a result, the damage due to floods like loss of crops, dwellings and the suffering and possibly death of affected people will reduce. Safety and infrastructure protection from floods (the 2006' floods have caused in the area hundreds people and thousand animals dead besides 15,000 displaced population, with an estimate of over 17 million US$ of works needed for rehabilitation). With this regulation, areas prone to frequent flooding can be used for agricultural purposes.

The regulation of the flow will also make the river navigable all year round. Besides its leisure time use, the possibility of a water route could also involve new commercial relationship between villages and inhabited zones and all the way to Lake Turkana in Kenya which are currently separated from great distance or difficult connections, eventually permitting the improvement of the economical life of the interested Weredas. This will be a shorter and most likely cheaper route for export of agricultural product and livestock in the region. This is considered like an interesting tourism activities by the National Park Authorities, related to foreign and local people spare time.

Several of the potential adverse environmental impacts will be short-term because they stem from ground disturbance, operation of equipment and housing of the labour force during construction therefore impacts could be controlled within acceptable limits, provided that appropriate mitigation and compensation measures are adopted. There are, however, a number of unavoidable aspects of project implementation and operation, which will have some adverse impacts and related to reservoir impounding, land take requirement to accommodate the different project facilities and change in the river flow, i.e.:

- Creation of the reservoir would result in the loss of some 17,158 ha of woodland on the hillslopes of the valley and 1,839 ha of narrow riparian vegetation along the river and streams;
- The project (reservoir, EEPCO’s permanent camp and the Chida-Sodo road realignment) will affect a total of 355 households, about 188.94 ha of privately owned land of which 138.7 ha is farmland, 47 residential housing units and 71,852 perennial crops and other trees;
- The historical sites known as King Ijajo Kella and King Halala Walls will be partially affected by the reservoir. The sections that will be flooded are less than 2% of the total lengths and those sections are not unique in type and location.
The downstream flow regularization, following project implementation, will represent in general terms an overall long-term environmental and human stabilizing and developmental factor, the prevailing social settings and traditional cultural context as well as the present pattern of utilization of natural resources in the Lower Omo would not continue to take place unhindered to the current level and with the same (traditional) modalities if appropriate mitigation measures, as planned, are not deployed and secured on a permanent basis.

In the medium to long-term main positive consequences may be expected from Gibe III Hydroelectric Project Development, first of all the annual flow regulation, in the Omo River, will avoid both disastrous floods and drought extremes and their consequences on the physical, natural, and socio-economic environment, as well as the stabilization of riverbanks, potentially increases the overall biodiversity values of fluvial and delta natural environments, and reduces the waterlogging and water-borne diseases downstream impoundment.

Furthermore, indirect consequences (potentialities) in terms of enhanced rural development opportunities such as infrastructures and electrification, road and river transportation, settled irrigation agriculture, modern fisheries and tourism developments may also be expected, representing a unique opportunity to be seized for sustainable amelioration of local living conditions and poverty alleviation.

The foreseen mitigation actions are designed to allow human activities (recession agriculture, animal husbandry and fisheries) to continue on the same scale as at present; a level which, at least in the case of agriculture, does not however guarantee self sufficiency in production.

In this regard the Project represents a real opportunity to sustainably develop agricultural technologies for both rainfed and irrigated cropping, thus aiming at achieving adequate productivity to meet local demand.

Costs for implementing the environmental mitigation, management and monitoring programmes have been estimated and the total costs amount to some ETB 445.2 million or about 40.5 million USD. It should be noted that no significant increase in construction costs is expected in connection with requiring contractor’s compliance with environmental protection clauses, since these merely require the contractor to behave in a responsible manner in relation to the environment and in accordance with good construction practice. The final cost of the environmental mitigation, management and monitoring plan will be considered as a component of the financial requirements of the project.

The Gibe III Hydropower Project is feasible, indeed exceptionally attractive and therefore such a worthwhile scheme, which will bring net benefits to the nation in general and the local communities in particular, should be implemented.

In the following, a number of recommendations are made as the project has moved towards implementation.

13.2 Recommendations

13.2.1 Follow-Up Programmes

A follow-up programme is recommended to analyse the overall impacts of the project implementation and operation. This would serve to verify that prediction of impact put forward in the planning stages are as expected and will detect any unanticipated effects. Hence, corrective measures could be undertaken before
irrevocable impacts have occurred. Information gathered from these programmes would also be used as input to refine future designs.

The proposed programmes would incorporate:

- Environmental management plan as presented in Section 9;
- Environmental monitoring plan as presented in Section 10;
- Site Environmental Management Plans; and
- Interim reports including: progress reports, Site Inspection Reports, Completion Reports, etc.

13.2.2 Public Consultation and Disclosure

Public Consultation and Disclosure (PCD) plays a key role in enabling the public to participate in the planning of the Project. As of the middle of 2006, 2007 and 2008, there have been more than 30 public consultation and participation briefings and meetings, which have taken place at the local, regional, and national levels. Dialogue has been established with stakeholders who are directly or indirectly involved in the Project. The PCD has been carried out to ensure that stakeholders’ concerns, experiences and recommendations, especially from affected persons, are integrated in the design, planning and implementation of the Project; and increasing public awareness and understanding of the Project; especially on mitigation measures to reduce impacts and improve the livelihood of the affected people. In the consultations, efforts have been made to include women and to encourage their participation.

It is imperative that this process continue and that local resident’s feel that they are involved in the project and that their views and concerns are being adequately considered as input into the project planning and implementation process.

During the construction phase it is recommended that the Contractor discloses information regarding construction progress to the stakeholders in collaboration with EEPCo and local authorities. Grievance resolution mechanisms should be put in place to ensure that potential problems are addressed promptly and efficiently.
14 REFERENCES

34 Jackson D. and Marmulla G. The Influence of Dams on River Fisheries Prepared for Thematic Review II.1: Dams ecosystem functions and environmental restoration - www/dams.org
41 National Meteorological Services Agency, NMSA, 1996. A map showing mean annual rainfall of Ethiopia averaged over the last five years (unpublished).


Web sites

www.fao.org/documents/show
ANNEXES

ANNEX 1:  FISH DIVERSITY IN THE OMO - TURKANA SYSTEM

(within the limits of Ethiopia)

<table>
<thead>
<tr>
<th>Family</th>
<th>Genera</th>
<th>Species</th>
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<tbody>
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<td>1. Polypteridae - bichirs</td>
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</tr>
<tr>
<td>2. Osteoglossidae - African bonytongue</td>
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</tr>
<tr>
<td>3. Mormyridae - elephant fishes</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>4. Gymnarchidae - aba</td>
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</tr>
<tr>
<td>5. Characidae - characins</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>6. Distichodontidae - purus</td>
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</tr>
<tr>
<td>7. Citharinidae - abeel</td>
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<td>1</td>
</tr>
<tr>
<td>8. Cyprinidae - carps</td>
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<td>23</td>
</tr>
<tr>
<td>9. Balitoridae - African stony loach</td>
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<td>1</td>
</tr>
<tr>
<td>10. Bagridae - bagrid catfishes</td>
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<td>5</td>
</tr>
<tr>
<td>11. Schilbeidae - schilbeid catfishes</td>
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<td>3</td>
</tr>
<tr>
<td>12. Amphiliidae - loach catfishes</td>
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<td>1</td>
</tr>
<tr>
<td>13. Clariidae - airbreathing catfishes</td>
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</tr>
<tr>
<td>14. Malapteruridae - electric catfishes</td>
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<td>15. Mochokidae - squeakers</td>
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<tr>
<td>16. Cyprinodontidae - toothcarp, killifishes</td>
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<tr>
<td>17. Centopomidae - Nile perch</td>
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<td>2</td>
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<tr>
<td>18. Cichilidae - cichlids</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>19. Teraodontidae - puffer</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42</strong></td>
<td><strong>79</strong></td>
</tr>
</tbody>
</table>

