Environmental and Social Impact Assessment

June 2017

SOL: Tina River Hydropower Project (Part 5)

Prepared by the Government of Solomon Islands for the Asian Development Bank.

CURRENCY EQUIVALENTS
(as of 9 June 2017)

Currency unit	–	Solomon Islands dollar (SBD)
SBD1.00	=	$0.1276
$1.00	=	SBD7.8308

NOTE

(i) In this report, "$" refers to US dollars.

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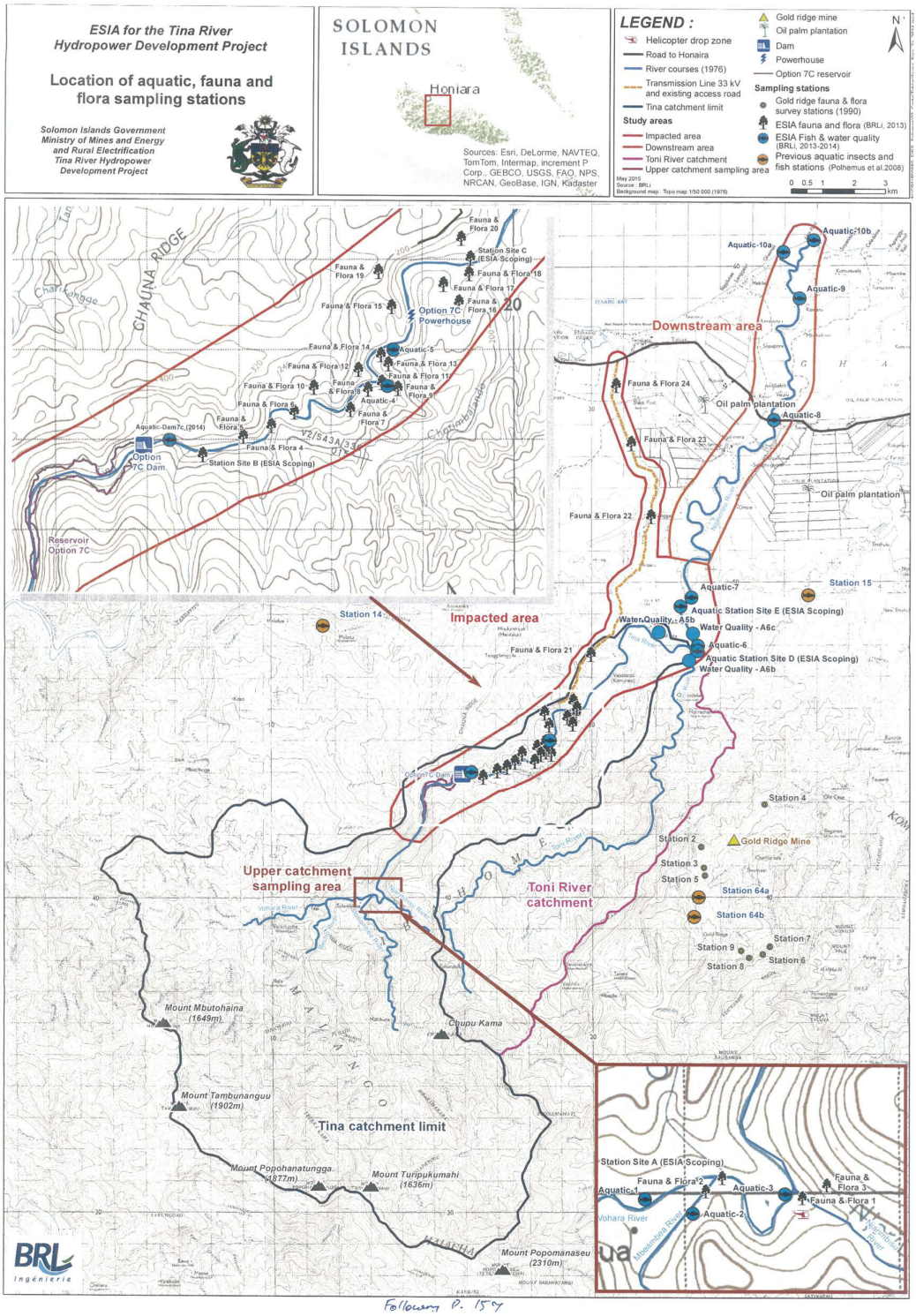
Figure 6-1 Biological sample sites



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6.3.3 Species of Concern

Three categories of habitat disturbance were defined according to their level of disturbance: weakly disturbed habitats, moderately disturbed habitats and highly disturbed habitats. According to the flora survey, the highly disturbed areas, such as the areas around the Black Post Road, have fewer species of concern (see Table 6-1 and Figure 6-2) (see Annex 8 in the Annex Report for the list of floral species, including species of concern).

Table 6-1 Number of flora species of concern

	Stations	Number of species of concern	Percentage of species of concern
Increasing level of disturbances	Fauna&Flora2	5	36
	Fauna&Flora1	5	17
	Fauna&Flora3	5	28
	Fauna&Flora7	5	15
	Fauna&Flora6	2	11
	Fauna&Flora5	4	18
	Fauna&Flora4	3	13
	Fauna&Flora14	5	33
	Fauna&Flora10	4	17
	Fauna&Flora19	2	10
	Fauna&Flora12	11	48
	Fauna&Flora15	4	29
	Fauna&Flora13	3	12
	Fauna&Flora9	3	13
	Fauna&Flora11	1	10
	Fauna&Flora8	2	11
	Fauna&Flora18	0	0
	Fauna&Flora17	5	23
	Fauna&Flora16	1	7
	Fauna&Flora20	0	0
	Fauna&Flora21	5	19
	Fauna&Flora22	0	0
	Fauna&Flora23	0	0
	Fauna&Flora24	0	0

Figure 6-2 Number and percentage of flora species of concern

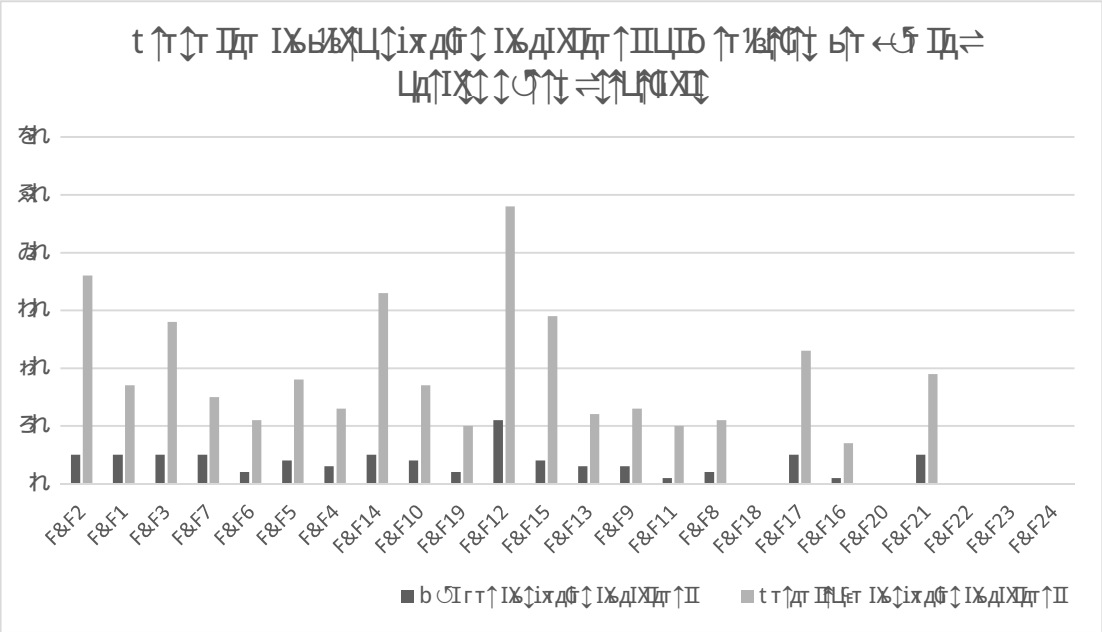


Table 6-2 identifies the threatened and vulnerable flora found within the study area (i.e. core area plus areas adjacent to the access road and transmission line). The majority of flora species listed as either threatened or vulnerable are timber species harvested for the local or export trade. Most of the area downstream of the dam has been affected by commercial timber harvesting, village settlements and gardens. With the exception of approximately 100m of access road, the road alignment from the powerhouse to the intersection with Black Post Road, and all of the transmission line, will be located within existing highly modified habitat.

Table 6-2 Threatened and vulnerable species of flora

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
Lowland forest, open vegetation, secondary regrowth along transmission line corridor ¯ Station #1	Canarium indicum	Ngali, Canarium nut	Planted, Few Trees	Threatened	Planted food nut tree, also used for timber
`	Intsia bijuga	Kwila, Iron wood	Few Trees	Threatened	High value timber species
`	Pometia pinnata	Pometia, Taun	Few Trees	Threatened	High value timber species
`	Vitex cofassus	Vitex, Vasa	Few Trees	Threatened	High value timber species
`	Alstonia scholaris	Alstonia, Milky Pine	Few Trees	Threatened	Export timber species
Lowland forest on ridge-tops along access road corridor ¯ Station #1	Pometia pinnata	Pometia, Taun	Few Trees	Threatened	High value timber species
`	Canarium indicum	Ngali, Canarium nut	Planted, Few Trees	Threatened	Planted food nut tree, also used for timber
Lowland forest on ridge-tops along access road corridor ¯ Station #2	Calophyllum peekelii	Calophyllum	Uncommon	Threatened	Export timber species
`	Syzygium onesima	Syzygium	Uncommon	Threatened	Shrub species
`	Syzygium tierneyana	Syzygium	Uncommon	Threatened	Shrub species
`	Syzygium myriadena	Syzygium	Uncommon	Threatened	Shrub species
`	Canarium salomonense	Small Ngali nut, Canarium	Uncommon	Threatened	Planted food nut tree, also used for timber
`	Pometia pinnata	Pometia, Taun	Uncommon	Threatened	High value timber species
`	Intsia bijuga	Kwila, Iron wood	Uncommon	Threatened	High value timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
`	Calanthe longifolia	Terrestrial Orchid	Uncommon	Threatened	
`	Calophyllum paludosum	Calophyllum	Rare, Uncommon	Vulnerable	Export timber species
`	Pterocarpus indicus	Rose wood	Uncommon	Threatened	High value timber species
Lowland forest on ridge-tops along access road corridor ¯ Station #3	Cycas seemannii	Cycad	Rare, Uncommon	Vulnerable	
`	Pterocarpus indicus	Rose wood	Uncommon	Threatened	
`	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
`	Pometia pinnata	Pometia, Taun	Uncommon	Threatened	High value timber species
Lowland Forest - Power Plant ¯ Station #2	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
`	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Syzygium onesima	Syzygium	Common	Threatened	
`	Canarium salomonense	Small Ngali nut, Canarium	Uncommon	Threatened	Planted food nut tree, also used for timber
`	Vitex cofassus	Vitex, Vasa	Uncommon	Threatened	High value timber species
Lowland forest - Secondary regrowth and riparian vegetation ¯ Reservoir Station #1	Vitex cofassus	Vitex, Vasa	Uncommon	Threatened	High value timber species
`	Pometia pinnata	Pometia, Taun	Uncommon	Threatened	High value timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
`	Drymophloeus salomonense	Drymophloeus	Uncommon	Threatened	Palm
`	Calophyllum peekelii	Calophyllum	Uncommon	Threatened	Export timber species
`	Elaeocarpus sphaericus 增	Elaeocarpus	Uncommon	Threatened	
Lowland forest overlapping secondary vegetation (old garden and village site) ¯ Reservoir Station #2	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Canarium indicum	Ngali nut, Canarium	Uncommon	Threatened	Planted food nut tree, also used for timber
Lowland forest - Secondary regrowth on a very steep slope ¯ Reservoir Station #3	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Paraserianthis falcata	Albizia	Uncommon	Threatened	Timber species
`	Terminalia brassii 增	Brown Terminalia Swamp Oak	Uncommon	Threatened	Export timber species
`	Alstonia scholaris 增	Alstonia, Milky Pine	Common	Threatened	Export timber species
Lowland forest - Riparian vegetation ¯ Reservoir Station #4	Paraserianthis falcata	Albizia	Uncommon	Threatened	
`	Terminalia brassii	Brown Terminalia, Swamp Oak	Uncommon	Threatened	Export timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
`	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
Riparian Vegetation ¯ Dam Station #1	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Paraserianthis falcata	Albizia	Uncommon	Threatened	
`	Nastus obtusus	Bamboo	Uncommon	Vulnerable	
Secondary Lowland Forest ¯ Dam Station #2	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Palaquium firmum	Pencil Cedar	Uncommon	Threatened	Export timber species
`	Calophyllum peekelii	Calophyllum	Uncommon	Threatened	Export timber species
Old Garden Area ¯ Secondary Forest ¯ Dam Station #3	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
Lowland forest and Riparian Vegetation on very steep cliff substrate ¯ Dam Station #4	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
Lowland forest - Secondary Vegetation	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
Uphill forest - Riparian vegetation on Very Steep Cliff Substrate ¯ Cliff Station #1	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
`	Cycas seemannii	Cycad	Uncommon	Vulnerable	
`	Pandanus sp?	Pandanus	Uncommon	Threatened	
`	Pholidota sp?	Orchid	Uncommon	Vulnerable	
`	Spathoglottis plicata	Ground Orchid	Common	Vulnerable	
Uphill forest - Riparian vegetation on Very Steep Cliff Substrate ¯ Cliff Station #2	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
`	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Pterocarpus indicus 增	Rose wood	Common	Threatened	
`	Elaeocarpus sphaericus 增	Elaeocarpus	Common	Threatened	
Lowland - Riparian vegetation ¯ Upstream Station #1	Pometia pinnata	Pometia, Taun	Common	Threatened	High value timber species
`	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
`	Crinum asiaticum	Crinum, Lilly	Uncommon	Threatened	
`	Pterocarpus indicus	Rosewood	Common	Threatened	
`	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species

Location	Species	Common Name	Distribution Status within Study Area	Protection Status	Comments
Lowland - Riparian vegetation ¯ Upstream Station #2	Paraserianthis falcata □	Albizia	Common	Threatened	
`	Pometia pinnata □ □	Pometia, Taun	Common	Threatened	High value timber species
`	Vitex cofassus	Vitex, Vasa □	Common	Threatened	High value timber species
`	Calophyllum peekelii 增	Calophyllum	Common	Threatened	Export timber species
`	Alstonia scholaris 增	Alstonia, Milky Pine	Uncommon	Threatened	Export timber species
Lowland - Riparian vegetation ¯ Upstream Station #3	Terminalia brassii	Brown Terminalia, Swamp Oak	Common	Threatened	
`	Calophyllum peekelii	Calophyllum	Common	Threatened	Export timber species
`	Pterocarpus indicus	Rose wood	Common	Threatened	
`	Pometia pinnata	Pometia, Taun	Common	Threatened	
`	Paraserianthis falcata □	Albizia	Uncommon	Threatened	

6.3.4 Plant Diversity and Protected Area Status

The project area lies outside any formally recognized protected areas. However, there are nearby areas that are considered to be of great landscape and biodiversity value, and are either protected or could be considered for protection. Despite its great biodiversity and landscape richness, the Solomon Islands has one of the poorest records for forest protection in the world, with only 0.28% of its terrestrial territory included in protected areas (WWF, 2005).

6.3.4.1 World Heritage Site

Guadalcanal does not have any World Heritage sites. However, one site, the Tropical Rainforest Heritage of Solomon Islands, is on its Tentative List (UNESCO, 2013). This site is comprised of four areas that, together, cover approximately 1500km^2:

- Mt. Popomanaseu region of Guadalcanal Province;
- Bauro Highlands of Makira-Ulawa Province;
- Mt. Maetambe region of Choiseul Province; and
- Central caldera forests of Kolombangara of Western Province.

