Solomon Islands Government

Ministry of Mines, Energy and Rural Electrification

Tina River Hydropower Development Project (TRHDP)

Environment and Social Impact Assessment

EXECUTIVE SUMMARY

August 2017

Project Name:	Tina River Hydropower Development Project
Report for:	Ministry of Mines, Energy and Rural Electrification

PREPARATION, REVIEW AND AUTHORISATION

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EXECUTIVE SUMMARY

This is an executive summary of the Environmental and Social Impact Assessment (ESIA) Report for the Tina River Hydropower Development Project (TRHDP), a 15-megawatt hydropower scheme on Guadalcanal, Solomon Islands. More precisely, the Project is located in Malango, Ward 20 of the Guadalcanal Province, 30 km southeast of Honiara. The TRHDP is managed by a dedicated Project Office (TRHDP-PO) under the Solomon Islands Ministry of Mines, Energy and Rural Electrification (MMERE). An Independent Power Producer (IPP) will establish a Special Purpose Company (SPC) to Build, Own, Operate and Transfer (BOOT) the hydropower infrastructure. The IPP will sell electricity to Solomon Power, the state-owned power utility. At the end of the lease, the IPP will transfer the infrastructure to the Solomon Islands Government.

E 1. LOCATION

Tina River is located 30 km South East of Honiara at the upstream end of the Ngalimbiu River Basin in Central Guadalcanal.

Figure E-0-1 – Map of Tina Hydro site in Guadalcanal context

The Project is located in Bahomea, winthin the Malango Ward (Ward 20) of Guadalcanal Province. The Map at Figure E-2 depicts the dam, reservoir and power station sites in the context of the Black Post Road, Main Highway and Ngalimbiu River.

Figure E-0-2 – Map of Project Location

E 2. The Project

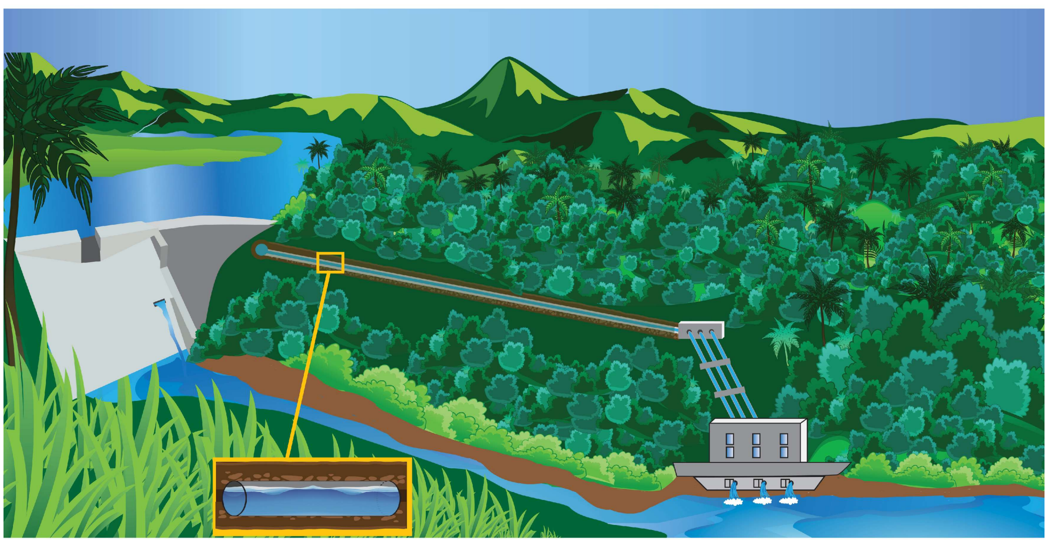
Currently, power in Guadalcanal is mainly provided by Lungga diesel power plant. The power supply in Honiara is barely adequate to meet demand, especially during periods of peak power consumption. TRHDP will reduce the peak demand requirement on the current diesel system and reduce the requirements for imported diesel. It is also expected to defer the need for further capital expenditure on the diesel generation plant for up to a decade.

Guadalcanal has abundant hydropower potential that could help the country reduce its dependency on diesel fuel, reduce the country's exposure to the uncertainties inherent in world oil markets, and lower the cost of energy production. The price of electricity in Guadalcanal is one of the highest in the Pacific region mainly due to the nearly total reliance on diesel for its power generation. Environmentally, electricity generated from diesel leads to impacts including: greenhouse gas emissions, air pollution and a risk of oil spills during extraction, processing, sea transport and transfer to Honiara (Entura, 2014). Electricity generated by hydropower has the advantage of allowing Solomon Islands to rely on its own renewable resource, and to import substantially smaller amounts of non-renewable diesel.

The Project consists of a 53 meter high Roller Compacted Concrete dam in an uninhabited area of Malango Ward at an elevation of approximately 122 meters above sea level (masl) and roughly 30 river km from the sea. It also incorporates a 3.3 km tunnel to a powerhouse and a tailrace at elevation 73 masl. The reservoir formed by the dam will extend upstream approximately 2.6km and will have a surface area of about 0.28km^2 at an elevation of 175 masl. The powerhouse will be located 5.4 kilometers downstream from the dam on the left bank of the Tina River, and water will be diverted to the powerhouse from the reservoir through the underground tunnel. Initially, the powerhouse will have 3 turbine/generator units, each with a capacity of 5MW, allowing a maximum discharge of about 18m^3/s and a minimum discharge of 2.4m^3/s. An environmental flow of 1m^3/s will be maintained between the dam and the powerhouse tailrace, a distance of 5.7km.

Figure E-3 shows an illustration of the proposed Project Scheme.

Figure E-0-3 – Project Scheme



Construction activities will last three years, and all construction activities will take place on land acquired for the Project in 2014, known as the "Core Area", as well asalong the Black Post Road. The Tina Core Land Company (TCLC), a joint venture between customary landowners and government, will hold rights to the Core Area, including the access road from the power station to the dam site. This land shall be leased to the IPP.

Table E-0-1lists the main project components and characteristics of the TRHDP.

Table E-0-1 TRHDP main characteristics (Option 7c) from feasibility study

Project Components	Characteristics
Dam	
Type of dam	Roller Compacted Concrete (RCC)
River Chainage	CH 7km
Height	53m
Base length at river	35m
Base length at crest	200m
Material needed for dam and the two cofferdams	Cement: 5.6 thousand m^3 Fly ash: 9.2 thousand m^3 Aggregate: 160 thousand m^3 Water: 30 thousand m^3 Retarding admix: 0.2-0.4 thousand litres
River level at dam	122masl
Minimum operating level (MOL)	170masl
Normal operating level	172masl
Full supply level (FSL)	175masl
Maximum flood level (MFL)	186.5masl
Spillway	
Release of floods	Up to the 1:10,000 year flood level (3,290m^3/s)
	The spillway will release flood water in by the by-passed river, on average, 8% of the time (when the inflow is higher than 24m^3/s)
Width	45m
Height (FSL)	175masl
Reservoir	
River Chainage	CH 7km – CH 4.5km
Number of days for filling	Between 5 and 9 days plus extra time for the minimum environmental flow to be implemented during reservoir impoundment.
Volume at FSL	7Mm^3
Volume at MOL	7.8M^3 +/-
Surface at FSL	30.52ha +/-
Length	2.5km
Power water intake	
Location	162.5masl
Size	3m diameter
Scour outlet	
Location	155masl
Head race tunnel	