Source: Golubtsov and Mina, 2003

Fish species list of the Omo River basin (from Baron et.al 1997)

**Characidae**
1. Alestes macrolepidotus (Valenciennes, 1849)
2. Alestes dentex
3. Brycinus ferox
4. Brycinus macrolepidotus
5. Brycinus minutus
6. Brycinus nurse
7. Hydrocynus forscalii
8. Micralistes elongatus

**Cyprinidae**
9. Barbus arambourgi
10. Barbus bynni
11. Barbus intermedius (Ruppell, 1849)
12. Barbus paludinosus (Peters, 1852)
13. Barbus prince
14. Barbus werneri
15. Chelaethiops bibie
16. Raiamas loati (Boulenger, 1901)
17. Labeo forskalii (Ruppell, 1835)
18. L. horie
19. L. coubie
20. L. niloticus
21. L. cylindricus (Peters, 1852)
22. Leptocypris niloticus
23. Neobola bottegi
24. Neobola stellae
25. Garra quadrimaculata (Ruppell, 1836)
26. G. dembeensis (Ruppell, 1836)

**Balitoridae**
27. Nemacheilus abyssinicus (Boulenger, 1902)

**Centropomidae**
28. Lates niloticus
29. Lates longispinnis

**Schilbidae**
30. Schilbe mystus
31. Schilbe intermedius
32. Schilbe uranoscopus

**Bagridae**
33. Aucheloglanis occidentalis
34. Aucheloglanis bicutatus
35. Chrysichthys auratus
36. Bagrus bajad
37. Bagrus docmak

**Mormyridae**
38. Hyperopesus bebe
39. Marcusenius cyprinoides
40. Mormyrops anguilloides
41. Mormyrus caschive
42. M. kannume
43. Pollimyrus isidori
44. Pollimyrus petherici

**Mochokidae**
45. Chilogalnis niloticus
46. Mochokus niloticus
47. Synodontis schall
48. S. serratus
49. S. frontosus
50. S. sorex

**Tetraodontidae**
51. Tertraodon lineatus

**Distichodontidae**
52. Distichodus niloticus
53. Nannocharax niloticus

**Cichlidae**
54. Thoracochromis macconneli
55. Thoracochromis rudolfianus
56. Thoracochromis turkanae
57. Hemichromis letourneuxi
58. Oreochromis niloticus
59. Sarotherodon galilaeus
60. Tilapia zillii

Clariidae
61. Heterobranchus longifilis
62. Clarias gariepinus

Malaptereridae
63. Malapterurus electricus

Citharinidae
64. Citharinus citharus

Amphiliidae
65. Andesonia leptura

Cyprinodontidae
66. Aplocheilichthys jeanneli
67. Aplocheilichthys rudolfianus

Polypteridae
68. Polypterus bichir
69. Polypterus senegalus

Gymnarchus
70. Gymnarchus niloticus

Osteoglossidae
71. Heterotis niloticus
## ANNEX 2: LIST OF SOME WILDLIFE AND BIRD SPECIES AROUND GIBE III RESERVOIR

### Annex 2.1: List of Some Wildlife Species in and around Gibe III Reservoir Area

<table>
<thead>
<tr>
<th>The Species English Common Name</th>
<th>The Species Scientific Name</th>
<th>The Sample Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Omo Bridge</td>
</tr>
<tr>
<td>1 Anabis Baboon</td>
<td>Papio anubis</td>
<td>✓</td>
</tr>
<tr>
<td>2 Black &amp; white Colobus</td>
<td>Colobus guereza</td>
<td>✓</td>
</tr>
<tr>
<td>3 Grevet Monkey</td>
<td>Cercopithecus aethiops</td>
<td>✓</td>
</tr>
<tr>
<td>4 Common Bush Buck</td>
<td>Tragelaphus scriptus</td>
<td>✓</td>
</tr>
<tr>
<td>5 Leopard</td>
<td>Panthera pardus</td>
<td>✓</td>
</tr>
<tr>
<td>6 Hyaena (Spotted)</td>
<td>Crocuta crocuta</td>
<td>✓</td>
</tr>
<tr>
<td>7 Warthog</td>
<td>Phacochoerus aethiopicus</td>
<td>✓</td>
</tr>
<tr>
<td>8 Duiker</td>
<td>Sylvicapra sp.</td>
<td>✓</td>
</tr>
<tr>
<td>9 Lion</td>
<td>Panthera leo</td>
<td>✓</td>
</tr>
<tr>
<td>10 Hare</td>
<td>Lepus spp.</td>
<td>✓</td>
</tr>
<tr>
<td>11 Hippopotamus</td>
<td>Hippopotamus amphibious</td>
<td>-</td>
</tr>
<tr>
<td>12 Lesser kudu</td>
<td>Tarage laphus imberbis</td>
<td>✓</td>
</tr>
<tr>
<td>13 Crocodile</td>
<td>Crocodylus niloticus</td>
<td>✓</td>
</tr>
<tr>
<td>14 Greater Kudll</td>
<td>Tragelaphus strepsiceros</td>
<td>-</td>
</tr>
<tr>
<td>15 Serval Cat</td>
<td>Felis serval</td>
<td>-</td>
</tr>
<tr>
<td>16 Mongoose</td>
<td>Herpestes sp.</td>
<td>✓</td>
</tr>
<tr>
<td>17 Buffalo</td>
<td>Syncerus caffer</td>
<td>-</td>
</tr>
<tr>
<td>18 Porcupine</td>
<td>Hystrix cristata</td>
<td>✓</td>
</tr>
<tr>
<td>19 Common Jackal</td>
<td>Canis aureus</td>
<td>✓</td>
</tr>
</tbody>
</table>
Annex 2.2: Common name of some Somali-masai biome and some other common birds species of Omo River

1. Pale Chanting Goshawk
2. Vulturine Guineafowl
3. D’Arnaud’s Barbet
4. Red & Yellow Barbet
5. Red-winged Bush Lark
6. Pink - Breasted Lark
7. Three streaked Tchagra
8. Taita Fiscal
9. Pale Prinia
10. Smaller Black - bellied Sunbird
11. Donaldson Smith’s Sparrow Weaver
12. Magpie Starling
13. Red napped Bush shirike
14. Bare - eyed Thrush
15. Boram Citicola
16. Grey - headed Silver bill
   (In dense Undergrowth)
17. Black - ramped Waxbill
18. Quail Plover
20. Dusky Babbler
21. Violet wood hoopoe
22. Allen’s Grallinule
23. Green - Blacked Heron
24. Egyptian plover
25. Pel’s Fishing owl
26. Snowy - headed Robinchat in revenue forest
27. African crakes (one of the places) in the south of Ethiopia where they have been found
List of Birds Encountered in the Study Area