Mt Popomanaseu region includes the nearby forest catchment and lowland valleys of the Itina River, which flows towards the windward coast. It partially overlaps the Tina River Catchment. The lowland riverine forests and montane forests, which make up this site, are intact. According to UNESCO, this site offers the best chance of conserving representative, distinctive and unique biodiversity. This area has outstanding biodiversity and a high proportion of endemic plants and wildlife (up to 75% of known species are endemic). The proposed area supports the largest contiguous area of montane forests in the country. Due to limited surveys, it is suspected that many of its species have not yet been identified. Endemic means that a species is only found in a restricted area, such as Guadalcanal. The area is customary land and any formal or informal protection would require the support of the local landowning tribes.

Unfortunately, the Sutakiki River headwaters of the Mt. Popomanaseu area are currently being prospected for gold, copper and zinc (Veronica Webster Pty. Limited, 2012).

6.3.4.2 National Park

Queen Elizabeth National Park is the only National Park in Guadalcanal Province. It covers an area of 1093 ha, and is located approximately 5km South of Honiara, along the Lungga River between the Matanikau River, Kolaa Ridge and Mount Austen. The British High Commissioner declared the area as a National Park in 1953. The local population disputed the government's right to use the land, and cleared vegetation to make way for farming instead. By the time money was allocated to rangers to protect the Park, squatters and farmers had already cleared much of the rainforest of Mount Austen. Today the National Park is highly degraded (Tedder, 2008). The National Park does not share any boundaries with the Project, or the Tina River catchment.

6.3.4.3 Areas with Informal Protection

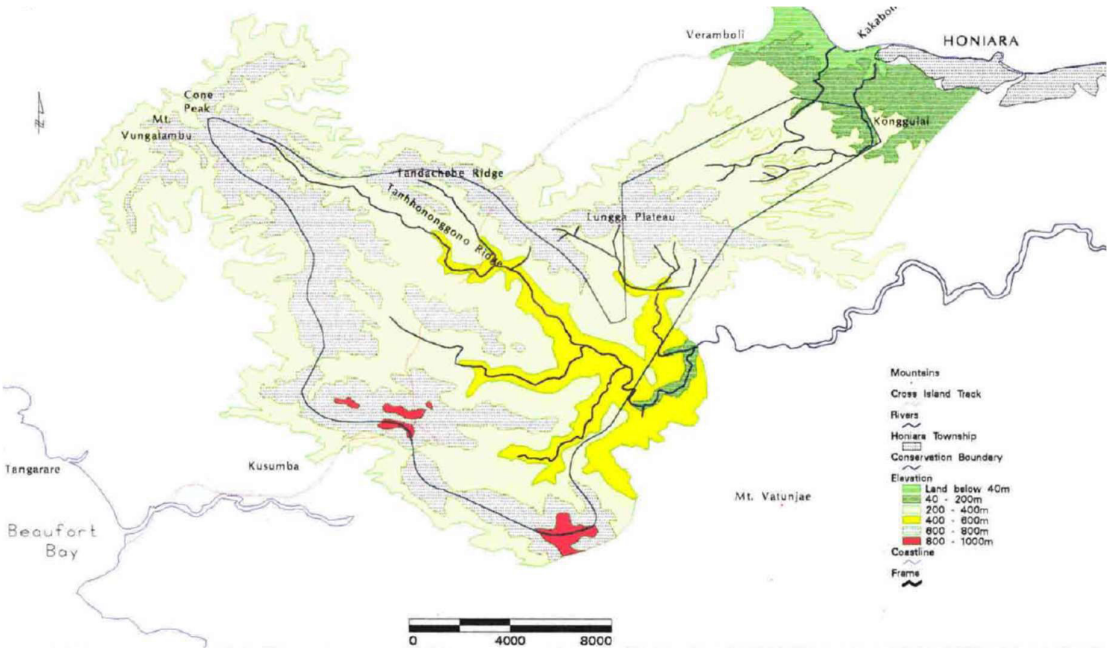
Informal protection of many small, natural sites is afforded by the local population, which protects these areas in a traditional manner. These sites are named `tambu_(for more information see Section 8). However, with modernization, traditional sacred beliefs associated with these sites have been eroded, and their protection is, therefore, threatened.

Komarindi Conservation Catchment Area (KCCA), located 30km west of the Project's Core Area, is a vast informally protected area, managed under customary estates. It was established as a Wildlife Sanctuary in the early 1990s, and covers an area of 19,300 ha. A community-based ecotourism development program functioned from 1997 to 1999 but was terminated due to ethnic unrest. Support for the conservation project came principally from the (then) Solomon Islands Department of Forests, Environment and Conservation (DFEC), the South Pacific Biodiversity Conservation Programme (SPBCP), and the South Pacific Regional Environment Programme (SPREP) (SPREP, 2013).

The KCCA was designed in conjunction with the Komarindi Hydroelectric Power Project, and was supposed to be integrated with the hydropower scheme, which was never implemented (SPREP, 2013). The parallel development of the KCCA ecotourism program and the Komarindi hydroelectric scheme was supposed to provide an opportunity for SIG to implement a locally-managed, integrated conservation and hydropower project, and to achieve economic and social benefits for the local landowners and the wider community, while conserving the natural environment and cultural heritage (SPREP, 1996).

Since the late 1990s, the KCCAP has ceased to function and there are no longer any ecotourism activities. Figure 6-4 shows the boundaries of the KCCA.

Figure 6-3 The former KCCA boundaries



Source: SPREP, 1996

6.3.5 Conclusions on Flora

The tropical forests from PNG, along with the forests of the Solomon Islands, represent the largest block of tropical rainforests in the Asia-Pacific region, and are part of the three great rainforests of the planet (WWF, 2005). As shown in Table 6-3, forests have high ecological values, and play an important role for people's livelihoods, providing sources of timber, medicinal plants, food and wood fuel.

The forests of Guadalcanal, especially the lowland forests such as those of the Project site, are threatened by logging, which is considered an important source of income for the country. According to FAO (2009), deforestation is a result of an increased population on the island, and is influenced by a high demand for agricultural land, new settlements, and timber.

The study area encompasses the Core Area around the Tina River, as well as the access and transmission line corridors, which traverse primarily grassland and plantation areas. 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 Tina River catchment upstream of the dam site, is dominated by highly valued, undisturbed lowland forest and, in its upper portion, undisturbed montane forest, 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, garden, trails, etc.). However, even though the forests are disturbed, they still show rich plant diversity, which is a factor of rapid vegetation regeneration due to a tropical humid climate and fertile soils. Indeed, disturbed forests are quickly recolonized by various second growth species of trees, shrubs and herbaceous plants. The Tina River catchment is primarily dominated by forests, with some grassland areas on its northern side. The mid-river catchment is dominated by lowland forests, whereas, the upper catchment is dominated by montane forests.

Table 6-3 Summary of habitat ecological values

Habitat Units	Location Relative to Project Components	Ecological value
Grassland	Transmission line and access road	Moderate
Undisturbed forest (primary lowland forest)	Reservoir and dam abutments	High
Undisturbed forest, montane forest	No interaction	High
Disturbed forest (secondary lowland forest)	Transmission line, access road, reservoir and dam abutments	Moderate
Remnant forest (secondary forest colonized by pioneer species)	Transmission line, access road, reservoir and dam abutments	Moderate
Riparian	Dam, reservoir and reaches downstream of dam	High
Cliffs	Dam and reservoir	High

Habitat Units	Location Relative to Project Components	Ecological value
Garden	Transmission line and access road	Low
Fallow brush land	Transmission line and access road	Low
Oil palm	Transmission line and access road	Low
Settlements	Adjacent to transmission line, access road and reaches downstream of dam	Low

The Project footprint, including areas of inundation during operation, access and construction activity, will affect parts of the study area which are largely disturbed forest and modified grassland with extensive and ongoing anthropogenic change.

6.4 TERRESTRIAL FAUNA

6.4.1 Methodology

Visual and auditory encounter surveys (diurnal and nocturnal), plot counts and mist netting, were used to identify terrestrial vertebrate, birds, reptiles, amphibians, and mammals. Informal interviews were carried out with villagers to determine the presence of important species. Point counts involved visual and auditory surveying from a set location (sampling station) for a duration of 20 minutes. Binoculars were used for the visual surveys. All faunal species (amphibians, birds, mammals and reptiles) observed (seen or heard) during the sampling period, were recorded. Sampling effort was the same for each station, with approximately 30 minutes per station. Mist netting involved the placement of 8 mist nets (15m x 2m, 20mm mesh size) at sampling stations to capture and record birds and mammals. Nets were placed in forested areas, and also in locations adjacent to waterways. Informal interviews with local populations were carried out to obtain local knowledge about important fauna, habitats, and associated use of fauna by local communities. These informal interviews resulted in the recording of local knowledge.

:Potential Presence˘ of each species in the Tina River study area was based on a review of the following available literature, and on species observations made in close proximity to the study site:

- TRHDP ESIA Scoping Study (Entura, 2011);
- Birds of Melanesia (Dutson 2011);
- Guadalcanal Island Bird Checklist (Tarburton 2007);
- Frogs of the SI (Pikacha et al. 2008);
- Reptiles of the Solomon Islands (McCoy 2006); and
- Gold Ridge Report (Ross Mining N. L. 1997) since Gold ridge mines are located nearby the Project site.

6.4.2 Terrestrial Fauna Survey Results

6.4.2.1 Invasive and Feral Species

Feral animals such as cats and rats, introduced species such as cane toads, invasive plants (e.g., Merremia peltata), and introduced trees (e.g., paper mulberry) are widely distributed in the study area. Feral cats are a major threat to many vertebrate species, such as ground nesting birds, and introduced rats compete with native rats and prey on fledgling birds and eggs (Pikacha, 2008).Cane toads have a devastating effect on the population of indigenous frogs (Pikacha, 2008), as they are aggressive predators of native frog species. Moreover, eggs and tadpoles are poisonous and affect native tadpoles that eat them (IUCN, 2014). These species were observed by the ESIA team as far upstream as the upper Tina River catchment area.

The Giant African Snail was introduced into Solomon Islands, most likely by foreign logging machinery contaminated with soil containing eggs and juvenile snails. It competes with native species and damages food crops. During mitigation workshops, it was mentioned that the Giant African Snail had already reached Veraande village (along Black Post Road) and is a concern for villagers.

Insects such as the fire ants (Wasmannia auropunctata) are also a concern. Pathways created by logging roads have allowed this aggressive ant species that affects native insect biota to colonize new sites.

6.4.2.2 Game Species

Some species in the area are opportunistically hunted for food. According to social surveys on food eaten by households in the Project area (see Annex 6 of the Annex Report), except for wild pigs, game species were not declared as a significant part of people's diet. The harvesting pressure on game species around villages is unknown. However, people from surveyed villages sometimes go to the upper Tina River catchment on hunting trips.

6.4.2.3 Amphibians

Amphibians are sensitive animals, and are often seen as good indicators of ecosystem health. This is due to their dependence on certain moisture regimes and their sensitivity to pollutants, as they are able to "breathe" through their skin. Therefore, amphibians require moist environments that are relatively pollutant free. Along the Tina River, flash floods bring water to riverine wetlands, these riverine wetlands are valuable habitats for amphibians. Heavy rainfalls in the project areas also bring moisture to forested areas. Amphibians are not highly mobile and, therefore, any changes to their habitat could lead to impacts on species. See Appendix B for a listing of amphibian species by family, including scientific and common names.

A total of 9 amphibian species were observed from a total of 13 potential species[24] from 4 families. This represents 64% of all amphibian species expected to occur within the Project study areas. None of the amphibian species is endemic to Guadalcanal or the Tina River catchment.

[24] The term "potential species" is defined as species that were found in the vicinity by previous studies and have a likelihood of being present, even if they were not observed in the course of this study.

Three native frog species deserve particular mention and are discussed below along with their relative vulnerability to the project.

Solomon Island˘s Treefrog (Litoria lutea) - This frog is deemed ecologically important because of its vulnerability based on the IUCN Red List assessment (IUCN, 2013). It is a rare forest frog in the Solomon Islands, and little information about it is available (Pikacha et al., 2008). It inhabits the upland forest habitats and was observed there during the ESIA field investigations. The Project would have minimal, if any, impacts on this species as it will not impact upland forest habitats.

Giant Webbed Frog (Discodeles Cornufer guppyi) - This frog is deemed ecologically important because of its dependence on the river system and is usually found along smaller rivers and streams (Pikacha et al., 2008). It is the largest frog in the Solomon Islands, and members of local communities report eating it. This species belongs to the riparian habitat. It was observed only in the upper catchment in small streams[25].

San Cristobal Treefrog (Hylarana Papurana kreffti) ¯ This frog is deemed ecologically important because of its dependence on the river system. It is an aquatic breeder that lays eggs in pools of water (Pikacha et al. 2008). It is the only Solomon Islands frog that has a tadpole stage, as opposed to direct development evident in the Ceratobatrachidae frogs (Figure 6-5). The species is found in the riparian habitats. Possible impacts of the Project on this species include loss of its wetland habitats for feeding. The creation of a dam may increase habitats for breeding.

Figure 6-4 San Cristobal Treefrog tadpoles and eggs

Figure 6-6 is a photo of two species of frogs found within the study area.

[25] Personal Communication with Pikacha 2016.

Figure 6-5 Weber's Wrinkled Ground Frog (left) and Solomon Islands Eyelash Frog (right)

Source: Edgard Pollard 2013

6.4.2.4 Insects

Species of damselfly (Odonata spp.), including Neurothemis stigmatizans, Neurothemis terminata and Xiphiagrion cyanomelas were commonly observed along the Tina River, and its adjacent micro-wetlands. The life cycles for these species are closely linked to the Tina River and riparian habitats, since they spend much of their life cycles as benthic organisms. Flash floods can occasionally convey water to small branches of the river allowing the Odonata to breed and reproduce there.

Photographs of four species of damselflies are shown in Figure 6-7

Figure 6-6 Odonata species observed during field surveys

Neurothemis stigmatizans (left) and Neurothemis terminata (right)

Xiphiagrion cyanomelas (left) and Odonate imago (juvenile) (right)

Many spiders were observed along the Tina River, including Spiny orb-weavers of the genus Gasteracantha and spiders of the genus Argiope.

6.4.2.5 Reptiles

Reptiles are important animals of the forest and provide a large proportion of faunal biomass, thus playing an important role in the food web of the ecosystem. Reptiles are ectotherms and require heat from the sun. Their body heat is regulated externally, similar to amphibians. Therefore, they can also be susceptible to changes in micro-habitats. Due to their size, reptiles are not considered to be very mobile species, and changes to their environment often lead to impacts, such as interactions with road vehicles, with damaging consequences to the reptile. Appendix C lists reptile species by family, including scientific and common names.

A total of 5 reptile species were observed from a total of 23 potential species representing 5 families. This is about 22% of all reptile species expected to occur within in the general study area. The ESIA team has observed evidence of salt-water crocodiles (Crocodylus prosus) in the mouth of the Ngalimbiu River. According to villagers, adjacent wetlands are used by the crocodiles.

The relative importance of 5 of the reptile species expected to occur within the general study area and their relative vulnerability to the project are discussed below.

Guadalcanal Bow-fingered Gecko (Cyrtodactylus biordinis) - This gecko is deemed ecologically important because it is a Guadalcanal island endemic (McCoy, 2006). It is commonly found on smaller trees and within tree hollows where it lays its eggs. In forested habitats it feeds on insects, especially moths. It is not considered as threatened. However, it will be affected by construction activities, such as forest clearing.

Solomon's Bent-toed Gecko (Cyrtodactylus salomonensis) - This species has been listed on the IUCN Red List (IUCN, 2013) as Near Threatened. It is also an endemic species that thrives in forested habitat up to 400masl, where it lives in the forest canopy. Its population is currently listed as static. It is a strictly arboreal species found in larger trees. In Solomon Islands, it is threatened by logging activities and the illegal pet trade. The TRHDP will overlap with the lower elevation range of this species, but not its upper elevation range. Given the relatively small footprint of the Project relative to the extensive area of available forested habitat upstream of the dam, the impacts accruing to this species as a result of the Project are expected to be minimal.