Project Components	Characteristics
Internal diameter	3.3m, suitable for flow rates up to 24m^3/s
Flow rate	24m^3/s
Length	3.3km
Powerstation	
River Chainage	CH 12.7km
Average net head of powerstation	102m
Turbine floor	72masl
Turbines	3 Francis x 5MW
Operating capacity	15MW, 18m^3/s
Energy production and taking into account a 1m^3/s Environmental flow	78.35MWh
Environmental Flow	
Riparian outlet for the environmental flow	162.5masl
Environmental Flow (EF) in bypassed river section	1m^3/s
Minimal flow downstream of the Powerstation during any overnight (off peak) filing	3.4m^3/s
Road	
Permanent existing Black Post road unsealed	13.3km
Permanent access road to powerhouse sealed	1.45km
Permanent access road to dam sealed	4.7km
Temporary access road to intake portal unsealed	0.25km
Permanent road to dam base	0.66km
Road to quarries	to be confirmed at detailed design
Transmission line	
Length	23km
Type	33kV double circuit
Project cost	
Full scheme extension of the powerhouse	US$133.3 Million
Unit cost for the Project	US$165 to 185/MWh
Diesel energy unit cost (Lungga powerstation)	US$330 to 400/MWh
River hydrology	
Mean flow at dam	11.5m^3/s
Tina catchment area	150km^2
Catchment area above the dam	125km^2

Chainage is based on distance from the confluence of the Tina River and the Mbeambea River which is (CH 0). The dam is localized at CH 7.

E 3. BASIS FOR ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

To implement the TRHDP, an Environmental and Social Impact Assessment (ESIA) is required by both the Solomon Islands Government (Schedule 2, Section 16 of the *Environment Act 1998*) and the World Bank (Performance Standard 1 - Assessment and Management of Environmental and Social Risks and Impacts). This ESIA was prepared for MMERE in accordance with SIG national requirements, and World Bank performance standards and safeguard policies.

Flora and fauna surveys were carried out, and project-affected communities were consulted extensively through the use of social surveys and mitigation workshops as part of the preparation of the ESIA. In addition, a program of ongoing consultation has been carried out by the TRHDP PO since 2011.

The ESIA examined changes to baseline environmental and social conditions that could potentially result from the construction and operation of the proposed Project. Measures were proposed to avoid, mitigate or compensate impacts. A cumulative impact assessment was also carried out, and an Environmental and Social Management Plan (ESMP) is included in the document. Under the Solomon Islands' *Environment Act*, the developer of a project must submit the project ESIA to the Ministry of Environment, Climate Change, Disaster Management and Meteorology. Consequently, the IPP will prepare the official ESIA for submission based on this ESIA, along with a Construction ESMP and various other management plans meeting the minimum requirements of the Framework ESMP. An Operation ESMP will be submitted to the Ministry prior to commencement of operations.

E 4. ANALYSIS OF ALTERNATIVES

E.3.1 Alternative Energy Sources

The ESIA includes an analysis of alternative means to meet the present and projected energy demand of Guadalcanal. The analysis compared sources on the basis of energy production; economics; reliability and limitations; and environmental and social benefits and constraints. It covered demand-side management, wave and tidal energy, diesel-fueled generation (which, as a continuation of present practice, is also the « no-action alternative »), standard and pumped-storage hydro, solar, wind, geothermal, and gas-fired thermal. The rationale for the selection of the proposed project was thatyydropower is a reliable and proven source of renewable energy within the local environment as it has:

- Suitable hydrological conditions;
- Project locations with minimal social and manageable environmental impacts;
- Availability of natural resources (water);
- Relatively long economic lifetime;
- Low maintenance costs; and
- Reliable base load power supply.

E.3.2 Alternative Locations and Configurations

Previous studies had already identified the Tina River as hydrologically the most attractive river on Guadalcanal for hydropower development. Over the course of two phases of feasibillity studies, receipt of recommendations from the TRHDP-PO's Dam Safety Panel based on geotechnical conditions, and preparation of the ESIA, seven different possibiilities for the location of the dam and configurations of the project were investigated. Two of the options had multiple sub-options so that, in all, ten alternatives were examined. Possible locations ranged from a site near the headwaters in a completely undisturbed reach of the river to a downstream site among riverside settlements. Configurations included building the powerhouse at the toe of the dam and locating it at various distances downstream, entailing tunnels of various lengths.

Location 7c with a dam height of between 35 and 65 m, the preferred option, was chosen based on superior technical, financial, and economic performance, complete avoidance of physical displacement of households, and manageable environmental and social impacts.

E 5. BASELINE CONDITIONS

Information on baseline conditions covers a range of topics and was used to assist project-affected communities, stakeholders and the TRHDP PO to understand the natural and human components of the study areas, from the upstream Tina River catchment to the mouth of the Ngalimbiu River.

E.4.1 Physical Environment

The Ngalimbiu River drains in a northerly direction from some of the highest peaks (2000+ m) on the island of Guadalcanal. The river has two main tributaries, the Tina and Toni rivers. The catchment area of the Tina River is about 150 km^2 compared to 45 km^2 for the Toni River. The Tina River contains a diverse fish community and is unaffected by human development in its upper reaches.

The Tina River is a single channel meandering river. It has torrential behaviour with regular flash floods. The texture of its bed includes gravel, cobbles and boulders, and fine and coarse-grained sand. In the higher elevation headwaters of the Tina River, very large boulders are intertwined with logs. The upper Tina River is characterized by sequences of pools and rapids and sharp meanders. Major boulders, some greater than 3 m diameter, have accumulated along the channel bars. These large boulders indicate that intense floods occasionally occur within this reach.

In its middle reach, the river enters steep limestone gorges where its course is more confined and less meandering. At this location most of the river's course is made of rapids. In many areas, river banks are dominated by rock outcrops. The dam and reservoir site are located in this area.

The river reach downstream of the dam site flows through an area having shallower shoreline slopes, lower gradient, and many meanders. The powerhouse will be located in this area. The density of human settlements also gradually increases with distance downstream to the confluence with the Toni River, where the river becomes the Ngalimbiu River. The Ngalimbiu River flows across a flat coastal plain characterized by denser human settlement, oil palm plantations, and gravel extraction.

Average daily temperatures in Guadalcanal range from 22°C to 31°C throughout the year, with a yearly average of 26.6°C in Honiara. The island has a tropical moist climate with regular rainfall. Rainfall increases with altitude and is higher on the windward coast (South shore). Annual rainfall at both Honiara, and Honiara International Airport is 1972mm, with summer months being the driest. It was estimated that annual rainfall at the dam site exceeds 2500mm per annum, and in excess of 3500mm of total annual rainfall in the headwater reaches of the Tina River.

Guadalcanal is periodically subjected to tropical cyclones that are most likely to occur between November and April, and are associated with extreme rainfall events. The Tina River experiences flash floods almost immediately after heavy rainfall events occur in the upper catchment. Flow and water level can change rapidly during such events.