<table>
<thead>
<tr>
<th>Family</th>
<th>English Names</th>
<th>Scientific Names</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Scopidae</td>
<td>Hammer kop</td>
<td>Scopus umbreta</td>
</tr>
<tr>
<td>2. Threskirnithidae</td>
<td>Hadada ibis</td>
<td>Bostychia hegedash</td>
</tr>
<tr>
<td>3. Accipitridae</td>
<td>Black Kite</td>
<td>Milvus migrans</td>
</tr>
<tr>
<td>4. Accipitridae</td>
<td>Pale chanting Goshawk</td>
<td>Melierax canorus</td>
</tr>
<tr>
<td>5. Numididae</td>
<td>Helmeted Guinea fowl</td>
<td>Numida meleagaris</td>
</tr>
<tr>
<td>6. Otidida</td>
<td>Black-bellied Bustard</td>
<td>Eupodotis melanogaster</td>
</tr>
<tr>
<td>7. Solopacidae</td>
<td>Common Sandpiper</td>
<td>Actitis hypoleucos</td>
</tr>
<tr>
<td>8. Columbidae</td>
<td>Red-eyed dove</td>
<td>Streptopelia Semitorquata</td>
</tr>
<tr>
<td>9. Columbidae</td>
<td>Loughing Dove</td>
<td>Streptopelia senegalensis</td>
</tr>
<tr>
<td>10. Columbidae</td>
<td>Ring-necked Dove</td>
<td>S.capicola</td>
</tr>
<tr>
<td>11. Psitacidae</td>
<td>Orange-bellied parrot</td>
<td>Poicepholus rufiventris</td>
</tr>
<tr>
<td>12. Musophagidae</td>
<td>White-cheeked Touraco</td>
<td>Touraco leucotis</td>
</tr>
<tr>
<td>13. Cuculidae</td>
<td>African Cuckoo</td>
<td>Cuculus gularis</td>
</tr>
<tr>
<td>14. Colidae</td>
<td>Speckled Mouse Bird</td>
<td>Colius striatus</td>
</tr>
<tr>
<td>15. Alcedinidae</td>
<td>Malachite King Fisher</td>
<td>Alcedo cristata</td>
</tr>
<tr>
<td>16. Trogonidae</td>
<td>Narina Trogon</td>
<td>Apaloderma narina</td>
</tr>
<tr>
<td>17. Meropidae</td>
<td>Little Bee-eater</td>
<td>Merops pusiilus</td>
</tr>
<tr>
<td>18. Phoeniculidae</td>
<td>Red-billed wood Hoopoe</td>
<td>Phoeniculus purpureus</td>
</tr>
<tr>
<td></td>
<td>Silvery- cheeked</td>
<td>Bycanistes brevis</td>
</tr>
<tr>
<td>20. Picidae</td>
<td>Nubian wood pecker</td>
<td>Campethera nubica</td>
</tr>
<tr>
<td>21. Motacillidae</td>
<td>Yellow wagtail</td>
<td>Motacilla flava</td>
</tr>
<tr>
<td>22. Turdidae</td>
<td>West African Thrush</td>
<td>Turdus Pelios</td>
</tr>
<tr>
<td>23. Turdidae</td>
<td>White-crowned Robin chat</td>
<td>Cassypha albicapilla</td>
</tr>
<tr>
<td>24. Turdidae</td>
<td>Spotted Palm Thrush</td>
<td>Cichaladusa guttata</td>
</tr>
<tr>
<td>25. Monaciildae</td>
<td>Paradise Fly catcher</td>
<td>Terpsiphone viridis</td>
</tr>
<tr>
<td>26. Timalidae</td>
<td>Brown Babbler</td>
<td>Turdoides piebejus</td>
</tr>
<tr>
<td>27. Nectarimidiae</td>
<td>Yellow-bellied sun bird</td>
<td>Nectarinia venusta</td>
</tr>
<tr>
<td>28. Nectarimidiae</td>
<td>Beautiful Sunbird</td>
<td>N.pulchella</td>
</tr>
<tr>
<td>29. Malacoantidae</td>
<td>Tchagra sp.</td>
<td>Shirke Malacoonotus blanchoti</td>
</tr>
<tr>
<td>30. Sturnidae</td>
<td>Greater Blue- eared starling</td>
<td>Lamprotornis chalybaeus</td>
</tr>
<tr>
<td>31. Sturnidae</td>
<td>Yellow – billed Oxpecker</td>
<td>Buphagus africanus</td>
</tr>
</tbody>
</table>
### ANNEX 3: LIST OF PERSONS CONTACTED AND INSTITUTIONS VISITED