Prehensile-tailed Skink (Corucia zebrata) - This skink is deemed ecologically important because of its CITES protection status (UNEP-WCMC, 2013). It is endemic to the Solomon Islands (McCoy, 2006) and is classed as Near Threatened on the IUCN Red List (IUCN, 2013). It is also opportunistically hunted for food. This species is probably the largest skink in the world and prefers large trees with dense foliage in forest habitats. It has a vegetarian diet and feeds on vine leaves, vines, fruits and flowers. It may be threatened by habitat loss and so may be affected by project related construction activities, such as forest clearing.

Schmidt's Crocodile Skink (Tribolonotus schmidti) - This skink is deemed ecologically important because it is a Guadalcanal island endemic (McCoy, 2006). It is relatively common and prefers moist areas under fallen and rotting timber in forest habitats, where it feeds on insects. It is not threatened. However, it will be affected by construction activities, such as forest clearing.

Solomons Ground Boa (Candoia paulsoni) - This common snake is deemed ecologically important because of its CITES protection status (UNEP-WCMC, 2013). It occurs in a wide variety of habitats, from forests to gardens, and feeds on frogs, skinks and smaller snakes. It is not threatened. However, it will be affected by construction activities such as forest clearing and, being a snake, probable persecution by workers.

Figure 6-8 includes photos of two different species of skinks that occur within the study area.

Figure 6-7 Pacific Black Skink (left) and Solomons Blue-tailed Skink (right)

Source : Edgard Pollard 2013

6.4.2.6 Avifauna (Birds)

There are a wide variety of birds that occupy different ecological niches, in various habitats, from grasslands to waterways to upland forests. Birds play an important ecological role in the dispersal of plant seeds, the control of insects and the pollination of plants, amongst other things. Specialist birds that occupy very narrow niches are very good environmental indicators as their disappearance indicates a degraded habitat. Appendix D lists bird species by family, including scientific and common names, along with their CITES or IUCN (Red List) status, and endemicity, and their relative vulnerability.

A total of 41 bird species, representing 28 families, were observed out of a total of 67 potential species previously recorded. This is around 61% of all birds expected to occur in the general study area.

Of the species of birds that potentially occur within the study area, one species ¯ the White-eyed Starling (Aplornis brunneicapilla) -- is listed as endangered on IUCN˘s Red List (IUCN, 2013). As a result of this status, it is deemed ecologically important. Although not listed as a Guadalcanal endemic, it is identified as a Solomon Islands endemic (Dutson, 2011), where it is found in forested habitats, feeding on insects, flowers and fruits. It is threatened by habitat loss and human predation. The ESIA and feasibility report baseline studies did not detect presence of this species in the study area, which extends 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 (in colonies in trees with high epiphyte cover), it also regularly feeds in semi- and heavily-degraded areas, where small fruit trees provide abundant food.[26] Even when present, it is not always easy to find this species during field surveys, and it appears to have seasonal or interannual movements which are not yet understood.[27] There is thus potential for the species to use the project area, for example on a seasonal or periodic basis in response to fruit availability.

An additional seven species of birds (see Table 6-4) that could potentially occur within the study area, are listed as vulnerable or near threatened. Of these, only four species were observed during field investigations. These four species are discussed below:

Solomon Sea-Eagle (Haliaeetus sanfordi) - This bird is deemed ecologically important because of its CITES protection status (UNEP-WCMC, 2013) and its vulnerability based on the IUCN Red List assessment (IUCN 2013). It is also important as being endemic to Solomon Islands (Dutson, 2011). It feeds mainly on pigeons, doves, fish, possums and lizards. The eagle is wide ranging, from coast to upland forests, and is found throughout the entire study area. Although it is considered to be rare, it was observed at sampling site #5 on the proposed transmission line corridor, and above the proposed dam site at upstream sampling station #1. The Project will likely have only minimal impact on it, given that the project footprint is small in relation to its wide-ranging territory, and parts of the range it inhabits will not be affected by project construction.

Guadalcanal˘s Rail (Hypotaenidia woodfordi) - This bird is deemed ecologically important because it is endemic to Guadalcanal (Dutson, 2011) and is classified as being Near Threatened on IUCN˘s Red List (IUCN, 2013). It is opportunistically hunted by inhabitants of local communities as a source of food. During the ESIA field studies, it was observed at sampling stations #1 and #3 along the proposed transmission line corridor, where the forest habitat has already been significantly modified. The impacts of the hydropower project on this rare rail should be minimal because the project is not expected to have significant impacts on the thicket and grassland habitat where it occurs.

[26] Guy Dutson, in litt. 2017; Chris Filardi, pers. comm. 2017

[27] Chris Filardi, pers. comm. 2017

Red-knobbed imperial pigeon (Ducula rubricera rufiglia) ¯ This bird is deemed ecologically important because it is listed as Near Threatened on IUCN's Red List (IUCN, 2013) due to rates of deforestation largely associated with development of oil palm plantations. It is found on nearly all forested islands in Solomon Islands and inhabits lowland rainforest up to 1,200m on Guadalcanal. Although it is still common where extensive forest remains, it is much rarer in degraded habitats. Its population is suspected to have declined rapidly in recent years due to ongoing clearance of lowland forest, at least in parts of its range. During the ESIA field studies, this species was observed at multiple sampling stations throughout the study area. Owing to the relatively small footprint of the hydropower project, the widespread distribution of this species within the study area, and its wider distribution in unaffected rainforest areas at elevations well above the TRHDP, the Project is unlikely to have only minimal potential impact on this species of bird.

Crested Cuckoo-Dove (Reinwardtoena crassirostris) ¯ This bird is deemed ecologically important because it is listed as Near Threatened by IUCN's Red List (IUCN, 2013), primarily as a result of removal of lowland forests. It is a large pigeon endemic to Bougainville (Papua New Guinea) and Solomon Islands, where it occurs at relatively low densities that suggest the total population is small. It may be declining rapidly in the lowlands, although the hill populations are probably declining very slowly. Within the study area, it was observed on the right bank of the river, which is an area that has been previously logged and has secondary forest regrowth. Given that the Project footprint is primarily in areas where populations have already been affected (i.e., close to village settlements and where commercial tree harvesting has already occurred), it is unlikely to have an effect on this species. Further, the Project will not materially affect hilly, forested areas outside the Tina River Gorge, where populations of this species are considered to be less threatened.

Table 6-4 Near to threatened and vulnerable bird species

Scientific name	Common name	IUCN category	Population trend	Observed in ESIA Extended[28]
Haliaeetus sandfordi	Solomon sea eagle	Vulnerable	Declining	Yes ¯ Station TL5; Upp1
Hypotaenidia woodfordi	Guadalcanal rail	Near threatened	Declining	Yes ¯ TL1, TL3
Ducula rubricera rufigila	Red-knobbed imperial pigeon	Near threatened	Declining	Yes ¯ multiple stations and reports
Reinwardtoena crassirostris	Crested cuckoo dove	Near threatened	Declining	Yes - Tun
Charmosyna margarethae	Duchess lorikeet	Near threatened	Declining	No
Edolisoma holopolium	Solomon cicadabird	Near threatened	Declining	No
Monarchus b. barbatus	Solomon's monarch	Near threatened	Declining	Yes ¯ Res3, Dam2

[28] The extended ESIA includes the ESIA survey stations, the scoping study by Entura in 2011, and recorded local knowledge

Figure 6-9 includes photos of two different species of Monarch that occur within the study area.

Figure 6-8 Solomons Monarch (left) and Chestnut-bellied Monarch (right)

Source: Edgar Pollard, 2013

6.4.2.7 Mammals

Guadalcanal is home to some of the most cryptic and rare mammals in the Pacific, including flying foxes and giant native rats. Appendix E lists mammal species by family, including scientific and common names.

A total of 5 mammal species were observed out of a total of 14 potential species from 4 families. This is roughly 36 percent of all mammals that are expected to occur within the general study area. The 5 species were the Island Tube nosed Fruit Bat (Nyctimene major), the Rousette Bat (Rousettus Amplexicaudatus), the Fawn Leaf nosed Bat (Hipposideros cervinus) the Solomon's Flying Fox (Pteropus rayneri) and the Wild Pig (Sus scrofa).

Of the 14 potential mammal species, the relative importance of the 5 most ecologically significant and their relative vulnerability to the project are discussed below.

Solomon's Flying Fox (Pteropus rayneri) - This bat is deemed ecologically important because of its CITES protection status (UNEP-WCMC 2013) and its classification as Near Threatened by the IUCN's Red List (IUCN 2013), and because it is endemic to the Solomon Islands. It is opportunistically hunted as a food resource by inhabitants of local communities. This large bat is found over a wide variety of habitats, though it uses forests for roosting, especially large trees and caves, and for foraging for fruits. It is threatened by habitat loss and hunting. Forest clearing and removal of big trees for access roads will likely affect the species.

Island Flying Fox (Pteropus admiraltatum) - This bat is deemed ecologically important because of its CITES protection status (UNEP-WCMC 2013). Like the Solomon's Flying Fox, it is also opportunistically hunted as a food resource by inhabitants of local communities. This large bat is found in forest habitats, where it feeds on wild and cultivated fruits. It is threatened by habitat loss and hunting. Forest clearing and removal of big trees to construct access roads will affect the species.

Emperor Rat (Uromys imperator) - This species 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).

Listed as Critically Endangered (Possibly Extinct) because it has not been recorded with certainty since three specimens were collected between 1886 and 1888. Anecdotal information suggests that the species survived until the 1960s. This species is quite possibly extinct, however, Guadalcanal has not been adequately surveyed (Lavery 2013). Should this species still exist, it is almost certain to be very few in number.

It seems as though this was a largely terrestrial species that was at one point found throughout much of Guadalcanal, including the dry northern lowlands and areas close to the coast. Later reports suggest that the species became restricted to mossy montane forest (IUCN 2016a).

Resent surveys for native rodents have been conducted at sites between 200m and 1,500m altitude across Solomon Islands using baited camera traps. So far, the emperor rat has not been detected, increasing fears it is extinct. According to Tyrone Lavery of the University of Queensland (Lavery, 2016),

> . . . camera traps used to carry out the surveys have provided some alarming data on densities of feral cats present in the archipelago. These data support long-held suspicions that predation by cats has been the main cause of extinction for Solomon Island mammals and ground dwelling birds such as the Makira moorhen.

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.

King Rat (Uromys rex) - This species 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. It is listed as Endangered because its area of occupancy is probably less than 500 km^2, its distribution is fragmented, and the extent of its forest habitat is declining.

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. Interviews with local inhabitants conducted by Roger James (pers. comm. in IUCN 2016b) suggest that the species may occur elsewhere on the island. However, no specimens have been captured that would confirm this anecdotal information.

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 the 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.

Northern Common Cuscus (Phalanger orientalis) - Cuscus are the only marsupial mammal in the Solomon Islands. Northern Common Cuscus has a good tolerance to degraded forested areas (IUCN, 2013). It feeds on fruits, leaves and seeds, and dwells in Ficus trees. Cuscus forage in the high canopy but will also feed in gardens. Cuscus require shade, moderate temperature and humidity (Pikacha, 2008). The species is nocturnal and sleeps in hollow trees. They mate and give birth only once a year between June and October. They will be affected by project related forest clearing. Figure 6-10 shows an exposed Cuscus following forest clearing.

Figure 6-9 Exposed Cuscus after forest clearing

Source: Pikacha, 2008

Figure 6-11 includes photos of two different species of bats that occur within the study area.

Figure 6-10 Fawn Leaf-nosed Bat (left) and Rousette Bat (right)

6.4.3 Conclusions Based on Fauna Surveys

Valued species occupy ecological niches that can be simplified in four categories:

- Grassland species ¯ which require openings and limited tree cover;
- Forest interior species ¯ which require high canopy coverage and dense vegetation, and do not tolerate openings and dryer environments;
- Disturbed forest and forest edge species ¯ for most of the time these are ubiquist species, that can occupy a range of ecosystem types;
- Riparian species ¯ which need to be close to rivers and wetlands.

Table 6-5 shows the ecological niche of each valued species.

Table 6-5 Ecological niches occupied by valued species found within the study area

Valued species	Grassland	Forest interior	Disturbed forest and forest edge	Riparian
Amphibians				x
Giant Webbed Frog				
Solomon Island's Treefrog		X		
San Cristobal Treefrog				x
Reptiles				
Guadalcanal Bow-fingered Gecko		X		
Solomons Bent-toed Gecko		X		
Prehensile-tailed Skink		X		
Schmidt's Crocodile Skink		X		
Solomon Ground Boa		X	X	
Birds				
Nankeen Night Heron				x
Little Pied Cormorant				x
Pacific Black Duck				x
Brahminy Kite	X	X	X	x
Pacific Baza	X		X	
Variable Goshawk	X		X	
Meyer's Goshawk	X		X	
Solomon Sea-Eagle	X	X	X	x
Red-backed Button-Quail	x			
Guadalcanal Rail	x			
Common Sandpiper				x
Yellow-bibbed Fruit-Dove		X		
Ducorp's Cockatoo		X	X	
Cardinal Lory		X	X	
Coconut Lorikeet		X	X	
Yellow-bibbed Lory		X	X	
Duchess Lorikeet			X	
Finsch's Pigmy Parrot		X	X	
Eclectus Parrot	x	X	X	
Song Parrot	x	X	X	
Guadalcanal Boobook		X	X	
Blyth's Hornbill		X	X	

Valued species	Grassland	Forest interior	Disturbed forest and forest edge	Riparian
Common (River) Kingfisher				x
Variable Dwarf Kingfisher				x
Cockerell's Fantail		X		
Rufous Fantail		X	X	
Golden Whistler		X	X	
Midget Flowerpecker		X	X	
Black-headed Myzomela		X	X	
Brown-winged Starling	x		X	
White-eyed Starling		X	X	
Mammals				
Solomon's Flying Fox		X	X	
Island Flying Fox		X	X	
King Rat		x (mostly upland forest)		
Emperor Rat		x (upland forest)		

6.5 WILDLIFE HABITAT VALUE DELINEATION

This section describes the value of the general habitat types for terrestrial wildlife (highly valued, moderately valued, weakly valued) in all study areas. This section also defines what are considered to be the important habitats found within the study area from a strictly biological point of view. These include areas: with protected species colonies; with endemic species, with migratory species; and with endangered species. Natural habitats include grassland, riparian and forests.

6.5.1 Natural habitat and critical natural habitat

Forests provide high ecological values, as they play an important role as wildlife habitat, and provide livelihood for inhabitants of local communities who selectively harvest timber, obtain medicinal plants, and hunt and forage for food (fruits, nuts, wild game), fuel and non-wood products. The forests of Guadalcanal, especially lowland forests, are threatened by logging which provides an important source of income for the country. However, according to FAO (2009), deforestation is also a result of increasing population in the islands that fuels demand for rising agricultural activities, new settlements, and timber harvesting.

After the tropical forests of PNG, the forests of the Solomon Islands comprise the largest block of tropical rainforest in the Asia Pacific region, and are one of the three great rainforests of the planet (WWF, 2005).

Appendix F contains information on the types of natural habitat found within the Tina River

catchment, the characteristics of each habitat type (vegetation assemblage, elevation, etc.), the ecological value of each type of habitat, and provides photographs to illustrate how the habitat typically appears. The map in Figure 6-12 illustrates the different habitats and land use of the study area.

The World Bank considers conservation of natural habitats, particularly Critical Natural Habitats, as essential for long-term sustainable development and supports projects that apply a precautionary approach to natural resource management.

Natural Habitats are defined as areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.[29]

Critical Habitats are areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered or Endangered species; (ii) habitat of significant importance to endemic and/or restricted range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened or unique ecosystems; and/or (v) areas associated with key evolutionary processes.[30] The World Bank does not support projects that involve significant conversion or degradation of natural habitat unless :

- No other viable alternatives within the region exist for development of the project on modified habitat;[31]
- Consultation has established the views of stakeholders, including Affected Communities, with respect to the extent of conversion and degradation; and
- Any conversion is mitigated according to the mitigation hierarchy.