Soils that cover the steep slopes of the construction area, adjacent to the Tina River, are shallow and unstable. They are comprised of colluvial rock debris. However, in stable areas, soils are deep and leached. A significant number of landslides occur within the Tina River catchment, particularly on the steeper slopes. However, they remain relatively small, and are primarily associated with rockslides along bedding planes. Slope instability is an active and ongoing process within the proposed reservoir area.

The dam site is located in an area of significant seismicity. Along the South Solomon trench, seismicity is predominantly related to subduction tectonics, and large earthquakes are common. Fourteen earthquakes having a magnitude of greater than 7.5, have been recorded since 1900. A Seismic Hazard Assessment for the project was undertaken in 2014.

Alluvial deposits are the predominant riverbed material. Bed load sediment ranges in size from silts and sands in low flow areas, to large boulders in very high flow areas. It is assumed that the depth of alluvium reaches approximately 10 m within the river channel, and up to a depth of 25m in some locations. Alluvial terraces occur adjacent to the current river course and bars. Terraces vary from 1.5m to 5m above the current river level. Bed load sediments are materials likely to be deposited into the storage reservoir

Water quality in the upper Tina River upstream of inhabited areas is good as there are no anthropogenic sources (i.e., no domestic use, no gold panning, etc.) of pollution. Natural peaks in turbidity following flash flood events are considered to be the primary cause of degraded water quality. Air quality is generally excellent in the Project area and there are no air quality non-attainment areas in the vicinity.

Ambient or background noise is consistent with a largely un-mechanised society. Nighttime noise levels typically range from 30dBA to 40dBA, and 40dBA to 50dBA during daytime hours. Occasional spikes up to 75dBA to 80dBA may occur close to villages when chainsaws, petrol powered electrical generators or petrol powered water pumps are in use.

E.4.2 Terrestrial Environment (Flora and Fauna)

A total of 161 plants species were identified during field surveys. Among them 5 species are listed as being vulnerable, and 19 are listed as being threatened. The majority of flora species listed as either threatened or vulnerable are timber species harvested for the local or export trade. The primary habitats of the study area are comprised of forested and non-forested ecosystems, which represent a mix of modified and natural habitats. The level of disturbance increases with distance downstream in the catchment. The upper Tina River catchment, upstream of the dam site, is dominated by highly valued, undisturbed lowland forests, whereas, the area downstream of the dam site near Choro, is dominated by disturbed forests. This is mainly the result of anthropogenic activities (e.g., logging, settlements, gardens, trails, etc.). Disturbed areas such as Black Post Road, and the proposed access road and transmission line corridor, are colonized by invasive plant species. The pristine montane forests found in the upper Tina River catchment will not be directly affected by the Project.

The fauna baseline study has shown that wildlife species thrive in pristine forests of the upper Tina River catchment, but also in the more anthropogenically altered areas in the middle and lower reaches of Tina River. A total of 60 wildlife species were observed by the ESIA team in the study area (which encompasses the project affected area and wider catchment), including 9 amphibian, 5 reptile, 41 bird, and 5 mammal species. This includes 1 endemic amphibian, 1 endemic reptile, and 25 endemic birds. None of the three species listed as endangered or critically endangered (possibly extinct) identified in literature studies (the White-eyed Starling, King Rat and Emperer Rat) are known to be present in the Project affected habitats. The presence of the White-eyed Starling (Aplornis brunneicapilla) was not detected in the ESIA and feasibility report baseline studies, which extended several kilometers beyond the extent of project construction and operation activities. While the species does appear to have some reliance on primary forest for nesting, it also regularly feeds in semi- and heavily-degraded areas. It is not always easy to find this species during field surveys, and it appears to have movements which are not yet understood. There is thus potential for the species to use the project area at some point.

The Emperor Rat (*Uromys imperator*) is known from only three specimens collected by Charles Woodford between 1886 and 1888, at Aola, a coastal location on northern Guadalcanal, Solomon Islands (IUCN 2016a). Anecdotal information suggests that the species survived until the 1960s. Recent surveys for native rodents have been conducted at sites between 200m and 1,500m. So far, the Emperor Rat has not been detected, increasing fears it is extinct. Later reports suggest that the species became restricted to mossy montane forest (IUCN 2016a). With respect to the TRHDP, the core area of the Project does not overlap with the mossy montane forest, which is found at higher elevations. Therefore, the Project is unlikely to have any effect on the Emperor Rat, should it still exist on Guadalcanal.The King Rat (*Uromys rex*) is listed as endangered and is endemic to the island of Guadalcanal, Solomon Islands, but is absent from large parts of the island. It has been recorded at elevations of 20 and 600 masl. It is an arboreal species that has been recorded from primary tropical moist forest, including relict patches of native forest. There are few recent records of this species. The most recent recorded captures include a single specimen in 1987 from a relict outlier of tall rainforest in the Poha Valley, approximately 35km west of the Project, and two specimens at Gold Ridge in 1989. An intensive survey of Mount Makarakomburu in 1990 failed to locate the species. Relatively recent records in and near the project area, and some apparent tolerance of the species to forest fragmentation and invasive species, suggest that the King Rat may still persist in higher quality forests of the project area. The absence of records on project surveys should not be taken as evidence of the species' absence, since it is extremely difficult to survey for rare, nocturnal, arboreal rodents.

There are no formal protected areas or proposed protected areas that could be affected by the TRHDP. Informal protection of many small, natural sites called “Tambu” is provided by the local population, which protects these areas in a traditional manner.

E.4.3 Aquatic Environment (Fish, Fisheries and Water Quality)

Current water quality in the Tina River does not appear to be a limiting factor for aquatic life, given the low level of pollution.

The householder survey along Tina River shows that fresh river fish do not feature prominently in people's diets, and that canned tuna is now the main source of fish protein. Despite local people's obvious knowledge of the fish species found in the Tina/Ngalimbiu River, from a livelihoods point of view, that the studies suggest that fishing is now only a minor activity. Fishing activities take place during “fishing trips” in the upper catchment, upstream from Choro. The main mode of fishing is by snorkel diving using a spear gun, and is sometimes carried out at night. Fishing is a significant source of livelihood only at the mouth of the Ngalimbiu River, where semi-commercial fishing occurs using mosquito seine nets, gill nets, and other methods.

Regarding aquatic ecology, 59 species of fish were recorded within the Tina/Ngalimbiu River system, from the upstream catchment area to the mouth of the river.

In Solomon Islands, as with other mountainous islands of the Indo-Pacific Region, Gobioid fishes are the dominant fresh water fauna, and are mainly represented by members of the Gobiidae and Eleotridae families. Baseline fish surveys showed that the Gobioid group was represented by 34 species (25 Gobiidae, 8 Eleotridae and 1 Rhyacichthidae).

Like other tropical islands of the Indo-Pacific Region, all native species encountered in inland fresh water are migratory species with a life cycle that alternates between ocean and river. Two main migration patterns are followed: catadromous and amphidromous. Eels are catadromous fish with adults migrating to the ocean to spawn, and juveniles migrating back into freshwater systems to grow to maturity. During their upstream migrations, juvenile eels are able to climb to the upper reaches of the Tina River.