#### List of Persons Contacted and Institutions Visited

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Organization</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ato Mesele Fischa</td>
<td>Basin Development Studies Department Ministry of Water Resources</td>
<td>Head of the Department</td>
</tr>
<tr>
<td>2</td>
<td>Ato Solomon Kebede</td>
<td>Environmental Protection Authority</td>
<td>Head, Environmental Impact Assessment Service</td>
</tr>
<tr>
<td>3</td>
<td>Ato Girma Demissie</td>
<td>Environmental Monitoring Unit, EEPCo</td>
<td>Head of the Department</td>
</tr>
<tr>
<td>4</td>
<td>Ato Yohannes Yoseph</td>
<td>Environmental Monitoring Unit, EEPCo</td>
<td>Environmentalist</td>
</tr>
<tr>
<td>5</td>
<td>Mr. Ettore Romagnol</td>
<td>Electro Consult</td>
<td>Power Environmentalist</td>
</tr>
<tr>
<td>6</td>
<td>Mr. Michele Tonioli</td>
<td>Electro Consult</td>
<td>Civil Works Specialist</td>
</tr>
<tr>
<td>7</td>
<td>Mr. Lorenzo Eccher</td>
<td>Electro Consult</td>
<td>Hydrology and Reservoir Operation Specialist</td>
</tr>
<tr>
<td>8</td>
<td>Mr. Carlo Boldo</td>
<td>Electro Consult</td>
<td>Civil Works Designer</td>
</tr>
<tr>
<td>9</td>
<td>Mr. Philipe De Felix</td>
<td>Coine et Bellier</td>
<td>Economic and Financial Analyst</td>
</tr>
<tr>
<td>10</td>
<td>Ato Tekle Demissie</td>
<td>Wereda Council, Genna Bossa Wereda</td>
<td>Chief administrator</td>
</tr>
<tr>
<td>11</td>
<td>Ato Kassahun Ayuba</td>
<td>Health desk, Genna Bossa Wereda</td>
<td>Desk Head</td>
</tr>
<tr>
<td>12</td>
<td>Ato Taybelo Shonko</td>
<td>Office of Agricultural and Rural Development, Genna Bossa Wereda</td>
<td>Head of the office</td>
</tr>
<tr>
<td>13</td>
<td>Ato Zekarias Sana</td>
<td>Office of Capacity Building, Genna Bossa Wereda</td>
<td>Office Head</td>
</tr>
<tr>
<td>14</td>
<td>Ato Akalu Dinku</td>
<td>Genna Bossa Wereda</td>
<td>Justice office Chief</td>
</tr>
<tr>
<td>15</td>
<td>Ato Beyene Gezimu</td>
<td>Youth and Sport desk, Genna Bossa Wereda</td>
<td>Desk Head</td>
</tr>
<tr>
<td>16</td>
<td>Ato Odocha Kuba</td>
<td>Wereda Council, Kindo Koyisha Wereda</td>
<td>V/ Chief Administrator</td>
</tr>
<tr>
<td>17</td>
<td>Ato Getachew Balcha</td>
<td>Chief administrator office, Kindo Koyisha Wereda</td>
<td>Head of Chief administrator office</td>
</tr>
<tr>
<td>18</td>
<td>Ato Mesele Taye</td>
<td>Office of Agricultural and Rural Development, Kindo Koyisha Wereda</td>
<td>Office Head</td>
</tr>
<tr>
<td>19</td>
<td>Ato Lemaro Banga</td>
<td>Kindo Koyisha Wereda</td>
<td>Administration service head</td>
</tr>
<tr>
<td>20</td>
<td>Ato Negatu Getachew</td>
<td>Rural development coordination office, Kindo Koyisha Wereda</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Ato Medhin Mamo</td>
<td>Wereda Council, Loma Wereda</td>
<td>V/administrator</td>
</tr>
<tr>
<td>22</td>
<td>Ato Girma Belayneh</td>
<td>Rural development coordination office, Loma Wereda</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Ato Lemma Bekele</td>
<td>Youth and sport office, Loma Wereda</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Ato Solomon Ayele</td>
<td>Office of Agriculture and Rural Development, Loma Wereda</td>
<td>V/head</td>
</tr>
<tr>
<td>25</td>
<td>Ato Tadese Unde</td>
<td>Wereda Council, Loma Wereda</td>
<td>Information officer</td>
</tr>
<tr>
<td>26</td>
<td>Ato Mesele Taye</td>
<td>Office of Agricultural and Rural Development, Kindo Koisha Wereda</td>
<td>Head of the Agriculture Desk</td>
</tr>
<tr>
<td>27</td>
<td>Ato Hailemichael Megabo</td>
<td>Modula Town, Timbaro Wereda</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Mamo Landebo</td>
<td>Administration Office, Soro Wereda,</td>
<td>Project Evaluation and monitoring expert</td>
</tr>
<tr>
<td>29</td>
<td>Desalegn Dawit</td>
<td>Office of Rural Development Bololso Sore Wereda</td>
<td>Agriculture Expert</td>
</tr>
<tr>
<td>30</td>
<td>Petros Lamenjo</td>
<td>Office of Agriculture and Rural Development, Kacha Bira Wereda</td>
<td>Agriculture Expert</td>
</tr>
<tr>
<td>31</td>
<td>Tefera Meskele</td>
<td>Wereda Administration Office, Bolos Sore Wereda</td>
<td>Head of the Office</td>
</tr>
<tr>
<td>32</td>
<td>Seba Seta</td>
<td>Office of Youth and Sport</td>
<td>Head of the Office</td>
</tr>
<tr>
<td>33</td>
<td>Belete Lembebo</td>
<td>Office of Agriculture and Rural Development</td>
<td>Head of the Office</td>
</tr>
<tr>
<td>34</td>
<td>Selamo Araso</td>
<td>Office of Agriculture and Rural Development</td>
<td>Agriculture Expert</td>
</tr>
<tr>
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<td>Organization</td>
<td>Responsibility</td>
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<tr>
<td>----</td>
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<td>---------------------------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>39</td>
<td>Petros Lamejo</td>
<td>Office of Agriculture and Rural Development</td>
<td>Deputy Head</td>
</tr>
<tr>
<td>40</td>
<td>Petros Andamo</td>
<td>Office of Agriculture and Rural Development</td>
<td>Head, Agriculture Desk</td>
</tr>
<tr>
<td>41</td>
<td>Ashenafi Abore</td>
<td>Wereda Administration Office, Omo Sheleko Wereda</td>
<td>Administrator</td>
</tr>
<tr>
<td>42</td>
<td>Teklu Gintabo</td>
<td>Wereda Administration Office, Omo Sheleko Wereda</td>
<td>Head of the Office</td>
</tr>
<tr>
<td>43</td>
<td>Yohannes Gornalo</td>
<td>Office of Agriculture, Omo Sheleko Wereda</td>
<td>Head of the Office</td>
</tr>
<tr>
<td>44</td>
<td>Tariku Tekle</td>
<td>Office of Agriculture, Omo Sheleko Wereda</td>
<td>Plant Science Expert</td>
</tr>
<tr>
<td>45</td>
<td>Haile Michael Megabo</td>
<td>Office of Agriculture, Omo Sheleko Wereda</td>
<td>Plant Science Expert</td>
</tr>
<tr>
<td>46</td>
<td>Mesfin Mentale</td>
<td>Office of Agriculture, Omo Sheleko Wereda</td>
<td>Soil and Water Conservation Expert</td>
</tr>
<tr>
<td>47</td>
<td>Tesema Tadesse</td>
<td>Water Resources Desk, Soro Wereda</td>
<td>Expert</td>
</tr>
<tr>
<td>48</td>
<td>Tamirat Orgeno</td>
<td>Office of Agriculture and Rural Development, Soro Wereda</td>
<td>Head of the Office</td>
</tr>
</tbody>
</table>
List of Participants for the Project Affected Persons Consultation Meeting and Attitude Survey

Wereda: Omo Sheleko
Peasant Association: Waro

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of contacted person</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ato Melaya Mamiso</td>
<td>Farmer</td>
</tr>
<tr>
<td>2</td>
<td>Ato Matiyos Oledo</td>
<td>Farmer</td>
</tr>
<tr>
<td>3</td>
<td>Ato Tagessa Arechebo</td>
<td>Farmer</td>
</tr>
<tr>
<td>4</td>
<td>Ato Enderias Ginsso</td>
<td>Farmer</td>
</tr>
<tr>
<td>5</td>
<td>Ato Desta Ashebo</td>
<td>Farmer</td>
</tr>
<tr>
<td>6</td>
<td>W/ro Bernsh Ayel</td>
<td>Farmer</td>
</tr>
</tbody>
</table>

Wereda: Omo Sheleko
Peasant Association: Geacha

<table>
<thead>
<tr>
<th>No.</th>
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<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>W/ro Welka Ashebo</td>
<td>Farmer</td>
</tr>
<tr>
<td>2</td>
<td>W/ro Berada Botu</td>
<td>Farmer</td>
</tr>
<tr>
<td>3</td>
<td>Ato Alemayehu Ashango</td>
<td>Farmer</td>
</tr>
<tr>
<td>4</td>
<td>Ato Sheferaw Ashango</td>
<td>Farmer</td>
</tr>
<tr>
<td>5</td>
<td>Ato Decho Chefam</td>
<td>Farmer</td>
</tr>
<tr>
<td>6</td>
<td>Ato Debena Denta</td>
<td>Farmer</td>
</tr>
</tbody>
</table>

Wereda: Omo Sheleko
Peasant Association: Boloso Sora

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of contacted person</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ato Tefera Miskale Tikamo</td>
<td>Farmer</td>
</tr>
<tr>
<td>2</td>
<td>Ato Seba Seta Wegaso</td>
<td>Farmer</td>
</tr>
<tr>
<td>3</td>
<td>Ato Ashenafi Abora</td>
<td>Farmer</td>
</tr>
<tr>
<td>4</td>
<td>Ato Tekelu Gentiso</td>
<td>Farmer</td>
</tr>
<tr>
<td>5</td>
<td>Ato Teshoma Patros</td>
<td>Farmer</td>
</tr>
<tr>
<td>6</td>
<td>Ato Tamerat Orgeno</td>
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</tr>
<tr>
<td>7</td>
<td>Ato Temesgen Alefo</td>
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</tr>
<tr>
<td>8</td>
<td>Ato Tesema Tadessa</td>
<td>Farmer</td>
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Wereda: Soro
Peasant Association: Archa