In areas of natural habitat, mitigation measures will be designed to achieve no net loss of biodiversity where feasible.[32]

The World Bank does not support projects in areas of critical habitat unless:

- No other viable alternatives within the region exist for development of the project on modified or natural habitats that are not critical;
- The project does not lead to measurable adverse impacts on those biodiversity values for which the critical habitat was designated, and on the ecological processes supporting those biodiversity values;
- The project does not lead to a net reduction in the global or national/regional population of any Critically Endangered or Endangered species over a reasonable period of time; and
- A robust, appropriately designed, and long-term biodiversity monitoring and evaluation program is integrated into the project management program.

[29] World Bank Performance Standard 6

30 Ibid.

31 Performance Standard 6 defines modified habitats as areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological function. Note that a modified habitat may also be a critical habitat if it meets any of the criteria in the critical habitat definition above.

32 Performance Standard 6

Where a project is able to meet all of those requirements, the mitigation strategy must be described in a Biodiversity Action Plan and must be designed to achieve net gains of those biodiversity values for which the critical habitat was designated.[33]

For the purpose of habitat analysis, the study area has been divided into three sub-regions based on elevation: the higher elevation area of the upper Tina River catchment (above 400 masl) which lies to the south, and is dominated by undisturbed montane forests; the mid-elevation river gorge area which is dominated by lowland forests modified by extensive logging and semi-commercial timber operations, as well as gardens and habitation clearings; and the lower elevation area which is dominated by grassland and plantations within the downstream (northern) Tina River catchment. The degree of anthropogenic modification increases markedly with decreasing altitude, with a large proportion of the Project area comprising modified habitats.

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 terrestrial or aquatic species have been found within these project-affected areas. Likewise, the area does not support any 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 larger habitat area available to these species adjacent to, and upstream of, the proposed development.

Except for the upper catchment area, most habitats in the vicinity of the project site are not in a pristine state, having been used and degraded, to a certain extent, by human activity including clearing land to establish settlements and gardens, and commercial and artisanal logging.

The undisturbed montane forest above 400masl in the upper catchment to the south and east of the dam site and reservoir, and remaining areas of undisturbed lowland forest below 400 masl, 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 natural forest which could potentially be considered Critical Habitat. These impacts are not considered significant.

A range of measures will be implemented to mitigate against impacts on natural habitat, indirect impacts to the Critical Habitat, to provide for no net loss of biodiversity, and to achieve net gains of those biodiversity values for which the potential critical habitat was designated.

The Project will take a series of steps to protect the upper Tina River catchment. Immediate protection measures will include actions of the TCLC and Project Company to restrict access to vehicles (including commercial logging machinery) to the upper catchment through the Core Area, to monitor changes in forest coverage in the upper catchment, to monitor logging truck activity on existing logging roads, and to support SIG to enforce seldom used statutory restrictions on logging at elevations above 400 masl (which if enforced would represent the vast majority of the upper catchment).

[33] Ibid.

This protection work will be furthered by Project Office funding for an NGO to facilitate consultations with customary landowners to seek support for the creation of a protected area in the upper catchment and to conduct mapping and forestry studies, towards preparation of a management plan. The NGO will work closely with customary landowners as in Solomon Islands, establishment of a protected area should originate with the customary landowners of the land.

In addition to upper catchment offset activities, the Project Company will implement measures including a post construction rehabilitation plan for disturbed areas, and an offset within the Core Area which will include measures to protect the remaining natural habitat in the Core Area, and to rehabilitate an area of modified habitat within the Core Area of at least 9.5 ha. These measures will be set out in the Biodiversity Management Plan.

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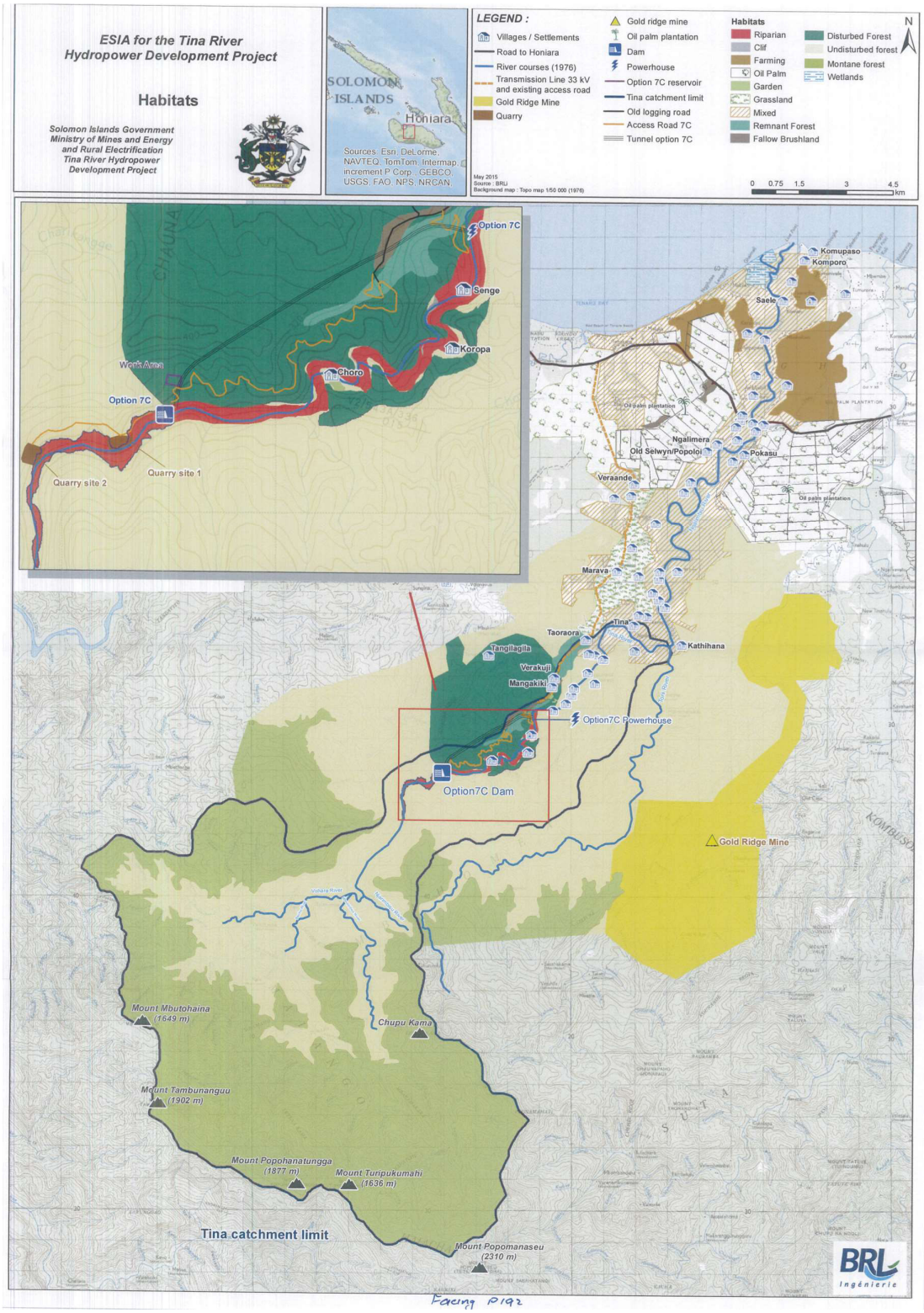
Figure 6-11 Study area habitat types and land use


ESIA for the Tina River Hydropower Development Project
Habitats
Solomon Islands Government Ministry of Mines and Energy and Rural Electrification Tina River Hydropower Development Project
SOLOMON ISLANDS
Honiara
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN,
LEGEND :
Villages / Settlements
Road to Honiara
River courses (1976)
Transmission Line 33 kV and existing access road
Gold Ridge Mine
Quarry
Gold ridge mine
Oil palm plantation
Dam
Powerhouse
Option 7C reservoir
Tina catchment limit
Old logging road
Access Road 7C
Tunnel option 7C
Habitats
Riparian
Clif
Farming
Oil Palm
Garden
Grassland
Mixed
Remnant Forest
Fallow Brushland
Disturbed Forest
Undisturbed forest
Montane forest
Wetlands
N
May 2015
Source : BRLi
Background map : Topo map 1/50 000 (1976)
0 0.75 1.5 3 4.5 km
Option 7C
Senge
Koropa
Choro
Work Area
Option 7C
Quarry site 1
Quarry site 2
Komupaso
Komporo
Saele
Oil palm plantation
Ngallmera
Old Selwyn/Popoloi
Pokasu
Veraande
Oil palm plantation
Marava
Tina
Taoraora
Kathihana
Tangilagila
Verakuji
Mangakiki
Option7C Powerhouse
Option7C Dam
Gold Ridge Mine
Mount Mbutohaina (1649 m)
Chupu Kama
Mount Tambunangu (1902 m)
Mount Popohanatungga (1877 m)
Mount Turipukumahi (1636 m)
Tina catchment limit
Mount Popomanaseu (2310 m)
BRL Ingénierie

Facing P192

6.5.2 Discussion on Wildlife and Wildlife Habitat

The ESIA team observed a general trend of habitat degradation from upstream areas to downstream areas. Human settlement increases in a downstream direction, and land use shifts from forested areas to remnant forests and grasslands. Disturbed forests were observed in all of the study area, but the level of disruption was low in Choro. The upper catchment area, inland and up-elevation from the project site, remains covered by pristine forest.

Except for birds, the impacts of habitat degradation is not noticeable when observing the number of species. This could be attributed to some species being able to thrive in modified habitats that are close to settlements. Regarding endemic species (except for birds), their abundance does not decrease with habitat degradation. Most of the areas covered by the project are utilized by endemic wildlife species.

Table 6-6 classifies three types of modified habitat: weakly disturbed, moderately disturbed and highly disturbed. As shown in the table, the number of species observed in each habitat type, during the period when field surveys were conducted (August, 2013), did not decrease with habitat disturbance, except for birds, which seem to prefer undisturbed areas.

Table 6-6 Number of species observed by habitat quality

	Weakly disturbed												Moderatly disturbed					Highly disturbed				
	Upper Stream		Middle Tina River sampling area										Middle Tina River sampling area					Transmission line sampling area				
	F&F2	F&F1	F&F7	F&F6	F&F5	F&F4	F&F14	F&F10	F&F13	F&F9	F&F11	F&F8	F&F19	F&F12	F&F18	F&F17	F&F16	F&F24	F&F23	F&F22	F&F21	F&F20
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Table 6-7 Number of endemic species observed by habitat quality

	Weakly disturbed												Moderatly disturbed					Highly disturbed				
	Upper Stream		Middle Tina River sampling area										Middle Tina River sampling area					Transmission line sampling area				
	F&F2	F&F1	F&F7	F&F6	F&F5	F&F4	F&F14	F&F10	F&F13	F&F9	F&F11	F&F8	F&F19	F&F12	F&F18	F&F17	F&F16	F&F24	F&F23	F&F22	F&F21	F&F20
! Ii2Gf CLII	れ	わ	れ	わ	わ	ろ	れ	れ	れ	わ	ろ	れ	れ	れ	れ	れ	れ	れ	れ	れ	れ	れ
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6.5.3 Conclusions on Wildlife Habitat

The fauna baseline study has shown that wildlife species thrive in the undisturbed forest of the upper Tina River catchment, upstream of the Project, but also in the more anthropogenically modified areas in the lower reaches of the Tina River, in which the Project is located. The ESIA team observed a total of 60 species of wildlife within the study area, including: 9 species of amphibians; 5 species of reptiles; 41 species of birds; and 5 species of mammals. Approximately 45% of the species are endemic, including: 1 species of amphibian; 1 species of reptile; and 25 species of birds;. The extent of potential impacts of the TRHDP on these fauna, and proposed measures to mitigate impacts to them, are addressed in Section 10.

7. BIOLOGICAL ENVIRONMENT BASELINE - AQUATIC

7.1 METHODOLOGY

Various methods were used to characterise the baseline aquatic environmental conditions within the study area, including:

- a review of existing information (literature & previous studies);
- a field survey of the Tina river system undertaken from 30 July to 06 August 2013, which encompassed water quality sampling, observations on fish and river system, and interviews with local fishermen and other river users. Field surveys were carried out by Lo¾ Tr¶baol, with the assistance of Robson S. Hevalao;
- a second fish and water quality survey carried out by Robson S. Hevalao in February 2014, the results of which are compiled in this ESIA report. In addition to the dry season stations, this additional survey included sampling at the proposed dam site (Site 7C); and
- a supplementary study of environmental flow requirements and associated habitat suitability for migratory fish, prepared by Jowett Consulting in March and July 2016 in association with Robson S. Hevalao and David Boseto. The methodology and result of this study are summarised in Section 7.5.6.

7.2 LITERATURE REVIEW

The following sources of available information were used to obtain an understanding of, and describe, the baseline freshwater ecology in the study area.

7.2.1 Fresh and Brackish Water Fishes in Guadalcanal, by Gray (1974)

This small publication records 36 fish species collected from roughly twelve sampling stations located in estuarine environments of Guadalcanal, mostly on the North coast, West of Honiara, and two stations on the South coast at Lauvi lagoon. It provides a representation of each species and a description of some ecological features.

Most species are marine forms entering into estuaries. Ten species are identified as being likely to occur in inland reaches of the rivers (Anguilla marmorata, Kuhlia marginata, Mesopritis argenteus, some Eleotridae and some pipefish), and represent only one component of freshwater biodiversity. Gobiidae, the predominant family in the inland river reaches of the Solomon Islands, was not described in the study.

7.2.2 Aquatic Ecology Surveys for the Gold Ridge Project (Since 1990)

In support of the Gold Ridge Project, extensive baseline studies and water quality and aquatic ecology monitoring has been undertaken from 1990 to the present.

The information collected is particularly useful for characterizing the baseline conditions of the TRHDP study area, as the Matepono River watershed is directly adjacent to the Tina/Ngalimbiu watershed and, therefore, shares a number of environmental features. Additional data were collected from the Tina/Ngalimbiu watershed, especially at Ngalimbiu River Bridge, to use as control data.

The different sets of data include:

Initial field studies by AMOCO/ARIMCO (1990)

In 1990, two studies were undertaken regarding the feasibility of discharging treated tailings fines into the river. These included:

- `Hydrology, meteorology and water quality_ (Scott Technical instruments, Aug 1990); and
- `Aquatic flora & fauna study_ (Dr D. Fannings, Sept-Oct 1990) in which 14 survey stations were sampled, including 8 stations on the Matepono River system, 1 station at Ngalimbiu River bridge, and 6 stations on other adjacent watersheds. Several species of prawns (dominant taxa in the samples), a variety of fish species, and a few species of frogs, were collected. Most species were unidentified due to a lack of information at that time regarding freshwater ecology in the SI.

The concentration of arsenic, mercury and cadmium in fish flesh was determined for each location. The results showed highly significant, naturally occurring levels of contamination, especially for arsenic (at, or greater than,1 mg/kg).

The discussion of aquatic ecology biota in the initial Gold Ridge EIS (Ross Mining N. L., 1996) was based on these field results.

Water quality samples (1989 to 1995)

- The Gold Ridge EIS report (Tables 3-13 and 3-14) refers to a compilation of water quality samples from 6 stations on the Matepono River system (1989-1992), with an additional sampling station added in 1995.

Additional aquatic fauna surveys (2003 & 2006)

- At the reopening of the Gold Ridge mine, following a period of political unrest, two additional aquatic fauna surveys were undertaken at 8 sample stations, including: 7 stations on the Matepono River system; and 1 station at Ngalimbiu River bridge. The methodology and main results are described in the Environmental Performance Report 2009 by Golder Associates (pp 99-100).
- A first survey by Golder Associates (Dec 2003) showed good fish and crustacean abundance in the river system. Analyses of heavy metal concentrations in fish/prawn flesh (As, Cu, Cd, Zn, Hg) showed evidence of increased arsenic (As) levels, resulting from bioaccumulation downstream of the mine site. The arsenic concentrations were below levels considered detrimental for human consumption.
- A second survey by Hydrobiology Pty Ltd (July 2006), using electrofishing and dip net methods of capture, was undertaken to collect additional specimens for tissues analysis.
- Gold Ridge's 2009 Environmental Performance Report includes a table with 32 species of fish recorded in Matepono River system and 45 species of fish recorded at Ngalimbiu River Bridge (see Annex 2 of the Annex Report).