Most of the other aquatic species, such as Gobioids Mesopristes and prawns, are amphidromous. Spawning occurs in the rivers, and larvae drift passively to the ocean before migrating back as juveniles to the freshwater system where they grow into adults. The factors triggering upstream migration of juveniles are not completely understood. However, it is postulated that flooding, which causes high turbidity, and lunar cycles, play a role for triggering migration in some species. Without mitigation measures, the hydroelectric project will impact fish migration to, and production within, the upper Tina River catchment. Given current limited knowledge of the Tina River's ecology, monitoring during the project will play an important role in understanding whether planned mitigation is effective in ensuring no net loss of fish species and densities in this catchment.

The upper Tina River catchment plays an important role in fish life cycle but not a critical one since:

- fish within Solomon Islands do not show natal stream homing behavior. Rather, juveniles will colonize any rivers to which they can gain access; and
- the mouth of the Ngalimbiu River is more critical to the life cycle of most fish species than upstream areas, as it is the only entry point to all fish that live within the catchment.

Based on current knowledge, the upper Tina River is a highly valued aquatic habitat but not a “critical habitat” for fish species present in Guadalcanal.

E.4.4 Social Environment

The baseline social studies included a review and consolidation of existing information regarding the project area and its various communities, along with an extensive program of community consultations. More than forty-five (45) village communities attended the survey meetings. Attendees included tribal chiefs, village chiefs, men, women, adolescents, and children. Overall, a total of five hundred and eleven (511) people attended the meetings. Valuable data and information was collected during the course of the social field surveys, from the village communities, and also from various stakeholders, including government ministries and provincial offices.

Kinship is the most important basis for community formation and action among the people of the TRHDP area. After kinship, church membership is the next most important basis for local social organisation and action.

The counts made during the social fieldwork put the Bahomea/Tina population at roughly 1800 persons, representing approximately 362 households. Of these, 9 people live in villages in the by-passed river reach between the dam and powerhouse. This includes the villages of Choro, Koropa and Senge. A further 1098 people live in villages likely to be affected by the quantity and quality of the water in the Tina and Ngalimbiu Rivers during and/or after construction. The remaining 693 people live in villages likely to be directly affected by roadworks, the creation of new roads, and by construction traffic.

In the absence of financial capital, local people use a range of livelihood strategies, including a mix of the following:

- traditional garden cultivation and gathering of staple foods for subsistence needs, combined with occasional hunting;
- cash-earning activities to raise money to pay for imported food, shop goods, school fees, technology, community obligations, and household needs. Such activities typical include one or several of the following:
  - household-scale cash crop production, with the produce sold in the central market in Honiara (The householder survey indicated that 100% of the households grew crops of some kind for home consumption, while 70% said they grew or collected produce for sale,);
  - small-scale timber milling for local and Honiara markets;
  - local day labouring, for example, in timber milling, garden clearing, house building, and other activities;
  - running a small home-based business, such as home baking, natural materials handicrafts, a local shop-canteen selling small items, vehicle hire, and other activities;
  - full or part time employment for a government agency or large company – typically the Gold Ridge Mining Company (GRMC), GPPOL, Earthmovers Logging Company, QQQ enterprises market gardens; and
  - fishing at the mouth of the Ngalimbiu River.

These strategies mostly rely on having good access to:

- local natural capital such as land, forests, rivers, and forest products;
- household human capital, including traditional and formal skills and knowledge, and labour;
- physical capital in the form of tools, equipment and transport infrastructure; and
- social capital in the form of assistance from neighbours, relatives, and fellow church members.

Important strengths of the residents of the project area are the depth of their traditional knowledge and skills and their ability to live in a largely natural environment and acquire a livelihood from it. The Tina River is an important natural resource and feature in the lives of people of the project area. For example it is:

- the main source of drinking and cooking water for the whole district;
- a source of irrigation water;
- a place to bathe, wash clothes, clean vegetables, and participate in recreational activities, such as swimming;
- a transport corridor;
- a source of food, including fish and crustaceans (although these are a minor part of the residents' diet), and a range of plants found in and around the river and tributary streams;
- a fence and boundary marker (e.g., in some villages pigs are kept on the opposite bank of the river);
- a source of rock, sand and gravel for use in local house building, and for villages in the West Ghaobata area to sell and collect royalty payments; and
- a car wash - in its lowest reaches.

Based on observations made in the villages of the TRHDP area, school attendance appears to be relatively low. The accessibility of health services is a significant issue for communities of the project area. This is particularly problematic in cases of accidents, complications of childbirth, and child diarrhea and fever. All of the local roads are unsealed, inadequately drained, poorly formed, badly located in some places, and lacking an adequate or durable surface.

E 6. IMPACTS AND MITIGATION MEASURES

E.5.1 Mitigation workshops

Mitigation workshops were held in February 2014 to meet with communities and present information on potential impacts of the Project, along with a first draft of possible mitigation measures. The aim of the workshops was to exchange ideas on these measures and to obtain input on people's issues and concerns, including any grievances, regarding the potential project impacts. Following these workshops, stakeholder issues and concerns were addressed in the impact assessment and mitigation sections of the ESIA. Mitigation measures were adapted to local population needs and aspirations.

Communities affected by dam construction and operation activities, landowners who have customary rights in the project-affected area, and downstream affected communities were present at the mitigation workshops. NGOs and government agencies participated in separate workshops. A total of 442 people attended the workshops.

Figure E-0-4 - Young people discussing the Project's impacts during the village workshops (Antioch (left) and Pachuki (right))

E.5.2 Environmental and Social Impacts and Mitigation

E.5.2.1 Impacts on Physical Environment and Mitigation

Potential physical environmental impacts may include induced seismic activity, local slope instability, soil compaction and erosion, changes in hydrology (surface water and groundwater), changes in sediment transport, temporary impacts on local air quality, and greenhouse gas (GHG) emissions. In turn, impacts on the physical environment may influence the project's viability or sustainability.

A range of mitigation measures have been proposed in the form of management plans and actions to address project construction and operation impacts on the physical environment. These are documented in the Environmental and Social Management Plan contained in Chapter 13. With the application of appropriate mitigation, monitoring and management methods, low to moderate direct and indirect impacts will accrue to the physical environment within the project area.

The Project will have a net GHG reduction potential of 49,500 tCO_2eq per year as a result of reduced use of diesel fuel for power generation. This takes into account potential emissions from the Project during construction, land clearing, and reservoir operation. The Project's net GHG reduction potential for the assumed Project life of 50 years is 2.48 million tCO_2eq.

Figure E-0-5 – Example of RCC Dam Construction

E.5.2.2 Impacts on Flora and Mitigation

Construction activities will necessitate clearing approximately 115.49 ha of natural vegetation in the Core Area, approximately 50 ha of which is disturbed forest and 9.5 ha of which is undisturbed forest, to create an access road and to prepare the reservoir area. Approximately 15 ha each of riparian and cliff vegetation will also be cleared. Measures to mitigate impacts include conducting a pre-construction road alignment survey to delineate environmentally sensitive areas where valued or protected species are to be avoided or, where avoidance is not possible, transplanted where feasible. Changes in road alignment may be necessary based on this survey. Good international industry practice (GIIP) will be implemented by the construction contractor that is responsible for forest clearing to minimize impacts, including maintaining canopy trees where possible. Some natural habitat will be disturbed beyond the road alignment and footprint of other project components, as a result of colonization by invasive species and fragmentation of habitats.