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<tr>
<td>1</td>
<td>Ato Desta Megu</td>
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</tr>
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<td>2</td>
<td>W/ro Etageng Denboka</td>
<td>Farmer</td>
</tr>
<tr>
<td>3</td>
<td>Ato Tesfay Achama</td>
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</tr>
<tr>
<td>4</td>
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Wereda: Soro
Peasant Association: Ole

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<td>2</td>
<td>Ato Bekele Wangera</td>
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<tr>
<td>3</td>
<td>Ato Lefam Silaka</td>
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<td>4</td>
<td>Ato W/Meskel Tumiso</td>
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<td>6</td>
<td>Ato Zewedu Deda</td>
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<td>7</td>
<td>Ato Lemengu Abusa</td>
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### Wereda: Boloso Sora  
**Peasant Association:** Bombe

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<td>2</td>
<td>Ato Negat Gesesa</td>
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<td>Ato Miskel Shenko</td>
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<td>4</td>
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### Wereda: Boloso Sora  
**Peasant Association:** Ose

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<td>1</td>
<td>Ato Melkamu Lachaw</td>
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<td>2</td>
<td>Ato Ostel Fola</td>
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<td>3</td>
<td>Ato Muna Berata</td>
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<td>4</td>
<td>Ato Selomonn Weysha</td>
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### Wereda: Gena Bosa  
**Peasant Association:** Boza Shota

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<td>Ato Boloae Boyena</td>
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<td>2</td>
<td>Ato Fereka Damore</td>
<td>Farmer</td>
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<tr>
<td>3</td>
<td>W/t Ehitabeba Degoye</td>
<td>Administration Worker</td>
</tr>
<tr>
<td>4</td>
<td>Ato Temesgen Demisse</td>
<td>Farmer</td>
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<tr>
<td>5</td>
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### Wereda: Kindo Koyisha  
**Peasant Association:** Mundia PA

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<td>Ato Temesgen Tero</td>
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<td>2</td>
<td>Ato Faleha Hateto</td>
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<td>3</td>
<td>Ato Dulo Anjajo</td>
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<td>4</td>
<td>Ato Eyasu Chafa</td>
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<td>5</td>
<td>Ato Alemyehu Gunta</td>
<td>Farmer</td>
</tr>
<tr>
<td>6</td>
<td>Ato Seta Graype</td>
<td>Farmer</td>
</tr>
<tr>
<td>7</td>
<td>Ato Admasu Lulue</td>
<td>Farmer</td>
</tr>
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</table>
ANNEX 4: SAMPLE MINUTES OF PUBLIC CONSULTATION MEETINGS

Annex 4.1: Unofficial Translation of the Transcription

Transcription of Zone Officials concerns as registered during the ‘preliminary consultative meeting’ (PCM) held with experts of the consulting firm (MDI) in connection with ‘Gibe III Hydro-Electric Power Project’.

<table>
<thead>
<tr>
<th>Place/Venue of the PCM:</th>
<th>In the Zone Office</th>
<th>Date:</th>
<th>09/01/08</th>
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<tbody>
<tr>
<td>Zone:</td>
<td>Dawro</td>
<td>PCM composition:</td>
<td>Representatives from different Zone Offices and MDI</td>
</tr>
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<td></td>
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The PCM members are composed of various Zone Officials/representatives and MDI representatives. The focus of the PCM is to identify:

- Project benefit;
- Negative effect resulting from the project;
- Relocation places/sites for the households that are going to lose farm lands and other assets by the reservoir; and
- Who or which of the organisations are pertinent to take part in the event of payment for compensation.

The following are outcomes of the consultation in the form of summary.

**Project Benefit:**
- It will provide better opportunity for the promotion of tourism and fishery;
- It will enhance income and employment opportunity; and
- It will provide ample opportunities for the expansion of basic infrastructural services.

**Negative effect:**
- Although there are a number of advantages that are going to be obtained from the project, it will also result adverse effects and these are:
  - Displacement of farmers and the loss of farm lands and other assets.
  - Ruin of forests and forest resources including organisms sheltering them.
  - The reservoir will damage the available crossings to adjacent Weredas and existing communication among communities will be blocked and there will be access problem to markets.
  - Devastation of hot springs that have healing effects both for human and livestock population.
  - Malaria infestation will increase as a result of the reservoir since it will create conductive environment for the breeding of the vector.
  - Increased spread of HIV/AIDS as there will be influx of migrants in search of work from other areas to the project site, and
  - Decimation of Halala Wall- a historical heritage of the Dawro people.

**Relocation sites:**
- Some displaced farms could be squeezed in kebeles where there are relatively some spaces to accommodate them.
- Others who would be interested to engage in trading should be given a sort of business skill training before they embark on the job.
Participants in compensation payment:
The form of compensation may not be limited to financial payment alone. Government sectors that could provide their services should involve in augmenting the compensation in kind. The Administration Office being as coordinator, the following representatives from Government Offices should be included in the compensation and rehabilitation activities:

- Agriculture and Rural Development;
- Health;
- Justice and Security; and
- Trade and Small Scale Enterprise.

<table>
<thead>
<tr>
<th>Place/Venue of the PCM:</th>
<th>Wereda Office</th>
<th>Date:</th>
<th>18/01/08</th>
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<tr>
<td>Wereda: Loma</td>
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<td>PCM composition:</td>
<td>Wereda Officials and represent.MDI</td>
</tr>
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<td>11</td>
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</table>

The PCM members are composed of officials of the wereda who are serving under various capacities and MDI representatives and the following were main points of the consultative meeting:

- Expected benefits accruing from the project; and
- The negative effects resulting from it.

Outcomes of the consultation are summarised below.

**Advantages of the project:**

- It will create employment opportunity for the local residents;
- Fish farming will be introduced and communities nearby the reservoir will increase their income through fishing;
- Electric light and power supply capacity of the country in general and to the local communities in particular could be enhanced;

**Negative impact of the project:**

- Displacement of limited number of farmers will occur;
- Trees where incense and Arabic gum are extracted from will be destroyed;
- Forest products which are essential for construction and energy sources will be affected;
- Grazing lands will be lost due to the reservoir;
- Potential agricultural areas will be covered by the reservoir water;
- Crossing points will be inundated and travel time to markets and other social services will increase and so will transportation cost;
- Malaria could be the major source of ill health for people living nearby the reservoir;
The PCM members are Officials who are serving under various capacities in the wereda and MDI representatives and the discussion centred more on the need for cooperation from the local government side in connection with environmental and social impact assessment that MDI is conducting. Likewise:

- The officials understand that the economic and social benefit that the project would bring about.
- The wereda Officials have learnt that historical artefacts will be lost due to the reservoir.
- They were also informed of some losses to be encountered with regard to the natural resources in the event of the emerging reservoir, and
- The Government Offices were willing to assign appropriate staff who could take part and facilitate in the various discussions that are going to be held at various levels in the wereda.

