Gariuai Mini HEP: The First Hydroelectric Plant in a New Country

Jan Hoeiseth[1] and Kassius Klei[2]

1) Norconsult/NORPLAN J.V. , Norway
2) Ministry for Natural Resources, Minerals & Energy Policy, The Democratic Republic of Timor-Leste

Email: *cleincosta@yahoo.com*

ABSTRACT

The Norwegian Water Resources and Energy Directorate (NVE) on behalf of NORAD has established institutional co-operation with the Ministry of Natural Resources, Minerals and Energy Policy in Timor-Leste. Development of hydropower projects is part of the co-operation. The Norconsult / NORPLAN J.V., which was a warded a contract in June 2003, has been the consultant with responsibility for design of the Gariuai mini HEP in the Baucau District.

Power generation in Timor Leste is by diesel engines feeding a large number of medium voltage, isolated systems. The total available installed peak load capacity in the main system is about 33 MW of which 22 MW in the capital Dili.

2 possible spring water fed schemes in the Baucau city were turned down in 2004 because of water use conflicts. During a reconnaissance study in sub-districts within the Baucau District the promising project in Gariuai was identified. A feasibility study concluded that the project was economically viable compared with diesel generated energy production. The main data were; annual mean flow of 112 litre/s, gross head of 205 m, penstock dia 400 mm / 250 mm with total length 2200 m, installed capacity 300 kW, annual energy production 1.5 GWh, construction costs Mill USD 1.4 and construction time 28 months.

In the financing agreement between Norway and Timor-Leste it is stated that the purpose of the project is to supply the people of Baucau District with a renewable and not polluting source of energy. Outputs of the project electricity supply during 24 hours a day, technology transfer on hydropower construction to selected personnel (for later projects) and labour intensive construction methods to reduce local unemployment. Further it was required that electromechanical works to be procured from qualified suppliers.

The Developer therefore organized and conducted the civil works as a "Timor Development Project" to secure full control on engagement of local workers, provide technology transfer to staff from the Ministry and other parties and minimize risk of disputes with the local community.

Tender competitions were held between a limited number of internationally acknowledged suppliers of electromechanical equipment and ductile pipes. Contracts were awarded to Wasserkraft Volk AG for supply and installation of turbine, generator and control system and Tyco Water Pty Ltd for supply of ductile pipes. The transmission line was constructed by skilled workers from the state owned utility Electricidade de Timor-Leste. The electromechanical equipment allows for operation of the plant both in parallel with diesel engines and stand alone (isolated) for supply to some villages in case the diesels are not operating.

The following principles have been agreed on and complied to for engagement of local unskilled labour:
- *The 8 villages within the Gariuai Sub-district to provide equal number of workers*
- *The workers to be engaged in two groups, each on a fortnight period but not in phase to achieve continuity*

• *The number of workers to fit the volume of the works*

The plant is expected to be completed by February 2008.

1 INTRODUCTION

1.1 Background

The Norwegian Water Resources and Energy Directorate (NVE) on behalf of NORAD has established institutional co-operation with the Ministry of Natural Resources, Minerals and Energy Policy in Timor-Leste. Development of hydropower projects including transmission lines is part of the co-operation. The objective is to some extent replace the costly operation of diesel power plants with cheaper and cleaner electricity from hydropower plants. NVE awarded in June 2003 a contract to the Norconsult / NORPLAN J.V. for development of 3 hydropower projects.

1.2 Project Identification

One of the three hydropower projects was to develop a mini HEP in the centre of the Baucau city based on the location of ground water springs at elevation 200 to 300 masl. The idea was to utilize the water flow remaining after tapping for agricultural irrigation and households and community services and generate electricity from the water head down to the sea level. Feasibility and water use studies for 2 possible schemes were carried out, and both schemes were found economically viable compared with diesel generated energy production. However, the independent environmental consultant EPANZ was unable to recommend any of the projects because of vulnerability with respect to sharing of water between the water users (irrigation/hydropower).

A reconnaissance study of ground water fed catchments in the Gariuai and Venilale Sub-districts was thereafter conducted. Based on a combination of head, water flow, seemingly small environmental consequences, location close to load centre and access conditions, one scheme in Gariuai Sub-district was selected for a feasibility study in February 2004. The location of Baucau town and the Project Area is provided by Figure 1.1.