Project operation will necessitate vegetation control under the transmission line. Herbicides will not be used for vegetation clearance, due to the potential toxic effects on amphibians and reptiles, fish and water quality. Instead, manual vegetation control methods will be employed for the Project to maintain the right-of-way.

The presence of the access road will provide local communities in the project area with improved access to harvest forest resources in areas that are currently accessible only by logging roads, including forest resources located in areas upstream of the dam. The access road would be an agent of change in the area if access is not controlled. Land use along the access road may also change with the arrival of new settlers. For this reason, access to the Core Area will be controlled throughout operation.

Improved access could also facilitate increased presence of people in the area around the dam, which could in turn lead to colonization by invasive plant species on areas cleared by, but no longer required for, the Project. Site restoration using native plant species will be undertaken in affected areas to minimise the potential for invasive plant species to become established. A washing station will be used to clean vehicles of soil that may carry the eggs of African Snails.

As part of the financing provided for the Project, SIG will provide funding to an NGO to undertake studies and consultations to determine the feasibility of establishing a protected area in the upper catchment of the Tina River. The NGO will work closely with customary landowners as in Solomon Islands, establishment of a protected area originates with the landowners of the land. No net loss of biodiversity is to be achieved by supporting the protection of the Tina River upper catchment, protecting the remaining natural habitat within the Core Area, rehabilitating impacted habitat post construction and rehabilitating 9.54 ha of existing modified habitat within the Core Area. These measures will be detailed in the Developer's Biodiversity Management Plan and the Post-Construction Rehabilitation and Revegetation Plan.

E.5.2.3 Impacts on Fauna / Fauna Habitat and Mitigation

E.5.2.3.1 Terrestrial Fauna

The TRHDP will be located within the mid-elevation river gorge and downstream catchment areas where human settlements and commercial logging activities have previously contributed to habitat alteration. No critically endangered or endangered species have yet been found within these project-affected areas. Likewise, there do not appear to beany areas associated with key evolutionary processes or globally significant numbers of migratory or congregatory species. Whilst there are restricted range and endemic species, the habitat available within these project-affected areas represents only a small portion of the larger habitat area available to these species adjacent to, and upstream of, the proposed development. Consequently, the areas directly affected by construction and operation of TRHDP are in the vast majority are not considered critical habitat.

The undisturbed montane forest above 400masl in the upper catchment to the south, west and east of the dam site and reservoir qualify as critical habitat because of this ecosystem's limited global distribution and particularly unique assemblages of species.The TRHDP footprint represents a very small proportion of the overall Tina River catchment (<3% of land area), and only directly impacts a very small area of forest which could potentially be considered Critical Habitat. These impacts are not considered significant. To ensure that indirect impacts to Critical Habitat found in the higher elevation area are minimised, measures will be put in place through the Tina Core Land Company who will hold the Core Land to restrict access to the upper Tina River catchment through the Core Land, in effect helping to preserve this area from future resource exploitation. This protection will be furthered by measures in the Biodviersity Management Plan to monitor forest clearing, including illegal logging (eg. logging on sloping land above 400 masl).

Forest clearing in the Core Area is the main activity that will adversely affect terrestrial fauna including less mobile species, such as amphibians and reptiles that are unable to avoid being struck by moving equipment and vehicles. Clearing will disturb fauna and fragment habitats upon which they are dependent. Just over 115 ha of vegetation cover will be permanently removed from the project area. Of that amount, 50 ha has forest cover, but only 9.5 ha can be considered primary forest. Half of the other 40 ha is disturbed secondary forest, and the other half is remnant forest, i.e., secondary forest formed by natural revegetation of cleared areas. The 50 ha represents 0.9% of the total area of non-montane forest and 0.3% of all forest in the catchment, In the context of the assemblage of terrestrial vegetation communities and the wildlife habitats they provide, this permanent loss within the Tina River catchment is not considered to be significant. Approximately 15 ha each of riparian and cliff vegetation will also be cleared. The proposed mitigation measures will help to ensure the direct impacts of vegetation clearing are confined to the 115ha. The developer will prepare a Biodiversity Management Plan (BMP) with the objective of achieving no net loss of biodiversity as a result of natural habitat conversion. The BMP will provide for an offset that will include measures to protect the remaining natural habitat in the Core Area and a program to rehabilitate modified habitat.

Some impacts identified during construction of the Project will continue to affect ecosystems during operation. These impacts are related to the access road. The access road will probably be a low-volume road, with impacts being related less to vehicle-wildlife interactions, and more to ecological modifications brought about by opening of the canopy and increased human presence. Together, these will act as agents of change in the areas adjacent to the road. Whether the access road will be beneficial to reptiles is difficult to assess. Some species, such as snakes, may benefit from openings in the forest canopy created when the road is established, while smaller species might be more vulnerable to feral cats. Grassland birds will be able to colonize areas along the access road. The access road will allow villagers to move into areas that are currently not heavily exploited, putting pressure on wildlife and other natural resources.

Impacts will also arise due to the operation of the dam, including reduction in water recharge of riparian micro-wetlands along Tina River. Conversely the changing water level of the reservoir will open up new aquatic/terrestrial contact zones providing new wetland habitats. These changes will have both positive and negative impacts on amphibians and aquatic insects.

Mitigation measures include controlling access into undeveloped areas as well as specific measures to mitigate impacts on individual species, such as no or low lighting (directed downwards) and fauna underpasses in stream culverts along the access road. Development and implementation of management and monitoring plans that apply good international industry practice (GIIP) will be employed in an effort to reduce the level of disturbance to wildlife.

E.5.2.3.2 Aquatic Fauna

Most impacts to the aquatic ecosystem of the Tina River, including fish and other aquatic organisms, are associated with the physical presence and operation of the dam and power station. Potential impacts during construction are short-term, mainly involving increases in suspended sediment concentrations and turbidity downstream as a result of land clearing and cofferdam installation. Possible spills of fuel, concrete washwater, and other chemicals could also affect water quality. Mitigation and monitoring measures including sediment traps and fuel tank bun ding are included in the ESMP to address these impacts.

Beginning with cofferdam installation and continuing throughout the life of the project, flow in the 5.7 km reach of river that is bypassed by the headrace tunnel would be drastically reduced, except in periods of heavy rainfall when water would spill over the dam. Simulation of the hydro operation indicated that floods or freshets would occur on average every 6 weeks, and their average duration would be between 4 to 6 days. Release of an environmental flow of 1 m^3/s will be required to avoid damage to the aquatic ecosystem in that reach; this has been determined to be sufficient to preserve the aquatic ecosystem and permit fish movement up and downstream. The 1m^3/s EF release at the base of the dam would act as an attraction flow to attract fish into the area for trapping before being hauled over the dam, as described below. It will have the further advantage of ensuring river users along the by-passed section or river (i.e., at Choro, Koropa, Sengue) continue to have access to some water, and that the aquatic ecology of the by-passed stretch of river is supported. Villages located along the bypassed section that depend on the river for drinking will be provided with alternative water supplies.