7.2.2.1 Survey of Freshwater Biota in Solomon Islands, by Polhemus Et Al. (2004-2005)

For the first time in the Solomon Islands, a scientific survey of Solomon archipelago freshwater biota was undertaken during 2004 and 2005, by staff from Bishop Museum Hawaii, and four other research organizations with long-standing interests in Melanesia.

Altogether, 70 stations were sampled with a focus on freshwater fish and aquatic insects. The insect taxa included: Heteroptera (aquatic true bugs), Odonata (damselflies), Coleoptera (whirligig beetles, Gyriniidae) and Diptera (Simuliidae).

Fish were sampled at 31 stations, on 10 islands. Sampling stations ranged in elevation from sea level to 460masl. Four stations were located on Guadalcanal (see following table), with two of them near the Gold Ridge facilities. Table 7-1 identifies the location of the four sampling stations that were located on Guadalcanal.

Fish survey techniques consisted of underwater observations using mask and snorkel at each site, as well as selective capture of specimens using small hand nets. Digital photographs were taken of most species, either in situ within their habitats, or with the captured specimen in a small field aquarium.

The results were compiled in the report `Freshwater biota of the Solomon Islands; analysis of richness, endemism and threats_ (Polhemus et al., 2008). Altogether, 52 species of fish were recorded in Solomon Islands, with 13 of these recorded from the Guadalcanal sampling stations.

Table 7-1 Location of fish sampling stations on Guadalcanal, Nov 2004 and Jul 2005 (Polhemus et al., 2008)

Stat né	Date	River	Location	GPS location	Elevation (m)
14	21/11 /05	Tenaru riv.	At Tenaru falls, 12 km SE of Honiara	9é31`01,0_S 160é00`59,5_E	40
15	27/11 /05	Tina Hulu riv.	Above Gold Ridge road bridge, at Bemuta village	9é31`26,8_S 160é09`20,3_	35
50	28/07 /05	Lungga riv.	At mouth of gorge, near proposed dam site, SW of Mt Austen	9é23`44.3_S 159é50`47.6_E	25
64	03/08 /05	Charebuma riv.	Above Gold Ridge mine	9é35`39.8_S 160é07`28.6_E	290-460

7.2.2.2 Survey of Freshwater Fishes on Tetepare Island (2006)

A very comprehensive freshwater fish survey was undertaken in September 2006 by Jenkins, A.P and Boseto, D., on Tetepare Island, Western Province. The area was considered at the time as being the `largest unlogged and uninhabited lowland rain-forest island in the South Pacific_. Fifteen 150 m sections were sampled from four rivers and 2 lakes for fresh water fishes and water quality, with 797 specimens being captured by different means.

Though taking place in the Western Province, this comprehensive scientific study is an important reference, as it provides a precise description of the fish assemblage in the fresh waters of Solomon Islands.

7.2.2.3 Survey of the Tina River System, by Entura (2010)

An ESIA scoping study of the TRHPD was prepared by Entura (2010). The study included a rapid ecological assessment survey of the Tina River system, that was undertaken from 10 to 12 September 2010 by Pacific Horizons Consultancy Group.

Observations on aquatic habitats and fish biodiversity were limited to the proposed dam and reservoir area, as it was then defined, with 3 sampling stations located at Habusi, Toni River and Horohutu, respectively, corresponding to Stations C, D and E, respectively. In addition, bacteriological quality was measured at stations C and E.

These first results on aquatic ecology in the project area (see Annex E of the ESIA scoping study) raised some environmental concerns about baseline data, and impacts of the project on aquatic ecosystems.

A total of 20 fish species were recorded, 12 of these based on visual observation.

7.3 FISH AND AQUATIC ENVIRONMENT SURVEY

7.3.1 Delineation of the Aquatic Ecology Study Area

The aquatic ecology study area covers the whole river system, upstream and downstream of the dam/reservoir sites, from the upper catchment to the river mouth. Delineation of the study area is based on the likely area of influence of the project, as follows:

- upstream of the reservoir area, the fish and crustacean assemblage is likely to be affected, with the hydroelectric facilities being a barrier to the migration of amphihaline species.
- within the reservoir area, a major change will occur to aquatic ecosystem, which will be transformed from rheophilic to lentic conditions.
- downstream of the dam site, changes in water quality, flow and sediment transport patterns are likely to impact aquatic ecology in Tina/Ngalimbiu River down to the river mouth.

7.3.2 Organization of Field Survey

The first aquatic ecology survey was undertaken between 30 July and 06 August 2013 by the local and international BRLi experts in aquatic ecology, who were assisted by local guides.

The schedule was optimized to take advantage of the availability of transportation to and within the study area (e.g., by helicopter and automobile), and meteorological conditions (e.g., rainfall events, flash floods)

The field survey of upstream the reservoir area, in the vicinity of the hydrometric gauging station, was undertaken on 07 August 2013, by the aquatic ecology team, which was transported to the area by helicopter.

Field surveys in the reservoir area and downstream of the dam site were undertaken separately by the aquatic and terrestrial teams, which were transported to and within the area, by automobile.

Night sampling of fish was carried out at a few sites (Koropa and Choro), when aquatic animals, especially eels and prawns, are active from dusk to dawn.

A second aquatic ecology survey was conducted by Robson S. Hevalao, with the assistance of Eric Deneut, during the rainy season in February 2014.

A third field survey to was conducted in March 2016 by Ian Jowett, Mark Taylor, Robson Hevalao and David Boseto, during the 2016 rainy season. This survey was part of a study specifically designed to evaluate the impact of scheme operation on migratory fish and determine minimum environmental flow requirements for the region between dam and powerhouse tailrace. The survey involved quadrat sampling for species density in different habitats, habitat characterisation as well as the measurement of river cross sections for the purposes of determining habitat suitability curves in terms of water depth, substrate type and flow velocity.

Jowett and Hevalao conducted a follow up survey in July 2016 to obtain more low flow measurements.

7.3.3 Location of Survey Stations

Eleven aquatic survey stations (A1 to A10b) were selected to identify aquatic ecosystem habitat types, determine presence of fish species, and undertake water quality sampling. The selection of stations was based on the longitudinal geomorphological zonation of the river, previous fish survey stations used by Entura (2010), and areas that would be most likely affected by the Project. The stations were located as follows:

- 3 stations in the upper Tina River, upstream of the reservoir area:
  - one at the Tina River gauging station (A3) and two on the immediate upstream tributaries, Becho/Voraha (A1) and Mmembea (A2). The confluence of these two rivers forms the Tina River;
- 2 stations in the middle Tina River area downstream of the dam site and upstream of the power station :
  - one at Koropa (A4), and one at Senge (A5);
- 2 stations in the upper Ngalimbiu River:
  - one on the Toni River at Kathihana (A6), and one at Horohutu (A7);
- 4 stations in the lower Ngalimbiu River:
  - Ngalimbiu River bridge (A8), Saele (A9), old river mouth (A10a) and new mouth (A10b)

The first survey included the 3 stations surveyed by Entura in mid-December 2010, at Senge, Kathihana and Horohutu (see ESIA Scoping Study, page 57).

Table 7-2 lists the location of the aquatic ecology survey stations. To take into account the environmental and flow changes brought by the rainy season on the Tina River and its aquatic biota, another fish survey was carried out in February 2014. An additional station (7C) was surveyed during the rainy season, it was located at the option 7C dam site.

Table 7-2 Aquatic ecology survey stations

Station	Area	River	Location	Chainage*	WQ sample
A1	Upper catchment	Bicho-Voraha Riv.	confluence	CH -1km	X
A2	Upper catchment	Mbembea River	confluence	CH -1km	X

A3	Upper Tina R.	Tina River	Gauging st	CH 1km	X
7C	Middle Tina R.	Tina River	Dam	CH 7km	
A4	Middle Tina R.	Tina River	Koropa	CH 11km	
A5	Middle Tina R.	Tina River	Sengue	CH 11.5km	
A6	Upper Ngalimbiu R.	Toni River	Horohutu	CH 19km	X
A7	Upper Ngalimbiu R.	Ngalimbiu River	Kathihana	CH 20km	X
A8	Lower Ngalimbiu R.	Ngalimbiu River	Ngalimbiu	CH 28km	X
A9	Lower Ngalimbiu R.	Ngalimbiu River	Saele	CH 34km	X
A10a	River Mouth area	Old River mouth	Komporo	CH 36km	X
A10b	River Mouth area	New River mouth	Komporo	CH 37km	X

*Based on Entura Phase 1 chainage, starting at Tina River between the upstream confluence of the Mbeambea River and the Voraha River (chainage 0km)

The fact sheets included in Annex 1 of the Annex Report, provide a comprehensive description of the survey stations, including their exact locations by GPS coordinate, altitude, and river length chainage relative to the Tina River/Voraha River confluence. The Annex also includes photographs that identify the biophysical and social characteristics of each site.

7.3.4 Survey Methodology

The methodology used to conduct the aquatic ecology survey is explained by the following steps.

7.3.4.1 Obtain Local Knowledge

For those sampling stations located in inhabited areas (i.e., from Senge to the river mouth), local guides accompanied the experts. Fishermen, and other river users encountered in the field, were interviewed, using an interview guide.

Questions were asked pertaining to:

- river system functions (e.g., historical floods and other main features, changes in river morphology, etc.);
- river and riparian area use (e.g., domestic use, drinking water, transporting logs, fishing, gold panning, recreation, access, gravel extraction);
- fish species observed in the area, and their abundance (e.g., dominant, common, occasional); and
- main features concerning fishing activities (e.g. type of fishing gear and fishing techniques, target species, seasonal and long-term capture trends, personal consumption versus commercial sale of catches).

7.3.4.2 Describe the River

Photographs were taken at each station, and observations made regarding the following (see fact sheets in Annex 1 of the Annex Report):

- physical environment (velocity and flow pattern, turbidity, water depth, characteristics of minor and major stream beds, sediments, banks and riparian areas);
- biological environment (aquatic and riparian vegetation, wetlands and other sensitive environments); and
- human environment (uses of the river and riparian areas, access, habitations, etc.).

7.3.4.3 Conduct Fish Surveys

Fish survey techniques consisted of:

(i) underwater observations using mask and snorkel at each site, obtaining digital underwater photographs of each encountered species; and

(ii) obtaining information on fishermen's catches, including whether they were subsistence fishing or commercial fishing, location of fishing sites, and the type of gear they were using.

7.3.4.4 Conduct Water Quality Sampling

A 1.5L sample was collected on each sampling site, and brought to SIWA WQ laboratory in Honiara, where they were analyzed for pH, conductivity, turbidity, nitrates, and total phosphorus. Other parameters were added in the second survey campaign, as well as in situ measurements of dissolved oxygen.

In addition, the baseline level of E. coli contamination was surveyed on 14 August 2013 at 4 stations (Toni river, Valekotcha, Birao and Ngalimbiu River bridge). Samples were transported to SIWA laboratory for E. coli and total coliform analysis.

7.4 AQUATIC ECOLOGY BASELINE

In addition to the baseline physical conditions of the Tina River system (watershed, river geomorphology, and hydrology), the following sub-sections describe the aquatic ecology baseline for: (1) aquatic habitats, (2) water quality and (3) aquatic biota, with a focus on fish assemblage.

Additional details are provided in the fact sheets and photographs describing the survey stations included as Annexes 2 and 3 in the Annex Report.

While the operation of the hydro scheme will divert most of the Tina River through the headrace tunnel, there will be sufficient minimum permanent flow, referred to as environmental flow (as determined in the Aquatic Ecology section) remaining in the river, between the dam and the powerhouse downstream, to meet the current water consumption needs (i.e., for washing, bathing, drinking water, and garden irrigation) of the people living along this reach at Choro, Koropa, and Senge. However, the dynamics of the river flow will change, and most noticeably, some swimming or fishing holes will shrink during the dry season, while river crossings that are necessary for accessing Koropa and Choro will become easier and safer to access. A regime for releasing water from the dam could be implemented by the operator to provide sufficient volume of flow to keep river pools adjacent to Koropa and Senge villages filled with water. This operating regime would have to be formalized prior to operation.

7.4.1 Fisheries

As discussed later in Section 5 Social Baseline Conditions, fresh fish from the Tina River do not feature prominently in the diet of local inhabitants that reside along the river. Rather, canned tuna is their main source of fish protein. Despite their knowledge of fish species found within the river, from a livelihoods perspective it appears that fishing is only a minor activity. Fishing is undertaken during `fishing trips_ in the upper catchment, upstream from Choro. The main mode of fishing is by snorkeling with 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 fishing techniques.

7.4.2 Aquatic Habitats

The Ngalimbiu/Tina River flows approximately 35km in a N/N-E direction, from the central ridge of Guadalcanal (Mt. Popomanaseu to Mt. Mbutohaina) to the sea. For the purpose of the study, the river was been divided into 5 areas, based on elevation and geomorphology (see Section 5.6 ¯ River (Fluvial) Geomorphology):

Several aquatic habitats of specific ecological interest have been identified along the river. These include:

Mountain streams - though not included in the surveys, the dense network of steep streams draining the central mountain ridge (cloud forest area) is likely to represent a particular aquatic habitat. Relative to other Pacific islands, these streams form rapids under a dense cover of vegetation. A few amphihaline species (Anguilla megastoma, Sicyniids, Macrobrachium sp.) are likely to be found at such altitudes.

Runs and riffles - these habitats, which are common in the Tina River reach (Figure 7-1), are characterized by current velocities that range from 1.5m/s to 3m/s, that decrease with decreasing river bed slope and elevation, and have a substrate comprised of cobbles and pebbles. The substrate is covered with a thin film of periphyton (algae and diatoms), which requires sunlight and nutrients (nitrogen and phosphorus) to thrive. Water depths are typically less than 2m. Run and riffle areas are significantly harsh environments in the riverine system due to their velocity and depth. Fish species found here are mainly rock-suckers Gobiids (Sicyopterus, Stiphodon) that use their mouths to suck the surface film on the cobble and pebble substrate.

Figure 7-1 Typical run/riffle sequence in Tina River

Beds of pebbles, gravels and coarse sands - these habitats are common in the middle and lower reaches of the Tina River. They represent a trophic resource for detritivores like Syciidinae and other Gobiidae. However, unlike European or North America rivers, this habitat is unlikely to be used for spawning, due to the substrates constantly shifting during flash floods.

Under-rock habitats - these habitats are present in high velocity areas of the Tina River where the substrate is comprised of pebbles, sands and gravels either in interstitial cavities of boulder or block accumulations, or where boulders are laying on a bed of sand and gravels. Fast flowing water removes the pebbles, sands and gravels from under the downstream side of boulders, creating cavities. These dark areas shelter juvenile prawns and fish, and are used as spawning substrate by Syciidinae. Fertilized eggs, forming white plates, are stuck onto the boulder or block surface. The cavities accumulate organic material, including algae and diatoms, providing a source of food for bottom dwellers and detritivores. They also offer dark shelters where prawns and eels can hide by day. Bottom dwellers and detritivores are also common. Fertilized eggs of amphidromous[34] Gobiidae were found in under-rock habitats. Anguilla marmorata and prawns are also usually found in such habitats.

Pools - these habitats are deep (up to 2m or more) sections of the river (Figure 7-2), with water velocity less than 0.5m/s, or near to being still. They typically occur on outside of river bends, where the current runs deep before coming up to the surface in areas of less than 2m. Pool areas are increasingly present in the upper reaches of the Tina River where the river channel more confined, and decrease on the flood plains (e.g., Ngalimbiu River floodplain and river mouth), where the river channel is less confined and more braided. Substrates in the pools of the upper reaches are predominantly cobbles and pebbles, with associated boulders on the banks, which are bounded on either side by cliffs. Fluctuations in water levels increase with increasing elevation, due to the narrow and confined nature of the river as it flows through mountain gorges. Pool habitats are areas known to be nutrient rich, where very large fish and eels were observed.