Figure 1.1 Map of Timor with project area location

2 PRESENT ENERGY SUPPLY / ELECTRIFICATION IN TIMOR-LESTE

At present there is no transmission system in Timor-Leste. However, a large number of medium voltage (MV), isolated systems exist and distribute the power from local diesel generators to local consumers. The largest of these systems is the distribution system in the capital Dili. The MV distribution networks are built for 20 kV. The 20 kV lines consist of three phases (conductors) strung on tubular steel poles and with no shield wires. The conductors used are mainly bare AAAC (all aluminium alloy) conductors with cross sections 70 mm^2, 95 mm^2 and 150 mm^2. Due to shortcomings in the billing system, no precise information about the electricity consumption exists for the last years. The peak demand in Timor Leste in 2007 is 22-23 MW. The major part of the load is located in Dili. Other important load centres are Baucau and Los Palos. At present there are 58 separate small power systems in the country. All power generation is based on diesel engines using automotive diesel oil as fuel. The largest generation capacity is in Dili with about 10 diesel units in operation totaling about 22 MW. There are a total of 84 diesel engines, whereof only 56 in operation, located in the 57 districts/sub-districts (other than Dili) and connected to the isolated 20 kV distribution networks. The operational installed capacity is 11,330 kW. Most of the 57 systems have very small installed capacity, ranging from 20 kW to 800 kW, with either one or two small high-speed diesel units. Most of the units have capacities of 20 – 100 kW. Only four systems outside Dili have higher operational capacity; namely Baucau (1,800 kW), Ermera (1,760 kW), Ainaro (870 kW) and Manatuto (800 kW). The electrification ratio for the country except for Dili is about 15%, and for Dili it is about 75%.

3 MAIN DATA FOR THE GARIUAI MINI HEP

From the Feasibility Study, which was concluded in November 2004, the main data given by Table 3.1 have been extracted.

Table 3.1 Main Data for Gariuai mini HEP

Main Data	Feasibility Design		
Total Catchment Area	Not available because of karst and ground water from springs		
Annual Mean Flow	Based on 5 current meter measurements in 2004	112	litre/s
Max / Min Annual Flow		202/48	litre/s
Mean Annual Yield		3.53	mill. m³
Intake Elevation under normal operation		352	masl
"Tailwater Elevation"	2 m below Pelton runner centre line	145	masl
Gross Head (to Pelton centre line)		205	m
Number of Units, Design Discharge	1 unit, 1 x max flow	202	litre/s
Maximum Net Head		196	m
Installed Capacity		326	kW
Firm Power Capacity	90% availability	92	kW
Load Factor		51	%
Energy production, exclusive of line losses		1 452 000	kWh
Type of Development	Run-of-the-River		
Live Storage, HRWL/LRWL		0	
New dirt road to powerhouse + temporary roads		2 + 1	km
Access to the project area	From Dili on exist. main road	140	km
Existing main road	From Baucau	20	km
Main Intake Weir Height	Embankment dam with core of geotextile covered "bamboo sheet piles"	2	m
Crest Length		7	m
Penstock Type	Ductile Cast Iron		
Total Penstock Length		2 200	m
Diversion Pipe Diameter		250	mm
Main Penstock Diameter		400	mm
Transmission to connection point in Gariuai	20 kV	4.2	km
Construction Costs with Transmission to Gariuai		1 400 000	USD
Construction Time		28	months