The dam and reservoir, and to some extent the associated by-passed section of the Tina River, will represent a barrier to the upstream and downstream migration of all native fish species that currently utilise the river system upstream of the dam site. Unless mitigation measures are implemented it is anticipated that most of, if not all, native fishes will disappear from the upstream Tina River catchment. In addition, fish mortality in the powerhouse turbines is a potential impact, as fish become entrained into the power intake of the reservoir and are conveyed to the turbines via the headrace tunnel and penstocks. Mortality of upstream migrating juvenile fish would also occur if they are attracted to the outflow of the powerhouse and then climb into the turbines.

The EF of $1m^3/s$ would be required to enable fish to move up the by-passed section of river to the base of the dam. This EF would be supplemented naturally by up to $1m^3/s$ of additional dry season inflow from the lateral tributaries to the by-passed section of river. Fish density and species richness are likely to be greater with a flow of $1m^3/s$ than with the current median flow of 11.1 m^3/s. The estimated fish density at an environmental flow of 1 m^3/s is approximately 50 fish per 12 m^2. This is slightly less than the average of 60.4 fish/$12m^2$ observed in the Toni River and considerably higher than the 6.7 fish/$12m^2$ observed in the Tina River. Similarly, the estimated number of species per quadrat with an environmental flow of $1m^3/s$ is 2.1 compared to the observation of 2.61 and 1.17 in the Toni and Tina rivers, respectively.

A 1 m^3/s flow will provide for fish passage and maintain pool habitat for the pool dwelling species and good riffle habitat for the riffle dwelling species that comprise the majority of fish in the river. In addition, the study suggests there will be an improvement in habitat quality resulting from a reduction in the amount of fine gravel and sand in the river channel.

A minimum of $2.4m^3/s$ will be released to the river from the powerhouse during nighttime hours and those parts of the day when power is not being generated to maintain habitat for aquatic organisms downstream and dampen somewhat the fluctuations in flow between full power generation and reservoir refilling. When combined with the $1m^3/s$ EF release from the dam, this will mean a minimum dry season flow in the river immediately below the powerhouse of $3.4m^3/s$ -- more if small upstream tributaries continue to discharge during the dry season.

An extensive examination of alternative technologies to enable fish migrating upstream to pass the dam led to the conclusion that a combination of a trap-and-haul system at the dam and an EF of $1m^3/s$ from the dam, and a trap-and-haul system at the powerhouse, is considered the only potentially viable system to ensure fish can continue to populate the upper catchment area. If necessary, this would be further augmented by netting swimming species of fish as they congregate in the mouth of the river or at the base of the dam, for transport and release above the dam. The proposed mitigation would be undertaken using an adaptive environmental management approach in accordance with the EBRD's policy for hydropower projects. This approach would evaluate the effectiveness of the system, and look at other means of ensuring upstream fish passage, in the event that a trap-and-haul system is not successful.

Figure E-0-6 shows a trap system with ramp leading to a holding tank and piped water supply installed at Waitaki Dam, New Zealand. Fish from the trap are to be released in or upstream of the reservoir at a location that will avoid the possibility of fish being entrained by spillway or power station flows. The ramp allows migratory fish to climb to the trap, where they remain until transferred to an upstream location.

Figure E-0-6 – Example of trap system

Installation of fish screens is recommended at the power intake structure to prevent entrainment of eels during their downstream migration. This should be supplemented with periodic releases over the spillway to facilitate movement of adult eels during peak migration conditions. Likewise, a fish barrier or repelling system is recommended for installation in the powerhouse tailrace to prevent mortality of upstream migrating juvenile Syciinids when they enter the turbines. Further, it is recommended that the potential to farm fish within the reservoir be considered if this could be accomplished using species of fish that are native to the Tina River, and which could thrive in a lentic environment. Monitoring of species would need to be done to verify the efficacy of such a program.

Although none of the fish species utilizing the Tina/Ngalimbiu River system will be permanently lost from Solomon Islands if these mitigation measures are not implemented, the loss of viable fish populations from the upper Tina River catchment is an unnecessary impact that can largely be avoided, given the apparent efficacy of mitigation measures that are available.

Fish populations and benthic invertebrates will be monitored upstream and downstream of the dam beginning prior to construction in order to determine actual impacts on fishes and the aquatic ecosystem in this pristine portion of the Tina River and provide a basis for adaptive management if neejded. Comparative monitoring will also take place in the Toni River. Aquatic invertebrates will also be monitored downstream, since they are good indicators of long-term impacts on water quality.

E.5.2.4 Social Impacts and Mitigation

The social survey fieldwork covered all of the settled area within the anticipated direct, indirect, infrastructure, and wider impact areas. A high level of participation by the village communities was achieved, with all levels of community members attending focus community workshops and follow up consultations, including adults, youth, women and children.

Several types of social impacts could occur, as a result of the TRHDP. These include:

- direct physical effects on nearby people and households, such as: intrusive noise and vibration, shock waves from blasting, dust and air emissions, soil and groundwater contamination, degraded water quality, and visual intrusion, all of which have the potential to affect health, wellbeing and/or use of local amenities. Physical impacts were identified as a major concern in the vicinity of the dam, tunnel and power house construction (e.g., noise and vibration). This is particularly the case for people living in the villages of Habusi, Managikiki, Namopila, Pachuki and Senge;
- loss of access to the abundant clean fresh water provided by the Tina River during construction and in the low flow river stretch;
- destruction and/or loss of: access to fishing areas on Tina River; food garden areas; hunting areas; plant and related materials; and other important resources; with negative impacts on wellbeing;
- opportunities for improved incomes through employment on project construction and operations, and in new ventures;
- increased risk of disruptions to movement and accidents, given the increase in project-related transport;
- improved road mobility between villages in the project area and between the project area and Honiara;
- threats to indigenous land, natural resources, security, and local culture from intrusion by outsiders;
- potential reduction in gravel extraction over the long term;
- safety issues related to daytime powerhouse flow releases of 24 m^3/s, and;
- opportunities for improved quality-of-life, through the provision of replacement services and facilities.

The people and communities most likely to be adversely affected by the project are those living in or utilising areas for their livelihoods, that are close to the proposed project sites.

In addition, people in most riverside communities, especially women, expressed concern about the potential for the failure of the hydropower storage dam and the devastation and loss of life that would occur in the unlikely event that this happened. Members of the indigenous communities expressed anxiety about the potential for social conflict between landowning groups and with the SIG over land and resource ownership and access rights, royalties, compensation payments, and access to development opportunities and benefits.

To most local people and communities, the Project is seen as offering the opportunity for their villages, churches, and houses to be electrified. Stakeholders believe the construction of the Project will provide opportunities for direct and indirect employment and training in the trades, plant and machinery operation, administration, and security work. The creation of the access roads and the upgrading of the existing Black Post-Tina-Mangakiki Road are seen by local people as a considerable benefit to the community. The TRHDP will be accompanied by a community benefit share fund anitipcated to provide non-cash development benefits to the host community. This fund is outlined further in the Community Development Plan.