The PCM members are composed of officials of the wereda who are serving under various capacities and MDI representatives and the following were main points of the consultative meeting:

- Expected project benefit;
- Harmful effects that could result from the project/reservoir; and
- Measures to mitigate the project adverse effects.

The outcomes of the consultation are summarised below.

**Project Benefit:**
- It will hasten the pace of rural electrification and hence expanding the scope for using power for social and economic activities;

**Harmful effects:**
- Although no households’ farms and assets are lost to the reservoir other communal assets like accessing to grazing lands will be difficult;
- Hadya livestock farmers of the wereda usually travel across The Ghibe River in search of grazing for their animals and due to loss of cross points this may not be possible;
- The loss of crossing points would also seriously undermine trading between communities;
- Incidence of wildlife attack like lion will increase as the flooding would force to leave their habitats in the lowlands near the edges of the river and would migrate to higher places, nearby to human settlements, exposing the residents to high risk situation; and
- Forest resources that are now available will not be any more due to inundation.
Mitigating measures:

- Bridges or appropriate accesses that link communities one another should continue doing so;
- Hadya farmers who cross to the other side for grazing should be given the opportunity for settlement in Omonada or other places across Gibe River;
- Improved varieties of breeds should be introduced to improve the production and productivity of livestock; and
- Irrigation should be promoted to farmers who reside relatively nearer to the river.

<table>
<thead>
<tr>
<th>Place/Venue of the PCM:</th>
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The PCM members are composed of Officials of the wereda who are serving under various capacities and MDI representatives and the following were the main points of the consultative meeting:

- Harmful effects that could result from the project/reservoir; and Measures to mitigate the adverse effects.

The outcomes of the consultation are summarised below.

The consultation team has learnt that there were no people that could lose their private plots or assets as a result of inundation. However access to market, facilities and communal resources will be impeded by the emerging reservoir and these are:

- Hot springs that have healing effects for human;
- Trees that produce incense and Arabic gum;
- Crossing points that serve as a route for trading with other communities will be curtailed;
- Wildlife are going to decimate as a good part of their habitat is going to be claimed by the emerging reservoir;
- Communally owned trees that are vital to construct houses and to make farm implements will be submerged; and
- Important herbs and different spice plants that are naturally grown will be destroyed.

Finally the participants recommended that bridges or other better access opportunities should be put in place in order to reverse the project adverse conditions that might have been resulting from the flooding of the reservoir.

<table>
<thead>
<tr>
<th>Place/Venue of the FGD:</th>
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All FGD members are resident of small scale farmers of Gocho Kebele and the following were the main items of agenda for discussion:

- Benefit that the project would bring to the community;
• Undesirable effect of the project; and
• Measures for mitigating the adverse effects.

The points raised in the discussion are depicted below.

Benefit:

Understanding about the benefit that the project would provide to the community is not more than skin-deep although they are well aware of its disadvantages.

Disadvantages:

• As the reservoir is going to claim vast tracts of land, the community not only loses farm land, but also it will have very limited access to forest resources like wood for house constructions and grass for thatch roofs; including energy sources;
• Beekeeping will be impeded by the decimation of forests and resulting in the loss of income to the households;
• Loss of grazing land and browsing areas for domestic animals will take place; as well as the loss of land with salty soils, locally known as bole, where livestock very much prefer licking; and
• It will be no more possible to harvest root crops that are found naturally and vital sources of food in times of drought and distress.

Measures for offsetting the losses:

• FGD participants finally appealed to appropriate Government units to have exhaustively identify all those farmers who are going to be displaced and then compensate them with a means that commensurate their losses.

<table>
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<tr>
<th>Place/Venue of the FG:</th>
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<tr>
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<td>Kebele</td>
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The FGDs were composed of farmers who predominantly engage in livestock and topics of discussions have mainly revolved around three key areas.

• The benefit they believe that would result from the project;
• Adverse effects due to the project and;
• Solutions to be considered by the government.

Outcomes of the discussions are summarised below.

Expected benefit of the project:

• The FGD participants believe that the project is of immense benefit to the country as well as to the local communities.

Adverse effect of the project:

• Usually livestock producers are constrained by shortages of grazing land. In the face of such situation, for about nine months, they leave for other places hankering after grazing lands. They often travel to various weredas across vast expanse of land to the extent of crossing Gibe River to the
other side of adjacent weredas. When the project is realised, it will aggravate further the shortage of grazing land in two counts. Firstly, vast areas of land will be inundated by water resulting in loss of existing grazing lands. Secondly, the movement of farmers from place to place in search of grazing is going to be severely restricted by the emerging reservoir; and thus the combination of these factors will seriously jeopardise the livelihood system of livestock farmers.

**Solutions to be considered:**

- As a final remark, the participants requested the appropriate government agency to provide compensation to those who are going to be displaced. Besides, the compensation should be sufficient enough to cover their losses. They have also requested the Government to construct bridges that link their wereda with Yem and Omonada-Weredas to serve as important market outlays for the communities in Soro Wereda.

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<td>Wereda:</td>
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<td>Kebele leaders and members, and MDI</td>
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<tr>
<td>Kebele</td>
<td>Kara Korcho</td>
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The PCM members are composed of Kebele leaders and members including MDI representatives. The major theme of the PCM is:

- To learn and understand the effects that downstream communities would experience following the hydroelectric dam that is going to be built in the upper stream of Omo River; and
- To explore appropriate mitigation measures to avert the adverse effects that might have been encountered by the newly dam to be set up.

Major outcome of the PCM is summarised in the following manner. It was made known to the consultative group that:

- The Omo River has always been the lifeblood of the community providing essential water source for their livestock and crop production.
- Substantial numbers of community members in Hamer use flood plains to grow various crops both for consumption and for sale.
- They catch fish from the lakes that are filled by flood water for the purpose of household consumption and for marketing.

The absence of flooding will expose the communities to loss of income. Therefore, mitigation measures like irrigated agriculture should be introduced and intensified with the aim of crop and fodder production.
The PCM members are composed of officials of the wereda who are serving under various capacities and MDI representatives. The major theme of the PCM is:

- To learn and understand the effects of the project on the downstream communities; and
- To explore appropriate mitigation measures to avert the adverse effects caused by the project.

The identified major issues are summarised in brief below:

- Substantial numbers of pastoralists in downstream communities use flood plains (the river banks) to grow crops (mostly maize and sorghum). Flood plains become available when Omo River overflows;
- A total of about 6,000 ha of land use for receding cultivation in the wereda;
- Downstream crop productions under such system cover the food needs of the households for about three to six months;
- Whenever there is no adequate flooding shortfalls of production is augmented by the Government through food aid;
- About 30 spots of pasture lands or islands become apparent in the wereda due to the overflow of the river. The pastureland serve the communities for grazing all year round;
- Quasi lakes are also created by the overflows of the river where downstream communities use for fishing. They are source of income and food for Desanech communities; and
- The implementation of the project will affected the pasturelands and fishing activities of the downstream communities so that they will not have the indicated sources of income for their livelihood.