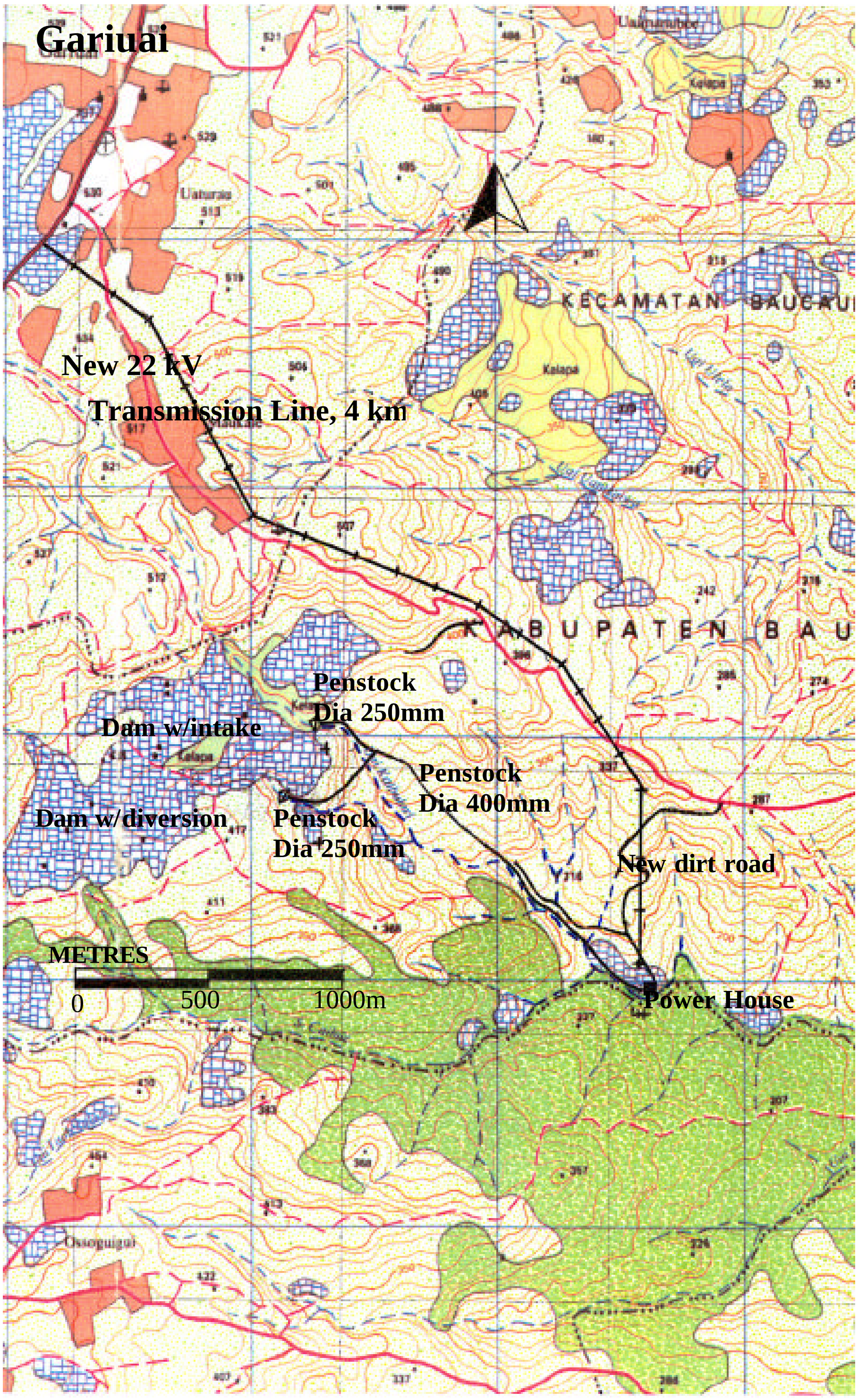

Figure 3.1 Project Area with main components

4 PROJECT IMPLEMENTATION

The first mini hydroelectric power plant to be operating in Timor-Leste is nowadays under construction in Gariuai, a small community situated in between Bacau city and Venilale. In the financing agreement from early 2005 between Norway and Timor-Leste regarding construction of Gariuai mini HEP it is stated that the purpose of the project is to supply the people of Baucau District with a renewable and not polluting source of energy. Outputs of the project were listed as follows:

- Electricity supply during 24 hours a day
- Technology transfer on hydropower construction to selected personnel (for later projects)
- Labour intensive construction methods to reduce local unemployment

Further it was required that electromechanical works to be procured from qualified suppliers.