Figure 7-2 Typical pool in Tina River

[34] Fish that move between fresh and salt water habitats at some point in their lifecycle, other than for purposes of spawning.

Aquatic/terrestrial contact zones (ATTZ) - these micro-wetland habitats, which are found at the margins of the river, are characterized by shallow stagnant waters, with fines (sands, silt and muck mud) deposited between boulders, pebbles and cobbles. These areas have high nutrient levels and available food resources for life cycles of various aquatic organisms, especially for Oligocheate worms, fish and larvae. Some areas are exposed to sunlight, which facilitates development of algae. Other areas are shaded under tree canopies.

Juvenile tree frogs were observed in this type of habitat at Njarimbisu. Nocturnal surveys confirmed that invasive Bufo sp. inhabit such areas at night to feed, mate and brood their young.

Some ATTZ, represented by ponds, were disconnected from the main river channel. These ponds were observed among boulders (see Figure 7-3) (see Station 6 factsheet in Annex 1 of the Annex Report), where species that were rarely observed at night in the river (Anguilla marmorata, Macrobrachium sp.) had become trapped.

Figure 7-3 Use of micro-wetlands by amphibians along the Tina River

Confluences where smaller tributaries enter the Tina River form another type of ATTZ. Here, the substrate is comprised of detritus, mud, clay and sand, deposited among boulders. Prawns and juvenile fish are abundant at these locations. Water velocity at some confluences is near to still, whereas at others, tributary streams enter as waterfalls, having very steep slopes at the point of confluence, and no still water pools are formed.

River mouths - this is a key habitat on the Ngalimbiu/Tina River system due to the diverse interaction between the ocean and freshwater entering from the river. Local inhabitants have confirmed that the river has changed course where it enters the sea, several times since Cyclone Namu. The new river mouth (Station A10a) is now considered as the main mouth of the river. It was formed in mid-2013 as a result of high river flood conditions and obstruction of the main channel by logs, and now flows laterally across the delta, roughly 500m West of the old river mouth. The old river mouth (Station A10b), occupied a more central position within the delta, and although it still connects the river to the sea, the outflow is much smaller.

As shown by measures of conductivity, only limited saltwater intrusion occurs into the mouth of the river. There appears to be no longitudinal gradient of brackish water. The river appears to discharge directly into the sea without forming a brackish water estuary. The presence of cane toad tadpoles and rushes along the banks of the river is evidence of sustainable freshwater conditions. Nutrients levels are high as a result of numerous connections to the many adjacent wetlands and swamps, estimated to cover 40ha. This area provides habitat for saltwater crocodiles and wetland species of fish.

The river mouth is a key habitat for fish populations, especially amphihaline species (larvae of Sicyniidae and other Gobiidae, adult and juvenile eels) that transit the area to reach the sea as part of their life cycles, and for marine forms that enter the mouth and lower reach of the river, which provides temporary feeding habitat. As observed during the field survey, the river mouth area supports intense fishing activity, for both subsistence and commercial purposes.

7.5 FISH BIODIVERSITY BASELINE

The following sub-sections present the baseline fish biodiversity conditions in the Tina/Ngalimbiu River system. Information has been compiled from the first BRLi fish survey conducted between 30 July and 06 August 2013, and from previous surveys conducted by others in Solomon Islands. A list of fish species identified from different surveys is included as Annex 2 in the Annex Report. An additional fish survey was carried out during the rainy season in February 2014.

Two fish surveys were conducted to ensure that identification was made of the widest range of species present throughout a given year. However, no conclusions can be drawn regarding migration behaviour based on the results of dry and wet season sampling. Therefore, any difference between dry and the wet season species distribution and abundance, across the different sampling stations, does not demonstrate any particular migratory behaviour.

7.5.1 Species Diversity

Table 7-3 provides a list of all fish species recorded by BRLi's local fish expert during field surveys both for dry and wet seasons. A total of 52 species, representing 30 genera and 15 families, was recorded during the dry season, and 57 species were recorded during the wet season. The letter `O_ in Table 7-3 represents fishes that were observed either in the dry or the wet season, while the letter `S_ represents the use of the site as a likely spawning ground, based on the literature review and observations made for other studies conducted since 2006 for the Ngalimbiu/Tina River catchment. A question mark `?_ denotes a supposition of presence or use, without benefit of field verification.

Fish biodiversity in the Tina River system is difficult to assess with certainty, given the following:

(i) scientific information on the fish of Solomon Islands is still poor, with taxonomic uncertainty and absence of field guides.

(ii) the survey methods (underwater observations and photographs), though particularly appropriate to large fast flowing rivers with clear water, do not always facilitate a precise determination. In some cases, the determination was limited to the genus level only.

Nevertheless, underwater observations and interviews with local fishermen, combined with information from previous studies, allowed a good picture of the fish assemblage to be developed for the Tina/Ngalimbiu River.

Compared to the previous quick survey conducted by Entura in 2010, when 20 species were recorded, the number of recorded species observed during the present study was higher. This is the result of increased sampling effort across different elevations, including the River mouth with its high diversity of marine forms.

The recorded species diversity (52 dry season / 57 wet season) is similar to that recorded in scientific surveys by Jentkins and Boseto (2006) for Tetepare Island, Western Province (60 species), and by Polhemus et al. (2008) for all Solomon Islands (52 species), and is higher than the diversity recorded by Golder Associates (2009) at the Ngalimbiu River bridge (32 species) and in the Matepono River system (45 species).

Nevertheless, when the results of the different surveys carried out for Solomon Islands are combined, a much greater diversity (122 recorded species) would seem to be the case (see Annex 2 in the Annex Report). However, this may be the result of uncertain or wrong determination, as well as changes in the taxonomy (i.e., synonymous species being identified).

7.5.2 Longitudinal Distribution

The distribution of fish species recorded from the various survey stations located along the river, during the first and second fish surveys, is summarized in Table 7-3. An additional station was added in the rainy season, to sample fish in the area of the proposed Option 7c dam site.

Table 7-3 Results of the BRLi fish survey

River area		Upper Tina			Middle Tina			Upper Ngalimbiu		Lower Ngalimbiu			Coastal or Marine *	Life Cycle	IUCN Status **	Remark regarding the species abundance in Guadal.
Stations		A1	A2	A3	7C	A4	A5	A6	A7	A8	A9	A10				
River & location	Seasons	Bicho-Voraha River	Mbembea River	Tina river gauging .station	Dam site	Tina River Koropa	Tina River Sengue	Ngalimbiu River Horohutu.	Toni River Kathihana	Ngalimbiu River bridge.	Ngalimbiu River Saele	Ngalimbiu River mouth				
Family and Species																
Ambassidae																
Ambassis interrupta	Wet										O S	O S		Amphi	LC	
	Dry											O				

Ambassis miops	Wet											O S		Amphi	LC	
Anguillidae																
Anguilla mamorata	Dry	O	O	O		O						O		Cata	LC	Rare
	Wet	O	O	O	O			O					S			
Apoginidae																
Apogon hyalosoma	Dry											O		Marine form	LC	
	Wet											O S				
Apogon sp.	Wet											O S		Marine form		
Carangidae																
Carangoides malabaricus	Dry											O		Marine form	NA	Common
	Wet											O S				
Caranx sp.	Wet	S?	S?	S?	S?	S?	S?	S?	S?	S?	S?	O	O	Marine form		Common
Caranx sexfasciatus	Dry											O			LC	

	Wet											O S	O	Marine form		
Scomberoides sp.	Wet											O	O S	Marine form		Rare
Scomberoids sp. Juveniles	Dry											O		Marine form		
Cichlidae																
Oreochromis mossambicus	Wet									O			S	Non migratory	NT***	Common invasive
Eleotridae																
Allamogurnda sp.	Dry					O								Amphi		
Belobranchus belobranchus	Dry					O				O				Amphi	DD	
	Wet	S?	S?	S?	S?	S?	S?	O S?	S?	S?	O S?	S?	S?			
Butis sp.	Dry															
Butis amboinensis	Dry						O			O				Amphi	LC	
	Wet					O	O S	S	O							
Eleotris fusca	Dry					O	O							Amphi	LC	

	Wet	O S	O S	O S						O						
Ophieleleotris hoedti	Dry					O	O			O				Amphi	NA	
Ophieleotris margaritacea	Dry													Amphi	NA	
Ophieleotris sp.1	Wet	O S	O S	O S		O			O					Amphi		Common
Ophieleotris sp. 2	Wet	O S	O S	O S	O				O					Amphi		Common
Ophiocara aporos	Dry													Amphi	NA	
Bunaka gyrinoides (Eleotris gyrinoides)	Wet				O S	O								Amphi	LC	Common
Gerreidae																
Gerres sp.	Wet												S	Marine form	NA	
Gobiidae																
Awaous guamensis	Dry	O	O	O		O	O							Amphi	LC	
Awaous melanocephalus	Wet	O S	O S	O S	O			O						Amphi	DD	Common
Awaous ocellaris	Dry	O	O	O		O	O			O				Amphi	LC	
Awaous sp.	Wet	O S	O S	O S										Amphi		Common

Bathygobius andrei[35]	Dry	O	O	O		O	O			O				Amphi	LC	
Glossogobius celebius	Dry						O			O				Amphi	DD	
Glossogobius sp. 1	Wet	S?	S?	S?	S?	S?	S?	O S?	O S?	S?	S?	S?	S?	Amphi		Common
Glossogobius sp 2	Wet	S?	S?	S?	S?	S?	S?	O S?	S?	S?	S?	S?	S?	Amphi		Common
Lentipes multiradiatus	Dry					O	O							Amphi	NA	
	Wet	O S	O S	O S	S	O S	O									
Lentipes sp.1	Wet	O S	O S	O S	O S		O							Amphi		Common
Lentipes sp. 2	Dry	O	O	O		O								Amphi		
Redigobius bikolanus	Dry	O	O	O		O	O		O					Amphi	LC	
Redigobius tambujon	Dry	O	O	O		O	O		O					Amphi	LC	
	Wet	O S?	O S?	O S?	S?	O S?	S?	S?	O S?	S?	S?	S?	S?			

[35] This identification is questionabe, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

Schismatogobius sp. cf. ampluvinculus[36]	Dry					O	O	O	O					Amphi	NA	
Schismatogobius sp. cf. roxasi[37]	Dry					O	O	O	O					Amphi	NA	
Schismatogobius sp.	Wet	S?	S?	S?	S?	S?	S?	O S?	O S?	S?	S?	S?	S?	Amphi		
Sicyopterus lagocephalus	Dry	O	O	O		O	O		O					Amphi	LC	Common
	Wet	O S	O S	O S	O	O	O	O	O	O						
Sicyopterus longifilis	Wet	O S	O S	O S										Amphi	DD	
Sicyopterus ouwensi	Wet	O S	O S	O S	O									Amphi	DD	
Sicyopterus sp.	Dry					O			O					Amphi		
Sicyopus discordipinnis	Dry					O	O		O					Amphi	DD	Rare
	Wet	O S	O S	O S		O										

[36] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

[37] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

Sicyopus mystax	Dry					O	O		O					Amphi	NA	
Sicyopus sp.1	Wet	O S	O S	O S	S									Amphi		
Sicyopus sp.2	Dry					O			O					Amphi		
Sicyopus zosterophorum	Dry					O	O		O					Amphi	LC	Common
	Wet	O S	O S	O S												
Stenogobius hoesei	Dry					O	O		O					Amphi	LC	
Stiphodon atratus	Dry						O			O				Amphi	LC	Rare
	Wet	O S	O S	O S	O S		O									
Stiphodon sp. cf. atropurpureus[38]	Dry					O	O	O	O					Amphi	NA	Common
	Wet	O S	O S	O S	O	O	O	O	O	O						
Stiphodon birdsong	Dry	O	O	O		O	O	O	O	O				Amphi	LC	Common

[38] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

	Wet	O S	O S	O S	O S	O	O	O								
Stiphodon sp. cf. multisquamus[39]	Dry	O	O	O		O	O	O	O					Amphi	NA	
Stiphodon sp. cf. ornatus[40]	Dry	O	O	O		O	O	O	O					Amphi	NA	
	Wet	O S	O S	O S	O	O	O	O	O	O						
Stiphodon rutilaureus	Dry					O	O		O					Amphi	LC	Rare
	Wet					S	O S									
Stiphodon semoni	Dry	O	O	O		O	O	O	O	O				Amphi	DD	Rare
	Wet	O S	O S	O S	O S	O	O	O	O	O						

[39] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

[40] This identification is questionable, based on known range and current understanding of species biogeography. Records are pending further confirmation of identification.

Stiphodon sp.1	Wet	O S	O S	O S										Amphi		Rare
Stiphodon sp.2	Dry					O	O							Amphi		
Kuhliidae																
Kuhlia marginata	Dry										O	O		Cata	LC	Rare
	Wet	O	O	O	O		O						S			
Kuhlia rupestris	Dry										O	O		Cata	LC	Rare
	Wet	O	O	O	O	O	O	O	O				S			
Lutjanidae																
Lutjanus argentimaculatus	Wet											O	O S	Marine form	NA	
Lutjanus fuscescens	Dry										O	O		Marine form	NA	
	Wet											O	S			
Lutjanus vitta	Dry										O	O		Marine form	NA	
	Wet	S?	S?	S?	S?	S?	S?	S?	S?	S?	S?	O S?	S?			

Mugilidae																
Liza tade	Wet											O	S	Marine form	LC	Rare
Liza vaigiensis	Dry					O		O		O				Marine form	NA	Rare
	Wet								O				S			
Muraenidae																
Gymnothorax polyuranodon	Wet								O				S	Cata	LC	
Ophichthidae																
Scolecenchelys macroptera (Muraenichthys macropterus)	Wet	S?	S?	S?	S?	S?	S?	S?	S?	S?	S?	O S?	S?	Marine form	NA	Rare
Poeciliidae																
Gambusia holbrooki	Dry	S?	S?	S?	S?	S?	S?	S?	S?	S?	O S?	S?	S?	Non migratory	LC	Common invasive
Rhyacichthyidae																
Rhyacichthys aspro	Dry					O				O				Amphi	DD	Common

	Wet	O S?	O S?	O S?	O S?	S?	O S?	S?	S?	S?	S?	S?				
Syngnatidae																
Chelon macrolepis	Dry					O				O				Cata	LC	
Microphis (Oosthetus) manadensis	Wet	S?	S?	S?	S?	S?	S?	O S?	O S?	S?	S?	S?	S?	?	NA	
Microphis sp.	Dry					O								?		
Microphis leiaspis	Dry											O		Amphi	LC	
	Wet							O S		O						
Microphis(Doryichtys) retzi	Dry											O		?	NA	
	Wet	S?	S?	S?	S?	S?	S?	S?	O S?	S?	S?	S?	S?			
Terapontidae																
Terapon jarbua	Wet									O			S	Marine form	LC	
Mesopristes argenteus	Dry										O	O		Marine form	LC	Rare
	Wet	O	O	O			O				S	O S				

Mesopristes cancellatus	Dry					O					O	O		Marine form	LC	Rare
	Wet	O	O	O	O		O				S	O S				
Zenarchopteridae																
Zenarchopterus dispar	Wet											O S		Marine form	LC	
Zenarchopterus sp.	Wet											O S		Marine form		
Total number of observed species, dry season	52	12	12	12	NA	33	25	8	17	12	6	14	NA	Number of species observed per station, dry season		
Total number of observed species, wet season	57	24	24	24	15	11	14	9	10	8	1	15	4	Number of species observed per station, wet season		

*Coastal area and Site 7C dam site location were only sampled during the rainy season, as Site 7C was had not been chosen until after the dry season sampling was completed

** Source: The IUCN Red List of Threatened Species. Version 2014.3. Unidentified species are not assessed. NT: Near Threaten; NA: Not assessed; LC: least concern; DD: Data deficient.