People in the wider project area believe that the TRHDP may be a good and, perhaps, easy, source of income. This is expected to come from access fees, meeting fees, royalties from use of the river water and construction materials, and rents for use of the land for infrastructure and project sites.

To mitigate potential impacts and enhance benefits the following measures will be implemented:

- Priority be given to job-seekers from the Bahomea and Malango landowning tribes, ahead of other national employment;

- The TRHDP developer and its construction contractors be required to implement a Workers' Code of Conduct covering, at the very least, working hours and conditions, safety, vehicle use, care for the environment, and socially and culturally acceptable behavior in the villages of the project area (see Annex 18 of the Annex report);
- All communities using the river as the main supply source for fresh water will be provided with reliable alternative clean water supply prior to start of construction;
- Road safety concerns on Black Post Road will be addressed by: installing roadside fencing adjacent to village areas, speed controls near residential areas, creation of safe crossing points, bus stop bays, and using best practices for the transport of dangerous goods;
- Use-rights for the storage reservoir and its margins, dam and powerhouse access roads, and other land acquired for the project Core Area will be defined by the Tina Core Land Company (TCLC) together with the Developer as lessee;
- The benefits-sharing program instituted by the SIG and the TRHDP PO will focus on delivering social services, education, training, and improved facilities to host communities. Cash payments and top-down delivery through individual leaders willbe avoided and both gender specific programs and gender mainstreaming will be incorporated into the fund design;
- Prior to construction, the TRHDP PO will put in place a protocol for managing cultural heritage. The protocol in the ESIA includes arrangements for avoidance or relocation of cultural or heritage assets, and for compensation where avoidance of assets is not possible or feasible;
- The TRHDP PO acknowledges the effects of project construction and operation on squatters and settlers;
- Consultations will continue with project-affected people and communities, including downstream communities, throughout the life of the Project, using culturally appropriate, inclusive and proven methods and arrangements of stakeholder engagement; and
- Impacts on gravel extraction will be monitored.

E.5.2.5 Land Acquisition and Livelihoods Restoration Plan

World Bank Environmental and Social Safeguard Policies require that where a project undertaken by a Client of the Bank involves land acquisition or restriction of access to sources of livelihood, the relevant Operational Policies (OP) must be followed. In the case of the acquisition of the project land, the relevant policies are OP 4.12 (Involuntary Resettlement) and OP 4.10 (Indigenous Peoples).

A usual consequence of these two safeguards would be the preparation of Resettlement Action Plan and an Indigenous Peoples Plan (IPP). For the TRHDP, the project area was selected to be sufficiently far upstream and sufficiently small that no residential buildings or households will need to be relocated. Therefore, to provide clarity to all stakeholders, the nomenclature for the resettlement action plan was changed to Land Acquisition and Livelihoods Restoration Plan (LALRP) to reflect that land was being acquired, and that the consequent impacts on livelihoods and livelihood assets were assessed and mitigated in accordance with the Safeguards. An IPP was not prepared in accordance with the provision of OP 4.10 that provides that a separate IPP is not required when the overwhelming majority of the project beneficiaries are indigenous peoples, and the elements of an IPP are incorporated into the project design.

A LALRP has been prepared that identifies the actions that have been and will be taken to avoid, minimise, mitigate, or compensate for the adverse livelihoods impacts of the land acquisition and restrictions on land use arising from the Project. The Plan seeks to achieve an equitable and socially and economically sustainable situation for the people whose land is being acquired. This includes ensuring those affected by the acquisition are engaged in its planning and have opportunities to participate in devising and implementing livelihood preservation and restoration. The key points of the plan are:

- Land acquisition was undertaken with the explicit, written consent of the customary landowning tribes;
- Landowing tribes receive payment for full market value of their acquired land including the value of commercial timber;
- Support provided to landowning tribes to establish, manage and invest in a corporation owned by their tribe (co-operative society) including accounting support. The TRHDP PO designed the framework legislation and rules for each society in close consultation with tribes to provide a culturally relevant governance structure;
- To prevent elite capture, and provide sustainable income, through the rules of the co-operative societies, land acquisition payments are divided between future investment, customary obligations, individual payments and administrative costs. Individual payments are made directly to individual bank accounts set up by TRHDP PO for every women, man and child in each tribe. Payments for children held in trust for school fees until 18;
- Creation of the Tina Core Land Company (TCLC) to hold the Core Area, a joint venture with SIG, with 50% of shares provided (free) to the customary landowninng tribes to ensure an ongoing ownership of the land and role in its future use and development;
- Targeted measures for gender equality including presence of women on tribal corporation executive committees; and
- Survey of all assets on project affected land, including gardens and fruit trees, identification of their owners (with or without formal rights to land) and entitlement matrix for compensation and livelihood restoration (see LALRP).

E.5.3 Free Prior Informed Consent (FPIC)

The flow of information from the TRHDP PO to the affected communities appears to have been of a high standard. The TRHDP PO recruited a well-known indigenous media person to develop and document its information sharing and awareness raising activities. The TRHDP PO has made use of a variety of culturally acceptable means for communicating with local communities and stakeholders. Important communications have been, and continue to be, done face-to-face, starting with tribe and village chiefs, and senior women, and then extending out to the wider village communities. Local communications are undertaken by the project's indigenous community relations staff and Community Liaison Assistants (CLAs), and endorsed by community leaders. A wide variety of communications tools have been used to inform the communities and to receive comment and advice in return. Among these are: printed materials, including a project booklet; face-to-face briefings and discussions with groups of community leaders, individuals, community interest groups (e.g., mother's clubs, and church groups) and agency representatives; mobile phone and SMS; presentations using video, photographs, maps, and posters; and site visits. Information briefings to local communities and various groups of stakeholders at key points in the project planning process has been done in local languages, and has been accompanied by the use of audio-visual aids.

Based on the records of the TRHDP PO, discussions with TRHDP PO staff and CLAs, observations, and explicit comments from participants during the 2013 ESIA village community workshops and 2014 mitigation workshops, it appears that:

- There is broad support among local communities for the Project and there is no clear direct opposition to it. A minority of clan leaders and aspirants have objected publically to the land identification and acquisition process undertaken by the Bahomea Land Identification Committee (BLIC) and to the market value valuation of acquired land by the Commissioner of Lands.
- Hydroelectric development is widely seen as the most preferred and least destructive development opportunity for the Tina/Ngalimbiu River catchment (others being gold mining and logging of primary forest);
- community concerns about the project are generally confined to the mitigation of potential impacts and the securing of benefits;
- There has been a comparatively high level of participation of community members of both genders and all ages in the TRHDP PO's activities.
- There is wide-spread understanding of the purpose of the TRHDP, and what it generally involves, although the details of particular hydropower generation options are not well understood, especially by women;
- There is a high degree of trust of the TRHDP PO and the information it has provided, and a sense that local peoples' concerns are being heard and dealt with, even though there is little trust in government, generally;
- There has been considerable discussion within the communities about the Project, including its benefits and potential impacts; and
- SIG acquired the Core Area with the prior, written, negotiated consent of the identified customary land owning tribes (see LALRP).