4.1 Project Organization

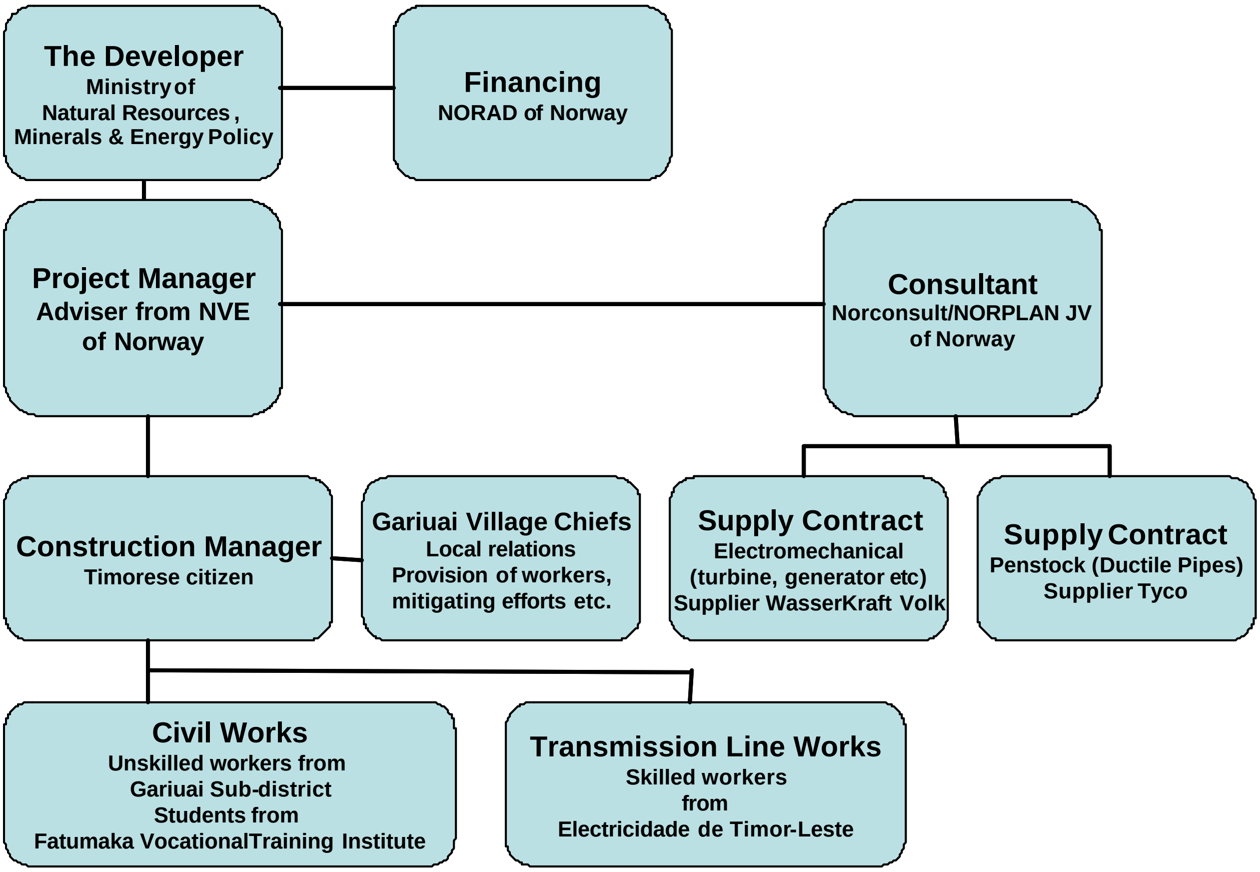

Figure 4.1 Project Organization

4.2 Civil Works

As the feasibility study was progressing in 2004 the local leaders and the population of Gariuai Sub-district were making expectations to the possible mini hydropower development. "Political impatience" in the Baucau District in general and in the Gariuai Sub-district in particular on lack of development projects had for a long time been known to the administration in the capital Dili. It was therefore important for the Developer to organize the project implementation in such a way that the local community would benefit as much as possible from the construction works. Engagement of an international civil works contractors with a Timorese branch after a tender competition was turned down for the following reasons:

1. Reduced influence on engagement of local workers
2. Costly mobilization and administration for a contractor on such a small project
3. Reduced technology transfer to staff from the Ministry and other parties
4. Risk of disputes between contractor and stakeholders

The other option was for the Developer to organize and conduct the civil works as a "Timor Development Project". The Project Manager and the Consultant were in favour of this but had to face the following challenges:

1. Secure the presence of a Project Manager being heavily involved in day-to-day matters
2. Identify and engage a qualified Timorese Construction Manager
3. Organize local unskilled workers in cooperation with local leaders
4. Carry out on-the-job-training on specialized civil works (ductile pipe installation & backfilling, culvert construction, concrete works, embankment dam works etc)
5. Engage and educate Timorese personnel for project administration
6. Establish a construction yard, storage areas and premises for accommodation and feeding
7. Procure or rent, learn to use and maintain various plant (crane lorry, hand held drill rig, concrete mixer, hand tools etc)

It is a pleasure to report in July 2007 that all the above challenges have been solved in line with the progress of the works. The photo below is provided to illustrate the engagement and skills related to installation of the ductile pipes.