In order to avert these adverse effects the consultative team believe that possible measures should be taken, among which include:

- Irrigation in the wereda is rudimentary and the scope should be expanded at least to offset the production losses from the estimated 6,000 ha of croplands;
- Development of pastureland irrigation for livestock;
- Appropriate marketing services for livestock and expansion of basic services; and
- Adopting various actions that strengthen the livelihood system of the communities.
The PCM members are composed of Kebele leaders and members including MDI representatives. The major theme of the PCM is:

- To learn and understand the effects of the project on the downstream communities; and
- To explore appropriate mitigation measures to avert the adverse effects caused due to the construction of the Dam;

The consultative group raised major issues with regard to the possible impacts of the project. The points are summarized below:

- The Omo River has always been the lifeblood of the community providing essential water source for their livestock and crop production;
- When riverbanks are adequately (not in catastrophic proportion) flooded communities in Desanech could grow crops primarily for consumption all through the year and any surplus obtained is sold or bartered in the market;
- Pasture lands which are created by the river outflows is the main grazing source for cattle all year round; and
- Fishing in the lakes created by the floods is very common and the product uses for household consumption and marketing.

The absence of river flood will bring problems on the livelihood of the communities. Thus possible mitigation measures should be identified and implemented. These include:

- The expansion of irrigated agriculture as it is currently underway has proven to be practical while pastoralist have begun to produce fruits and vegetables for markets.
- As grazing plains cease to grow grass with the absence of flood waters, it is important that well water be installed for human and livestock use.
- Improved varieties of fodder should be introduced so that pastoralists will not depend on grazing, and
- Improved varieties of vegetable seeds should be distributed in order to promote the development of cash crops.
ANNEX 4.2: SAMPLE MINUTES OF PUBLIC CONSULTATION MEETINGS
### Wereda Introduction Meetings

(Under the responsibility of MDI)

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
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<td>1</td>
<td>Tadesse Galcha</td>
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<tr>
<td>2</td>
<td>Zemenesh Klemichael</td>
<td>Women Affairs</td>
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<tr>
<td>3</td>
<td>Dergay Balu</td>
<td>Director</td>
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<tr>
<td>4</td>
<td>Abaye Abera</td>
<td>Senior Manager</td>
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<tr>
<td>5</td>
<td>Dawit Dana</td>
<td>Millishe Affairs</td>
<td>0164560784</td>
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<td>Amanesh Tibe</td>
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<td></td>
<td>Abo Girma</td>
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**Remarks:**
- All meetings were held in the morning.
- Participation was voluntary.
- The meetings focused on sharing project details and discussing community concerns.
- Public input was collected through open discussions and written comments.
- Follow-up actions were agreed upon.
- Minutes were recorded and distributed to all participants.
Gibe III – Environmental and Social Impact Assessment

Werada Introduction Meetings

(Under the responsibility of MDI)

Remarks / Notes

[Handwritten text not legible]
Consultation Meeting with Wereda Offices

Minutes of the Discussions

- Discussion about the project details.
- Questions regarding the environmental impact.
- Concerns about social displacement.
- Agreement on the need for further consultation.

Signed:
[Signature]
Mid-Day International Consulting Engineers
Minutes of the Discussions (ጎንመጽוח ያለው ያሆኔ)

Consultation Meeting With Wereda Offices

(ወመድ ከመልክት ያቀረበ ያስቀለ ሚኒስትሮች)

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[Handwritten text not legible due to quality of the image]
Consultation Meeting With Wereda Offices

Minutes of the Discussions:

- [Handwritten text]

[Signature]

[Stamp]
Consultation Meeting With Woreda Offices

Minutes of the Discussions

[Handwritten text in Amharic]
Minister of the Discussion (Wotfaa, 2007)
### Consultation Meeting With Communities/Focal Group

**Place of the Meeting**: [Location]

**Date**: [Date]

**Time**: [Time]

<table>
<thead>
<tr>
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<th>Name of the Participant</th>
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### Points of the Discussions

1. [Point 1]
2. [Point 2]
3. [Point 3]
4. [Point 4]
5. [Point 5]
### Consultation Meeting With Communities/Focal Group

**Point of Discussion:**

**Place of the Meeting:**

**Date:**

**Time:**

<table>
<thead>
<tr>
<th>Seq. No.</th>
<th>Name of the Participant</th>
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<th>PA</th>
<th>Village</th>
<th>Position</th>
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**Consultation Meeting With Communities/Focal Group**

**Point of Discussion:**

**Place of the Meeting:**

**Date:**

**Time:**

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</table>
Consultation Meeting With Communities/Focal Group

Points of the Discussions

1. The current project status.
2. The role of stakeholders.
3. The potential impact on the community.
4. The timeline for the project.

Mid-Day International Consulting Engineers
Consultation Meeting With Communities/Focal Group

Points of the Discussions ( Ethiopian 

- The impact of the dam on the local community was discussed. The community expressed concern about the displacement of their homes and land.
- The impact of the dam on the local environment was discussed. The community expressed concern about the impact on local wildlife and fisheries.
- The impact of the dam on the local economy was discussed. The community expressed concern about the loss of traditional livelihoods.

- The community was informed about the mitigation measures that would be taken to minimize the impact of the dam.
- The community was informed about the resettlement plans that would be put in place for those who would be displaced.
- The community was informed about the environmental and social impact assessment that would be carried out.

Participants:
- Community members
- Mid-Day International Consulting Engineers

Next steps:
- A detailed environmental and social impact assessment will be carried out.
- Mitigation measures will be put in place to minimize the impact of the dam.
- Resettlement plans will be developed for those who will be displaced.

Mid-Day International Consulting Engineers
Points of the Discussions:

1. Floods: The discussions centered around the impacts of floods. It was noted that the frequency and intensity of floods in the region had increased significantly. The community expressed concerns about the loss of property and livelihoods during these events. It was agreed that a comprehensive flood management plan should be developed to reduce the impact on the community.

2. Irrigation: The discussions also focused on the impact of the Gibe III project on irrigation systems in the region. It was highlighted that the project would disrupt traditional irrigation practices, leading to a decrease in crop yields. The community requested that measures be taken to ensure that traditional irrigation methods are not abandoned and that alternative irrigation systems are developed.

3. Livelihoods: The sustainability of the community's livelihoods was a major concern. It was emphasized that the project should not lead to a decrease in the community's ability to support themselves. The discussions recommended that a livelihoods strategy be developed to ensure that the community's economic status is maintained.

4. Water Quality: The quality of water in the region was discussed. It was noted that the increase in population and economic activities had led to a decrease in the quality of water resources. The community demanded that measures be taken to improve water quality and ensure access to clean water.

5. Infrastructure: The discussions also included the need for improved infrastructure in the region. It was agreed that the project should include funding for road and bridge construction to improve access to markets and other services.

6. Education: The importance of education was emphasized. The community requested that the project include measures to improve access to education, particularly for children from marginalized communities.

7. Health: The impact of the project on the community's health was discussed. It was noted that the project could lead to an increase in disease transmission due to the lack of proper sanitation and hygiene facilities. The community demanded that health services be improved and that adequate sanitation facilities are provided.

The consultation meeting concluded with a commitment from the authorities to address the concerns raised by the community and to develop a comprehensive plan to mitigate the impacts of the project.
Consultation Meeting With Woreda Offices

Minutes of the Discussions

1. The Gibe III Hydroelectric Project (Gibe III) is a significant hydroelectric project in Ethiopia, which involves the construction of a large dam and reservoir on the Omo River. The project aims to generate electricity and provide water for irrigation.

2. During the consultation meeting, it was discussed that the project has faced challenges due to environmental and social impacts. These impacts include changes in local ecosystems, loss of habitat for wildlife, and potential displacement of communities.