*** Near threatened in its natural habitat in East Africa

Amphi: Amphidromous; Cata: Catadromous; Pota: Potadromous

7.5.3 Fish Assemblage

7.5.3.1 Gobioids

In Solomon Islands, like other high islands of the Indo Pacific area, the fresh water fauna is dominated by Gobioid fishes, mainly members of Gobiidae and Eleotridae families. Most species are relatively small (< 10cm in length). In Solomon rivers, the species varies considerably in size. The largest species found was A. guamensis (adults reach 24cm). The most common species, S. semoni, does not exceed 5-6cm in length. Regarding the observations made during the first BRLi survey, the Gobioid group was represented by 34 species (25 Gobiidae, 8 Eleotridae and 1 Rhyacichthidae), representing 71% of the entire ichthyofauna.

Among Gobiidae, clinging gobies of the subfamily Sicydiinae (containing genera Stiphodon, Lentipes, Sicyopterus and Sicyopus) are particularly dominant in the study area, especially in the upper sections of the river where rock dominated, fast flowing clear streams, occur. These fishes present a `sucking disk_ formed by the two pelvic fins, allowing them to `cling_ to rocks in rapid stream flows.

Sicydiinae are typically brightly coloured, exhibiting neon shades of blue, gold and red. This group includes many recent discoveries and the taxonomy is relatively unstable, particularly for the genus Sicyopterus.

These species have an opportunistic diet. They feed on filamentous algae, worms, crustaceans, insects and suspended food particles. Sicydiins, which is the most abundant group in Solomon Islands rivers, feeds by sucking periphyton that grows on pebbles. They are known to play a key role in the food chain, especially as prey for eel A. marmorata (the top predator in such an environment), especially in the upper watershed.

During the surveys, Stiphodon semoni seemed to be the most common species, being largely present from Becho/Voraha River to Ngalimbiu River Bridge.

Among amphidromous species, the Sicydiinae are characterized by a massive migration of oceanic pelagic larvae entering the river and migrating upstream. Commercial harvest was observed at the river mouth, and shoals of juveniles were observed inland, migrating upstream along the banks. No doubt this group plays a crucial role in the river ecology (Keith, 2003).

According to discussions with local communities, Gobioids¨ fish size and abundance have decreased due to overfishing, both in the river and at the river mouth.

7.5.3.2 Non-Gobioids

A few non-gobioid species are likely to be found far upstream in the river. During the fish survey, the species observed beyond Choro were the giant Eel (Anguilla marmorata), pipefish (Microphis sp. Chelon macrolepis), jungle perch (Kuhlia sp.), mullet (Liza vaiengensis) and grunter (Mesopristes argenteus and M. cancellatus). With the exception of eels, that are likely to be found very far upstream, most species have limited abilities to migrate upstream from the first encountered waterfalls.

Most non-gobioid species are itinerant estuarine and marine forms tolerant to fresh water that will inhabit the lower reaches of streams. These fish are a combination of juvenile forms and adult forms that will spend periods in freshwater for feeding. The following species were recorded: Ambassis interruptus, Ambassia macracanthus, Carangoides malabaricus, Caranx sexfasciatus, Lutjanus vitta, Lutjanus fuscescens, Apogon hyalosoma, Scomberoides sp. Some of these fish are of sufficient size to represent an interest for subsistence/commercial fisheries. Some species, like C. sexfasciatus, L.vitta, L.fuscescens and A.interruptus, can be found as far as the Toni-Tina confluence. Some species are connected to the coastal wetland area surrounding the mouth of the river, estimated to be about 40 ha.

7.5.4 Migration Pattern and Life Cycle

Similar to other tropical islands of the Indo-pacific, almost all native species encountered in inland fresh water systems are migratory species, with a life cycle between ocean and river. Two main migration patterns can be distinguished: catadromous and amphidromous. In addition, Potadromous and Oceanodromous are less important migration patterns in the Ngalimbiu/Tina River system.

7.5.4.1 Catadromous

Catadromous migration involves downstream migration for adults to spawn, and upstream migration for juveniles to mature. Spawning takes place in the ocean.

Eels are catadromous, with adults migrating to the ocean to spawn, and juveniles (glass eels) migrating back into freshwater systems. During their upstream migrations, glass eels are able to climb to the upper reaches of the river. The life cycle starts in late November with adults moving downstream toward the ocean to spawn, and May with hatching of Juveniles in the ocean. Juveniles were observed moving back upstream to mature in July 2013. At their maturing stage, Anguilla sp. migrates to higher elevation reaches above 300masl. It will not mate until it reaches several kilometers upstream. After spawning in the ocean, the adult eels die. Compared to eels, Kuhlia rupestris (another catadromous species) spawns several times before it dies. The life cycle of Kuhlia begins in December with downstream migration. Upstream migration occurs in July (Note: females were observed with eggs in July during 2013 BRLi surveys). As with eels, Kuhlia migration reaches far upstream reaches of elevation 300 masl.

7.5.4.2 Amphidromous

Amphidromous migration involves downstream migration of larvae and upstream migration of juveniles to mature. Spawning takes place in the upstream river systems.

Most migratory species like Gobioids (e.g., Stiphodon, Sicyopterus, Awaous, Eleotris, and Glossogobius sp.), Mesopristes and prawns, are amphidromous. Spawning occurs in the rivers (under rocks for some Sicydiinae). Larvae drift passively to the ocean before migrating back as juveniles to the freshwater system to grow into adults. The factors controlling such upstream migration of juveniles are not well understood. Flooding (high turbidity) and lunar cycles are assumed to play a role in some species such as Sicydiinae. Migration from the ocean to upstream rivers takes place on a monthly basis. Amphidromous species migrate to the upper Tina River catchment attracted by its cooler water, better water quality and fewer habitat disturbances. For example, Sicyopterus lagocephalus was observed in the mountainous region of the upper Tina River catchment. Between maturing eggs, upstream migration and spawning in the upper Tina River, the average life cycle takes 3 to 4 months to complete. Important water temperature gradients found along the Tina River are suspected to trigger migration of fishes, as water temperatures are progressively cooler upstream.

7.5.4.3 Potadromous

One Potadromous species, Gambusia holbrooki, was found at Station 9 downstream in the Ngalimbiu River, upstream of the river month. The species was introduced by the Solomon Islands Malaria Training and Research Institute (SIMTRI) in the 1980s and 1990s, to control mosquito larva in swamp sites. It may be a threat to both adult and juvenile fish species.

Potadromous fish are characterized as species that are born in the higher reaches of freshwater systems and migrate downstream, where they mature before migrating upstream again. Gambusia holbrooki is present in the Guadalcanal plains near river mouths, where it tolerates harsh environments. Its migration might extend upstream to the confluence of the Tina and Toni rivers. It was not found at the higher reaches, probably due to lower temperatures upstream. Most of this species spawns in the lower reaches from the Toni-Tina confluence, downstream to wetlands of the Ngalimbiu River mouth.

7.5.4.4 Marine form (Oceanodromous)

Oceanodromous species spawn and hatch on the outer edges of reefs or mangrove areas. They drift in the ocean as larvae, before settling as juveniles and growing into adults, to migrate back to their spawning sites. Marine species are tolerant of fresh water, entering into the lower reach of the River as juveniles, sub-adults or adults, to feed.

7.5.4.5 Conclusions on Migration

Catadromous and Amphidromous regimes, besides playing a crucial role in the river ecology, have been considered with particular attention through supplementary studies in the project ESIA because the hydroelectric project will affect their colonization upstream of the dam. Most of the Gobidaea family species mature and spawn in the dam area (Awaous, Sicyopterus, Stiphodon, etc.).

7.5.5 Locomotion Behavior

Regarding the abilities of juvenile fish to pass obstacles when migrating upstream, different locomotion behaviors can be observed. These have been taken into account when designing possible fish pass systems.

7.5.5.1 Strict swimmers

Some species like silverfish Mesopristes sp., Kuhlia sp., river mullet (Liza vaiengensis), and others, can be qualified as `strict swimmers_ with a pelagic behavior. They remain constantly within the water column (i.e., make no contact with the substrate). These species are not capable of climbing obstacles, such as natural cascades, waterfalls or dams). In their natural environment, these species are not found upstream of waterfalls.

7.5.5.2 Crawlers and climbers

Other species of fish exhibit a benthic behavior (Syciinidae and other Gobiidae, prawns, eels), and are able to migrate upstream of cascades and waterfalls. They can be classified in two categories:

- ↙ Syciidinae juveniles or climbing gobies (genus Lentipes, Sicypoterus, Sicyopus, Stiphodon), are presumably the most abundant taxa in the Tina River, and are known to climb quasi-vertical smooth surfaces up to several hundreds of meters, using their pelvic suckers and, for some species, their buccal suckers.
- ↙ Eels and prawn juveniles, unlike Syciidinae, are not able to climb sub-vertical smooth surfaces. However, they are known to climb over steep slopes with wet and rough surfaces with asperities, by crawling on substrates of rocks, earth and vegetation over which runoff waters flow. Eels use undulations of the body axis whereas prawns walk on the substrate. In Tahiti, both eels and prawn juveniles are known to climb over earth dams, 15m to 20m in height. Therefore, as species they are still present and abundant upstream of dams built in the 1980s (Moirod & Trebaol, personal communication).

Table 7-4 presents locomotion behavior of identified fishes.

Table 7-4 Locomotion behavior

Locomotion behavior	
Ambassidae	
Ambassis interrupta	Strict swimmer
Ambassis miops	Strict swimmer
Anguillidae	
Anguilla mamorata	Crawler
Apoginidae	
Apogon hyalosoma	Strict swimmer
Apogon sp.	Strict swimmer
Carangidae	
Carangoides malabaricus	Strict swimmer
Caranx sp.	Strict swimmer
Caranx sexfasciatus	Strict swimmer
Scomberoides sp.	Strict swimmer
Scomberoids sp. Juveniles	Strict swimmer
Cichlidae	

Locomotion behavior	
Oreochromis mossambicus	Strict swimmer
Eleotridae	
Allamogurnda sp.	Strict swimmer
Belobranchus belobranchus	Strict swimmer
Butis sp.	Strict swimmer
Butis amboinensis	Strict swimmer
Eleotris fusca	Strict swimmer
Ophieleleotris hoedti	Strict swimmer
Ophieleotris margaritacea	Strict swimmer
Ophieleotris sp.1	Strict swimmer
Ophieleotris sp. 2	Strict swimmer
Ophiocara aporos	Strict swimmer
Bunaka gyrinoides (Eleotris gyrinoides)	Strict swimmer
Gerreidae	
Gerres sp.	Strict swimmer
Gobiidae	
Awaous guamensis	Climber
Awaous melanocephalus	Climber
Awaous ocellaris	Climber
Awaous sp.	Climber
Bathygobius andrei[41]	Data deficient
Glossogobius celebius	Data deficient
Glossogobius sp. 1	Data deficient
Glossogobius sp 2	Data deficient
Lentipes multiradiatus	Climber
Lentipes sp.1	Climber
Lentipes sp. 2	Climber
Redigobius bikolanus	Climber
Redigobius tambujon	Data deficient
Schismatogobius sp. cf. ampluvinculus[42]	Data deficient
Schismatogobius sp. cf. roxasi[43]	Data deficient

[41] This identification is questionable, based on known range. Records are pending further identification.

[42] This identification is questionable, based on known range. Records are pending further identification.

[43] This identification is questionable, based on known range. Records are pending further identification.

	Locomotion behavior
Schismatogobius sp.	Data deficient
Sicyopterus lagocephalus	Climber
Sicyopterus longifilis	Climber
Sicyopterus ouwensi	Climber
Sicyopterus sp.	Climber
Sicyopus discordipinnis	Climber
Sicyopus mystax	Climber
Sicyopus sp.1	Climber
Sicyopus sp.2	Climber
Sicyopus zosterophorum	Climber
Stenogobius hoesei	Climber
Stiphodon atratus	Climber
Stiphodon sp. cf. atropurpureus[44]	Climber
Stiphodon birdsong	Climber
Stiphodon sp. cf. multisquamus[45]	Climber
Stiphodon sp. cf. ornatus[46]	Climber
Stiphodon rutilaureus	Climber
Stiphodon semoni	Climber
Stiphodon sp.1	Climber
Stiphodon sp.2	Climber
Kuhliidae	
Kuhlia marginate	Strict swimmer
Kuhlia rupestris	Strict swimmer
Lutjanidae	
Lutjanus argentimaculatus	Strict swimmer
Lutjanus fuscescens	Strict swimmer
Lutjanus vitta	Strict swimmer
Mugilidae	
Liza tade	Strict swimmer
Liza vaigiensis	Strict swimmer
Muraenidae	

[44] This identification is questionable, based on known range. Records are pending further identification.

[45] This identification is questionable, based on known range. Records are pending further identification.

[46] This identification is questionable, based on known range. Records are pending further identification.

Locomotion behavior	
Gymnothorax polyuranodon	Data deficient
Ophichthidae	
Scolecenchelys macroptera (Muraenichthys macropterus)	Data deficient
Poeciliidae	
Gambusia holbrooki	Strict swimmer
Rhyacichthyidae	
Rhyacichthys aspro	Data deficient
Syngnatidae	
Chelon macrolepis	Data deficient
Microphis (Oosthetus) manadensis	Data deficient
Microphis sp.	Data deficient
Microphis leiaspis	Data deficient
Microphis(Doryichtys) retzi	Data deficient
Terapontidae	
Terapon jarbua	Strict swimmer
Mesopristes argenteus	Strict swimmer
Mesopristes cancellatus	Strict swimmer
Zenarchopteridae	
Zenarchopterus dispar	Strict swimmer
Zenarchopterus sp.	Strict swimmer

7.5.6 Habitat requirements

Together with locomotion behaviour, the use of habitat by species˘present in the river will determine the impacts that hydro scheme operation will have on migration and life cycle.

There is little published information about the habitat types in which the Tina River species are found and no specific information on the water depths, velocities and substrates in which they are found. Gobies are usually found in riffles, where coarse substrate (boulders, cobbles and large gravels) provide both shelter from the current and a food resource. Pools provide habitat for large eels, grunters and jungle perch.

Measurements of fish species and number, water velocity and depth and substrate composition in small areas (2-4 m^2) were made on 11 March 2016 and 13-14 July 2016 to determine habitat suitability for common fish species in the Tina River.

Very little is known about the factors controlling fish populations in Solomon Islands. As in other island countries, most Solomon Island fish species have evolved to cope with the conditions they

experience. Eels and most gobies are capable climbers and can penetrate to the headwaters of most rivers. The diadromous life history protects their early life stages from the vagaries of the riverine environment such as strong and variable currents caused by floods and freshets. The overwhelming influence of diadromy suggests that total fish numbers and diversity in a given reach will depend on access to the sea, with instream habitat controlling the density of fish within the reach.

7.5.6.1 Habitat modelling

Modelling of instream habitat availability for selected species, over a range of flows, is a valuable tool when assessing potential effects of flow changes and making decisions about environmental flow requirements. This method is one of the most commonly used methods of assessing flow requirements (Tharme 2003). The background to methods used here is discussed in Jowett et al. (2008).

Habitat modelling entails measuring water depths and velocities, as well as substrate composition, across a number of stream cross-sections at a given flow (referred to as the survey flow). Points on the banks, above water level, along the cross-sections are also surveyed to allow model predictions to be made at flows higher than the survey flow. Calibration data for fitting rating curves are obtained from additional measurements of water level at each cross-section, relative to flow, on subsequent visits. The stage (water level) with no flow in the river (stage of zero flow) is also estimated at each cross-section to help fit rating curves. These data allow calibration of a hydraulic model to predict how depths, velocities and the substrate types covered by the stream will vary with discharge in the surveyed reach.

The habitat suitability at each point in the reach is calculated from modelled depth, velocity and substrate from habitat suitability curves[47] (HSC). Habitat suitability weighted by the area represented by each point is summed over the reach to give area weighted suitability (AWS previously known as WUA weighted usable area) with units of m^2/m. The average habitat suitability of the reach is the AWS divided by the wetted area of the river and is a dimensionless number between 0 (totally unsuitable and 1 (ideal). Habitat modelling is undertaken over a range of flows to predict how habitat availability (AWS) and average habitat suitability will change with flow.