Figure 4.2 The Construction Manager preparing for jointing of ductile pipes Dia 400mm

The civil works include
- construction of 2 km access road to powerhouse and 1 km of temporary access roads
- trench excavation, installation and backfilling for 1440 m of ductile pipes dia 400mm including gabion & embankment works for bypassing 2 stream culverts
- trench excavation, installation and backfilling for 760 m of ductile pipes dia 250mm including 1 pipe bridge for crossing the main stream and 40 m of pipe bridge for bypassing a gorge
- 8 m long and 2 m high embankment dam at intake in stream Builai including concreted intake structure (see Figure 4.2 below)
- 6 m long and 1 m high embankment dam for diversion of stream Wainalale incl concreted intake structure
- powerhouse structure with concreted foundation sized 55 m^2 and masonry walls
- powerhouse outlet canal in concrete and stone pitching

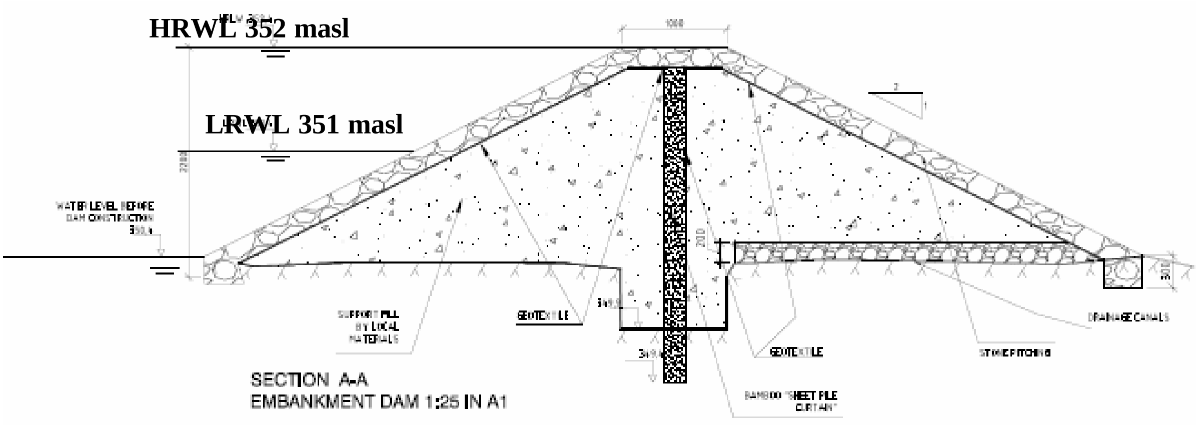

Figure 4.2 Cross section of embankment dam at intake

4.3 Electromechanical Works

The works have been split as follows:

1. Supply of ductile pipes with fittings
2. Supply, installation and commissioning of turbine, generator, transformer and control system
3. Supply and construction of 20 kV transmission line

Re. supply of ductile pipes with fittings: For a pressure head of 200m ductile pipes were considered both more durable and easier to install than the alternatives glass fibre reinforced (GRP) pipes and polyetylen (PE) pipes. It was difficult for the Consultant to motivate suppliers to tender for a supply to a new client in a new country with civil unrest. Finally a tender competition was arranged between 3 acknowledged suppliers from Japan, France and Australia. The Japanese tenderer backed out because of claimed problems with overseas transport. The Ministry awarded the contract to Tyco Water Pty Ltd of Australia in March 2006 for a price in the range of USD 200 000 after a time-consuming process where the supplier was released from almost all risks related to payment, unloading, guarantee issues etc. At present about 1 000 m of pipes with dia 400 mm have been successfully installed and backfilled.