3. It was agreed that a comprehensive Environmental and Social Impact Assessment (ESIA) should be conducted to address these issues. The ESIA will involve consultation with local communities, stakeholders, and government agencies to ensure that the project's impacts are minimized.

4. The project team assured that they are committed to implementing mitigation measures identified in the ESIA to address the environmental and social impacts. These measures will be monitored and evaluated throughout the project's lifecycle.

5. The importance of transparency and stakeholder engagement was emphasized. Regular updates and consultations will be held to keep affected communities informed and involved in the project's progress.

6. The meeting concluded with a commitment from all parties to work collaboratively to ensure that the Gibe III project is developed in an environmentally and socially responsible manner.

Mid-Day International Consulting Engineers

[Stamp]
Consultation Meeting With Woreda Offices

Minutes of the Discussions (12/05/2006)

The meeting was convened at 9:00 AM. The agenda included discussions on the environmental and social impact assessment of the Gibe III project. The participants included representatives from the local communities, government officials, and consultants. The discussion centered around the potential impacts of the project on the local environment and the need for effective mitigation measures.

It was agreed that regular follow-up meetings should be held to monitor the implementation of the agreed-upon actions. The consultants were tasked with providing comprehensive reports on the progress of the project.

Signed:
[Signature]
Mid-Day International Consulting Engineers
### Consultation Meeting With Communities (环境保护和利用情况)

**Point of Discussion:** 

**Place of the Meeting:** 

**Date:** 

**Time:** 

<table>
<thead>
<tr>
<th>Ser. No. (1-6)</th>
<th>Name of the Participant (环境利用和情况)</th>
<th>Village (村)</th>
<th>PA (区)</th>
<th>Village (村)</th>
<th>Position (职位)</th>
<th>Signature (签名)</th>
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</table>
Consultation Meeting With Communities

Points of the Discussions

1. The impact of the project (flood) on the local community
   The project is expected to have significant impacts on the local community, particularly in terms of flooding. The community has expressed concerns about the potential increase in floodwaters and the protection of their homes and livelihoods.

2. The benefits of the project (flood) to the community
   The community has identified several benefits of the project, including improved infrastructure and increased economic opportunities. However, these benefits need to be balanced with the potential risks and impacts.

3. The project's sustainability (flood)
   The community has raised concerns about the sustainability of the project, particularly in terms of flood protection measures. There is a need for ongoing monitoring and adaptation to ensure the project's long-term success.

4. The community's participation (flood)
   The community has emphasized the importance of their participation in the project planning and implementation. They have requested regular updates and involvement in decision-making processes.

5. The project's environmental impact (flood)
   The community has highlighted the need to minimize the environmental impact of the project, particularly in terms of floodwaters and the preservation of local ecosystems.

Mid-Day International Consulting Engineers
Consultation Meeting With Communities

Points of the Discussions

1. Environment and Social Impact Assessment
2. Water and Hydropower Development
3. Community Participation
4. Infrastructure Development
5. Employment Opportunities
6. Economic Development

Points of the Discussions

1. Environmental and Social Impact Assessment
2. Water and Hydropower Development
3. Community Participation
4. Infrastructure Development
5. Employment Opportunities
6. Economic Development
### ANNEX 5: EIA CONSULTANT TEAM

The experts that contributed to this EIA Report are as listed below.

<table>
<thead>
<tr>
<th>Team Member</th>
<th>Position/Profession</th>
<th>Qualification</th>
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<tr>
<td><strong>CESI</strong></td>
<td></td>
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<tr>
<td>Stigliano G. Paolo</td>
<td>Geologist, ESIA Team Leader</td>
<td></td>
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<tr>
<td>De Bellis Caterina</td>
<td>Environmental Land Planning Engineer</td>
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<tr>
<td>Vendrame Paolo</td>
<td>Geologist</td>
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<tr>
<td><strong>MDI Consulting Engineers</strong></td>
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<tr>
<td>Dejene Woldemariam</td>
<td>Team Leader/EIA Expert</td>
<td>BE, MTech</td>
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<tr>
<td>Seyoum Mengistu (Dr)</td>
<td>Aquatic Ecologist</td>
<td>BSc  MSc  PhD</td>
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<tr>
<td>Zerihun Woldu (Prof.)</td>
<td>Terrestrial Ecologist</td>
<td>BSc  MSc  PhD</td>
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<td>Tesfaye Wudneh (Dr)</td>
<td>Fishery Expert</td>
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<td>Laluto Sadore</td>
<td>Fishery Expert</td>
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<tr>
<td>Bedilu Amare</td>
<td>Agriculturalist/ Environmentalist</td>
<td>BSc  MSc</td>
</tr>
<tr>
<td>Habtamu Denboba</td>
<td>Socio-Economist</td>
<td>BA  MA</td>
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<tr>
<td>Mulugeta Sergawi</td>
<td>Resettlement Planner</td>
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<tr>
<td>Temsgen Yimer</td>
<td>Sociologist and Gender Specialist</td>
<td>BA</td>
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<tr>
<td>Demirew Dagne</td>
<td>Antropologist</td>
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<tr>
<td>Hailu Zeleke</td>
<td>Archaeologist</td>
<td>BA  MA</td>
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<td>Demeke Hailu</td>
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<td>BSc  MSc</td>
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<tr>
<td>Mesfin Alemu</td>
<td>Livestock Expert</td>
<td>BSc  MSc</td>
</tr>
<tr>
<td>Million Bekele</td>
<td>Forest Management</td>
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<tr>
<td>Sisay Nune</td>
<td>Land Use Expert</td>
<td>BSc  MSc</td>
</tr>
<tr>
<td>Mohammed Abdi</td>
<td>Wildlife Expert</td>
<td>BSc  MSc</td>
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<tr>
<td>Belay Seyoum</td>
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<tr>
<td>Kibret Mammo</td>
<td>Data Analyst</td>
<td>BSc  MSc</td>
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<tr>
<td>Getachew Tadesse</td>
<td>Biodiversity/Forester</td>
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<td>Mignote Zecharias</td>
<td>Water Supply Engineer</td>
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<td>Samuel Tegodahu</td>
<td>Autocad Expert</td>
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<tr>
<td>Bezawork Wondimu</td>
<td>Senior Surveyor</td>
<td>Certificate</td>
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## ANNEX 6: WATER QUALITY ANALYSES

### SELECTED PHYSIO CHEMICAL AND BACTERIOLOGICAL WATER ANALYSIS RESULTS

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<td>CLIENTS ID.NO.</td>
<td>Omo River near Muda</td>
<td>Gojeeb</td>
<td>Omo River at the bridge</td>
<td>Omo River at GG-III Dam site</td>
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<td>Total Solids 105°C (mg/l)</td>
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<td>T. Dissolved Solid 105°C (mg/l)</td>
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<td>Electrical Conductivity (μS/cm)</td>
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<td>Total Hardness (mg/l Ca CO₃)</td>
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<td>Calcium (mg/l Ca)</td>
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<td>Magnesium (mg/l Mg)</td>
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<td>Total Iron (mg/l Fe)</td>
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<td>Manganese (mg/l Mn)</td>
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**REMARKS:**

Checked by: ___________________________ Approved by: ___________________________

Date: 10/05/96 Date: 10/05/96

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