TRHDP planning to date appears to comply with the requirement of FPIC and, to date, community consent has been achieved at each stage.

E 5.4 Environment Social Management Plan

The Environmental and Social Management Plan allocates responsibilties for implementing each of the identified mitigation measures. The ESMP will form the minimum standards for the Developer's Construction Environment Social Management Plan (CESMP) and Operations Environment Social Management Plan (OESMP). The Ministry of Environment, Climate Change and Disaster Management will review and approve the final CESMP and OESMP, with support from the Project Office.

The ESMP sets out the roles and responsibilities of implementing actors, including their capacity building requirements, together with an implementation schedule.

Monitoring measures include an independent environmental and social safeguard specialist to undertake regular monitoring and auditing to ensure compliance with ESMP measures.

E 7. CUMULATIVE IMPACTS

There are four important sources of disturbance in or near Tina/Ngalimbiu catchment that when combined with the TRHDP could result in cumulative impacts. These include:

- GPPOL's Oil Palm production;
- Potential expansion of mining on the Gold Ridge tenement;

- Artisanal and commercial harvesting of timber; and
- Gravel extraction on the Ngalimbiu River.

As shown in Table E-2, many of the cumulative impacts are related to land tenure issues, water quality issues, loss of biodiversity and economic growth in the area.

Table E-0-2 Summary of cumulative impacts

<table>
<tr><th>Impacts of TRHDP</th><th>Timber Harvesting</th><th>GPPOL Oil Palm</th><th>Gold Ridge Mine</th><th>Gravel Extraction</th></tr>
<tr><td>Decrease in slope stability, leading to increased soil erosion, and decreased water quality during construction</td><td rowspan="3">Low risk of cumulative impacts as long as no clear cutting is allowed nearby Tina River
High risk of cumulative impacts if, in the future, clear cutting is practiced nearby Tina River</td><td></td><td rowspan="6">If new gold mines are exploited in the SPL 194, there is a high risk of cumulative impacts in the Tina/Ngalimbiu River Catchment</td><td rowspan="3">Cumulative impacts along the Ngalimbiu River</td></tr>
<tr><td>Disturbance to aquatic habitats and aquatic life during construction</td><td>Aquatic habitat disturbance from drainage of the palm fields in the Ngalimbiu River Catchment</td></tr>
<tr><td>Disturbance of water uses during construction</td><td></td></tr>
<tr><td>Colonization by invasive species</td><td rowspan="3">Risk of cumulative impacts if additional logging activities take place in the may increase in the upstream area thanks to improved access</td><td>Oil Palm has opened the way for plant and wildlife invasive species</td><td></td></tr>
<tr><td>Habitat fragmentation</td><td rowspan="2">Oil Palm has transformed some downstream areas into monoculture fields</td><td rowspan="2"></td></tr>
<tr><td>Direct habitat and biodiversity loss</td></tr>
<tr><td>Land Related Issues</td><td>Land dispute</td><td>Land tenure alienation and land dispute</td><td>Land tenure alienation and land dispute</td><td></td></tr>
<tr><td>Employment</td><td>Creation of unskilled employment</td><td>Creation of unskilled and skilled employment</td><td>Creation of unskilled and skilled employment</td><td>Creation of unskilled employment</td></tr>
</table>

Impacts of TRHDP	Timber Harvesting	GPPOL Oil Palm	Gold Ridge Mine	Gravel Extraction
Food security pressure		Increased pressure on food security	Increased pressure on food security	
Challenges to cultural and traditional practices		Added pressure on traditional norms and cultural practices	Added pressure on traditional norms and cultural practices	
Substance abuse and increased criminal activities	Substance abuse and alcohol related abuse among men	Substance abuse and alcohol related abuse among men	Substance abuse and alcohol related abuse among men	
Visual intrusion	Degradation of landscape quality	Degradation of landscape quality	Degradation of landscape quality	Degradation of landscape quality
Degraded water quality	Suspended solids release due to logging	Herbicides and fertilizers pollution in both water and sediment in Ngalimbiu River	Turbidity, metal and heavy metal pollution in both water and sediment in Matepono River and in the Tina/Ngalimbiu River if SPL 194 is developed	Increase of turbidity in the Ngalimbiu River
Pressures on natural resources availability	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	Improved livelihoods – leads to increased population and related increased pressures on land and availability of natural resources	

Impacts of TRHDP	Timber Harvesting	GPPOL Oil Palm	Gold Ridge Mine	Gravel Extraction
Natural hazards and dam safety	Removal of forest upstream of dam, leading to floods, landslides and debris flows that could threaten the dam			

Regarding the probability of occurrance of the cumulative impacts, it should be noted that Gold Ridge Mine has been closed since April 2014 and has been sold to a local consortium that may not have the capacity to reopen it. Resumption of mining activity is not very likely, expansion into the Toni or Tina catchments even less so. There are no known plans for oil palm cultivation to expand in the catchment, and TRHDP will not add to oil palm's most significant potential impacts – water pollution caused by agrochemicals and wastewater discharges. Gravel extraction is also unlikely to expand and may in the long term diminish as the dam traps sediment.

Many constraints limit the implementation of global actions to mitigate cumulative impacts, particularly the lack of capacity of the SIG, the mixed-land tenure system in the area, and the lack of transparency of some local industries. Since TRHDP will be located in the upstream area of the Tina River system, mitigation measures designed for the Project will also address some of the cumulative impact issues. A second phase of cumulative impact assessment will be conducted by the SIG, after which the SIG will prepare a Cumulative Impacts Management Strategy.

E 8. EFFECTS OF THE ENVIRONMENT ON THE PROJECT

The Project will be designed and operated to withstand the various environmental calamities that could affect the project, including seismic events, landslides and debris flows, and severe weather-related events, to ensure the structural integrity of all its components, especially the dam.

Plans relating to dam safety and response to operations related emergency events will be prepared by the Developer.A Construction and Quality Assuranace Plan,and an Operations and Maintenance Plan, will be submitted for review and approval prior to Bank Appraisal. An Instrumentation and Emergency Response Plan will be developed during the project design phase, and will be submitted for review and approval prior to project commissioning.

SIG has conducted a Climate Risk Assessment that reached the following conclusions.

- Precipitation changes projected by climate models are distributed fairly uniformly over the year; by 2050 projected changes range between a decrease of 15% and an increase of 15%, on average no significant change.
- Temperatures are projected to increase uniformly over the year. By 2050 the increase will be between 0.5 ^{0}C and 2 ^{0}C,
- Based on an analysis of multiple climate projections, it is concluded that by 2050 the average basin runoff can vary between 80% (-20%) and 120% (+20%) of the present runoff; by 2090 the range would likely be between 70% and 130% of the present runoff.
- Generated annual energy could vary most likely between -20% and +10% of the energy generated under the baseline hydrological conditions. This range of annual energy generation is reflected in the economic analysis.

- On a global scale, tropical cyclones are likely to show an increase in rainfall rates of the order of 20% within 100 km of the cyclone centre, which could cause for the Tina River basin an increase in extreme flows of 25% to 30%. The operation manual, dam break analysis and emergency preparation plans should take the possibility of extremely high flash flood flows during tropical cyclone conditions into account.