Re. supply of turbine, generator, transformer and control system: A number of 7 suppliers in Norway, Germany and the Czech Republic, both acknowledged and known to the Consultant for supply of small turbines, were invited to tender. A combination of high demand for hydroelectric equipment, a remote and unknown client and project site resulted in only one tender from the German supplier Wasserkraft Volk AG. Upon the Consultant’s recommendation the Client entered into a contract with Wasserkraft Volk in May 2006 for a price of about USD 1600 per kW installed capacity. At present the manufacturing is completed in the work shop in Germany and the equipment is safely stored awaiting a go-ahead for overseas transport from the Project Manager. The electromechanical supply is characterized as follows:

- Pelton turbine with horizontal shaft and one nozzle (see Figure 4.3 below)
- The turbine output is controlled by a spear valve and deflector
- The runner is directly connected to the generator
- A flywheel for stabilization of the speed
- A flexible coupling between the generator and the flywheel
- An old fashioned mechanical governor which is repair and maintenance friendly
- A synchronous generator with 400 V supply voltage
- The turbine efficiency is at maximum 88.5%
- The generator efficiency is at maximum 95.5%

At the time of the grant from Norway in 2005 the diesel engines in Baucau where only in operation at evening hours. The Consultant therefore had to facilitate for two modes of operation of the Gariuai mini HEP namely; (1) in parallel with the diesel engines in Baucau or (2) as stand alone (isolated) mode. The modes of operation are described as follows:

1. In parallel with diesel engines in Baucau. In this case the spear valve will be water level controlled.
2. Stand alone (isolated) with supply to a smaller number of consumers in some villages. In this case the spear valve will be water level controlled and the deflector will control the speed in order to react very fast on load changes.

Latest operating instruction: The Government has decided that the diesel engines in Baucau should be running day and night.

Figure 4.3 Turbine runner with housing at Wasserkraft Volk's premises

Re. supply and construction of 20 kV transmission line: The Project Manager called for tender from Indonesian supplier and the state owned utility Electricidade de Timor-Leste (EdTL) provided a team of skilled workers for the construction works. A 4200m long line with 92 steel poles (12m long) carrying three 70 mm^2 AAAC conductors was constructed in the period January – February 2007.

4.4 Progress of Works per July 2007

Installation of ductile pipes is about 50% completed. The remaining pipe works will go on in parallel with construction of the embankment dams for the intake and the diversion. Construction of the powerhouse started in May 2007 and is expected to be completed in October this year. The electromechanical installation is planned to be carried out by year end. Testing and commissioning of the plant to be performed in January – February 2008, which is close to 2.5 years after mobilization at site.

5 SOCIO ECONOMIC OUTPUT

Before start up of the civil works the Project and Manager and the Consultant held meetings with Baucau District Administrator and village chiefs to organize unskilled local workers. The principles agreed on and complied to are as follows:

- The 8 villages within the Gariuai Sub-district to provide equal number of workers
- The workers to be engaged in two groups, each on a fortnight period but not in phase to achieve continuity
- The daily salary is USD 4.5 including USD 0.5 for lunch meal

The number of workers has been scaled up and down depending on the volume of the works and varied in between 20-30 at minimum and 100 at maximum.

Local farmers in cooperation with truck owners have supplied high quality river stones for construction of gabions and for concrete aggregate for the price of USD 30 per full truck.

Concrete blocks for the powerhouse and steel frames for windows, aeration frames etc have been supplied by Fatumaka Vocational Training Institute being situated only 5 km from the site. The price of the concrete blocks is USD 0.85 per block.

6 ENVIRONMENTAL ASPECTS

As can be seen on Figure 3.1 the hydroelectric plant “borrows” the water at the downstream side of a rice paddy field area situated on the edge of the elevated Baucau plateau. Further the water is released at the powerhouse outlet on the upstream side of a big low leveled farmland area. In between the intakes and the outlet there is a small cultivated area that will have access to irrigation water from a small spring not affected by the hydroelectric plant.

The environmental authorities (DNSMA) carried out the environmental screening and worked out an Environmental Management Plan. The project was given the environmental class B, which is the second highest class with respect to environmental consequences. The reasoning for such high classification is because of the access road to be constructed in a slope likely to suffer from damaging erosion. Representatives from DNSMA have inspected the works on a regular basis and been involved in matters such as compensation for loss of fruit trees, compensation for loss of rice harvest etc.

REFERENCES

Norconsult / NORPLAN J.V., Feasibility Study, Gariuai mini HEP, November 2004
NORPLAN, Network Survey, Draft Report, July 2007
Høiseth, J / Mathiesen, K. (2005) Promising HEP in karstic limestone in Timor-Leste, *Proc. Hydropower 2005,* Stavanger, Norway