7.5.6.2 Habitat mapping

The first step in the process is to carry out habitat mapping along the length of the reach between the dam and tailrace locations. The habitat types are assessed in the field after traversing the affected reach; usually they would include riffle, run, pool, and rapid. The length and location of each habitat type is recorded. The habitat mapping between the Tina Village and dam site is presented in Table 7-5.

Table 7-1 - provides the percentage of habitat types between Tina Village, powerhouse site and dam site on 6 March 2016

[47] HSC describe the suitability of different depths, velocities and substrate sizes for given species of interest.

Habitat type	1 km upstream of Tina Village to powerhouse site	Upstream of powerhouse to 1 km downstream of dam site
Rapid	5%	5%
Riffle	31%	36%
Run	55%	46%
Pool	9%	13%

7.5.6.2.1 Cross-section selection

The number of cross-sections required depends on the morphological variability within the river. Studies have shown that relatively few cross-sections can reproduce the results from a survey with a large number of cross-sections (see Jowett et al. 2008 for details).

The total number of cross-sections needed to generate a robust result should be proportional to the complexity of the habitat hydraulics: 6-10 for simple reaches and 18-20 for diverse reaches.

Each cross-section is given a percentage weighting based on the proportion of the

habitat type in the reach that it represents. The underlying assumption is that the cross-sections measured provide a reasonable representation of the habitat throughout the reach. Reach results can be extended to longer sections of river, if the flows, river gradient and morphology do not change significantly.

Three cross-sections were surveyed - one in a pool, one in a run and one in a riffle. Water levels were measured at flows of 8.7 m^3/s and 19.7 m^3/s and these were used to develop rating curves at each cross-section[48].

7.5.6.2.2 Habitat suitability

It is the quality of the habitat that is provided by the flow that is important to density of stream biota, rather than the magnitude of the flow per se. In many streams, flows less than the naturally occurring low flow are able to provide good quality habitat and sustain stream ecosystems. The magnitude of this flow will vary with the requirements of the species and with the morphology of the stream.

Water velocity is probably the most important characteristic of a stream. Without it, the stream becomes a lake or pond. In gravel bed rivers, an average velocity of 0.2-0.3 m/s tends to provide for most stream life, because velocities lower than this provide unsuitable habitat for a number of fish species and stream insects, and allow deposition of sand and finer materials. In large rivers, water depth of more than 0.4 m provides habitat for swimming species, but benthic fish are often found in shallower water. Gobies feed either on algae or small invertebrates associated with algae growing on the stable cobbles and boulders.

[48] It would have been ideal to obtain calibration measurements at three flows, one as low as possible. However, experience has indicated that there is a probability (> 50%) that 3 cross-sections in the different habitats would give the same answer as a larger number of cross-sections. Although not ideal, these measurements can give some indication of the effects of a flow reduction on instream habitat.

The flow at which limiting conditions of depth and velocity occurs varies with stream morphology. Generally, minimum flow increases with stream size, because stream width increases with stream size. However, the relationship is not linear. In general, small streams require a higher proportion of the natural stream flow to maintain minimum habitat than do large rivers.

7.5.6.2.3 Method for determining habitat suitability

Fish densities were sampled across transects in the Toni River in a variety of habitat types (riffle, run and pool) on 11 March 2016. Thirteen quadrats of between 2 m^2 and 6 m^2 were sampled by electro-fishing using EFM300 (NIWA Instrument Systems, Christchurch, New Zealand) electro-fishing equipment. Flooding and turbidity prevented sampling in the Tina River

The quadrats were at regular intervals across each transect with a distance of at least 1 metre between quadrats to avoid fish disturbance. The quadrats were selected so that there was minimal variation in water depth, velocity and substrate composition within the quadrat.

Electro-fishing was conducted with a downstream stop net and a dip net to catch any fish that missed the stop net.

Water depths and velocities were measured across a diagonal of the area fished and matched to recorded species and lengths of fish caught. Afterwards, fish were released at their capture point.

A further 56 quadrats were sampled by snorkelling on the 13-14 July 2016; 23 in the Toni River and 33 in the Tina River. A total of 18 species were either caught or observed and 8 of these species were relatively common (present in more than 3 quadrats).

After fishing, water depth and velocity were measured (at 0.4 times depth) at 5-10 points in each quadrat usually on a diagonal. The percentage of five substrate size categories (bedrock, boulder, cobble, gravel, and fines) was estimated visually.

Potential cover such as banks with overhanging vegetation or large logs was also sampled. The average depth and velocity in each quadrat was calculated from the measurements taken within the quadrat. For substrate, a substrate index (s) was calculated from the visual percentage estimates using the formula (Jowett & Richardson, 1990)

s =0.08*bedrock + 0.07*boulder + 0.06*cobble + 0.05*gravel + 0.035*fines.

The most suitable habitat was be determined by the density of fish. For example if the highest average density of fish was in riffles and the lowest in pools, riffles would be the most suitable habitat and pools the least. A similar procedure was followed to determine habitat suitability for depth, velocity and substrate. The methods used for determining habitat suitability are described in Jowett & Davey (2007) and Jowett & Richardson (2008).

Some size-related habitat selection was observed with smaller fish in low velocity water than the larger individuals of the same species.

During the first survey, the proportion of the different habitat types was measured and cross-sections were identified in each of the habitat types. A large flood that occurred on the second day of the survey, removed more than half of the temporary staff gauges that had been installed. This meant that only 3 cross-sections could be surveyed. One cross-section was a wide riffle at the proposed powerhouse location and the other two were in a pool and run further upstream. Water levels were measured at flows of 8.7 m^3/s and 19.7 m^3/s and these were used to develop rating curves at each cross-section. The cross-section at the powerhouse site was selected to evaluate the effect of flow on water level between the powerhouse and Tina Village where the valley is wider than between the dam and powerhouse. Because the powerhouse cross-section was

unrepresentative of the habitat between the dam and powerhouse it was excluded from the habitat analyses.

The second survey (11-12 July 2016) comprised cross-sections in 2 pools, 5 runs, 5 riffles and 2 rapids; a total of 14 cross-sections. The flow was 9.91 m^3/s on the 11 July and 9.66 m^3/s on the 12 July. Water level and flow measurements were taken on 15 July and 25 July for rating calibration when the flows were 8.28 m^3/s and 5.39 m^3/s, respectively.

This sampling showed clearly that riffles were the preferred habitat of gobies and eels, with an average fish density in riffles of 7.2 fish/12 m^2 compared to an average density of 1.4 fish/12 m^2 in runs. We did not find any fish in association with log or bank cover.

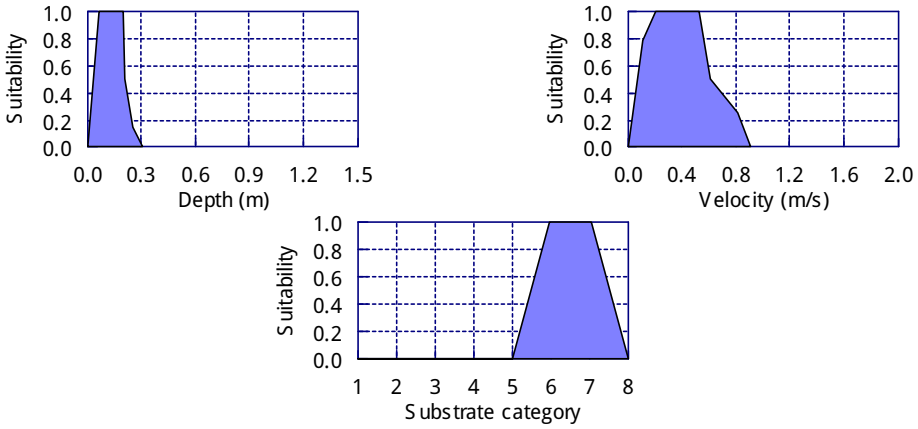
Fish density and diversity was higher in the Toni River than in the Tina River (Mann-Whitney non-parametric test, $P<0.001$), with an average of 60.4ě81.7 fish/12m^2 in the Toni River compared to 6.7ě17.1 fish/12m^2 in the Tina River and an average number of species per quadrat of 2.61ě1.44 in the Toni River compared to 1.17ě1.09 in the Tina River. There were no significant differences between rivers in sampling depth or substrate composition (Mann-Whitney non-parametric test, $P>0.1$) but sampling velocities were higher in the Tina River than in the Toni River (Mann-Whitney non-parametric test, $P=0.001$).

In general, the results were as expected with these goby species in shallow low-moderate velocity riffles and eels in a wider range of depths and velocities in the riffles. Shallow water (<0.3 m), a velocity of about 0.5 m/s, and cobble substrate tended to contain the greatest density of fish and the greatest number of species.

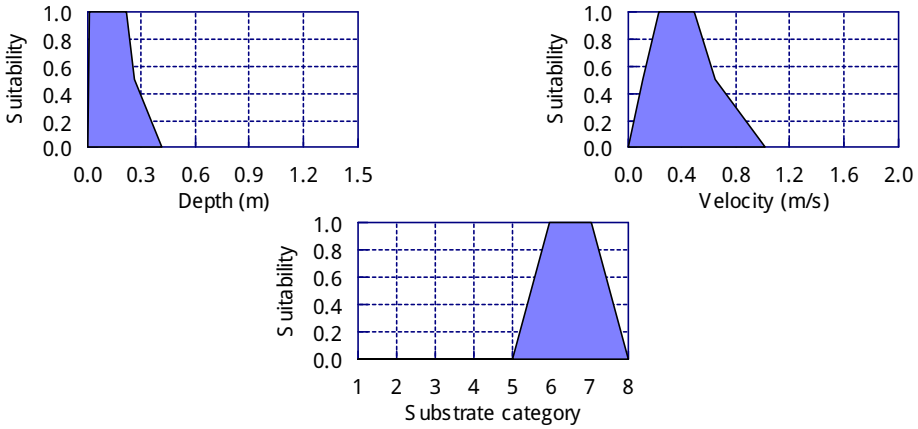
The preferred habitat of the goby species Sicyopterus stimpsoni in Hawaii (Fig. 7-4) was similar to the preferred habitat of the Solomon species in that they preferred low to moderate velocities and coarse substrate. However, the other Guam and Hawaii species seemed to prefer lower velocities than Stiphodon semoni and Belobranchus sp.

Figure 7-4: Habitat suitability curves for Stiphodon semoni, Belobranchus sp., Anguilla marmorata, fish density and species richness. The substrate categories are 1= vegetation, 2=mud/silt, 3=sand,4=fine gravel, 5=gravel, 6=cobble,7=boulder, 8=bedrock.

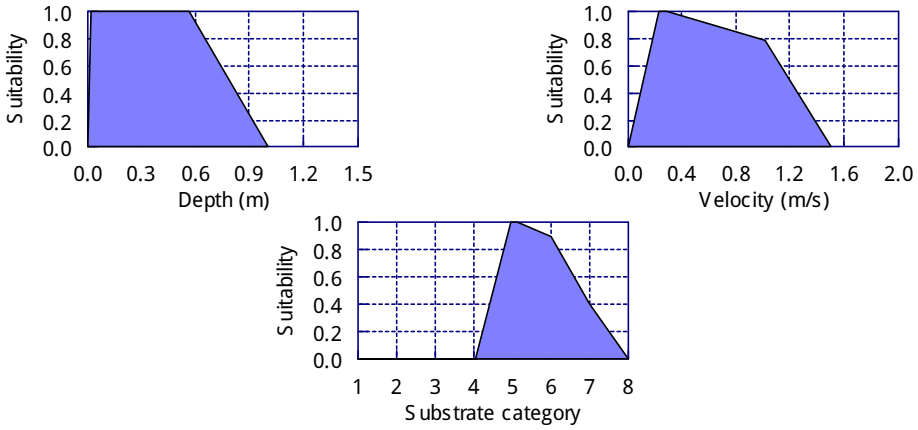
Stiphodon semoni



Belobranchus sp.



Anguilla marmorata (<150mm)



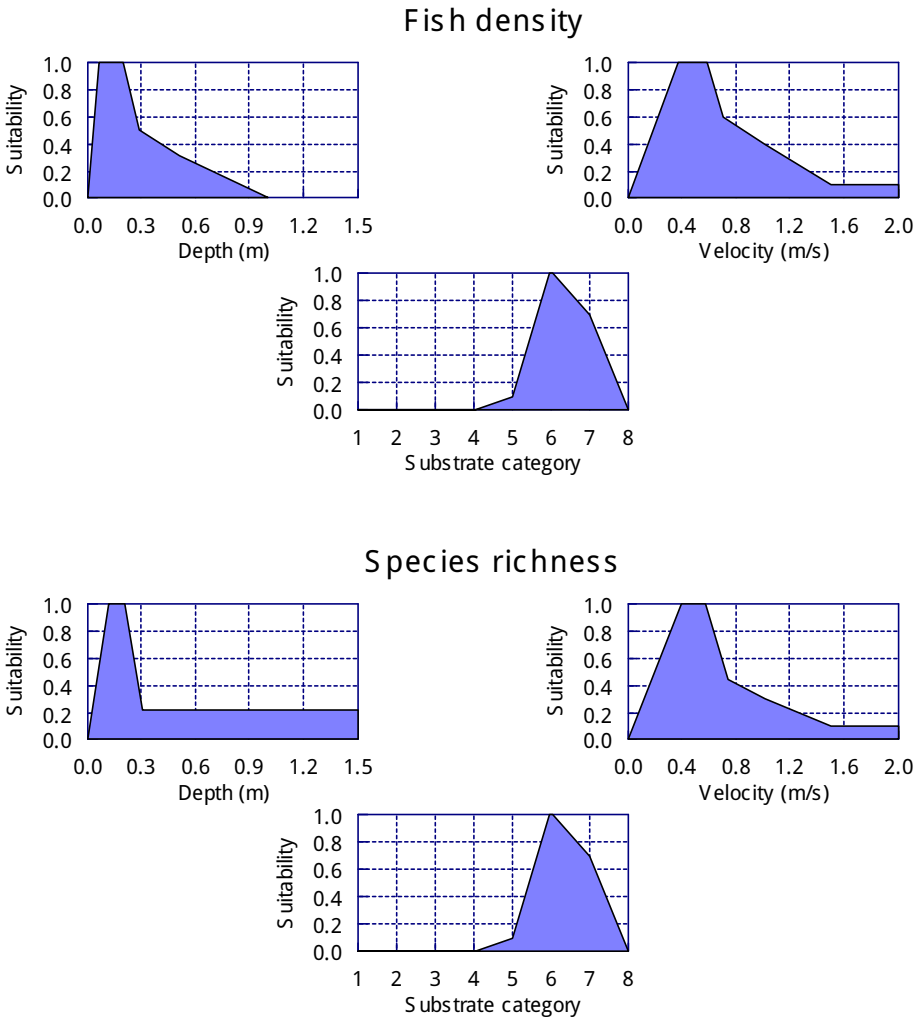
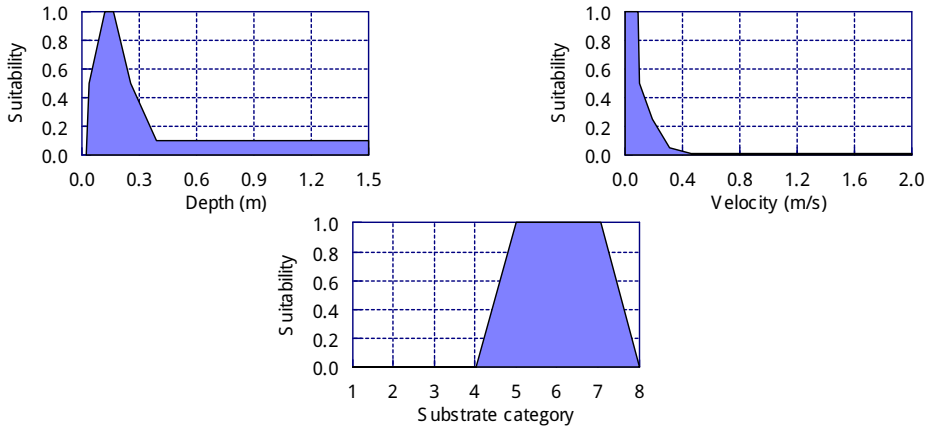
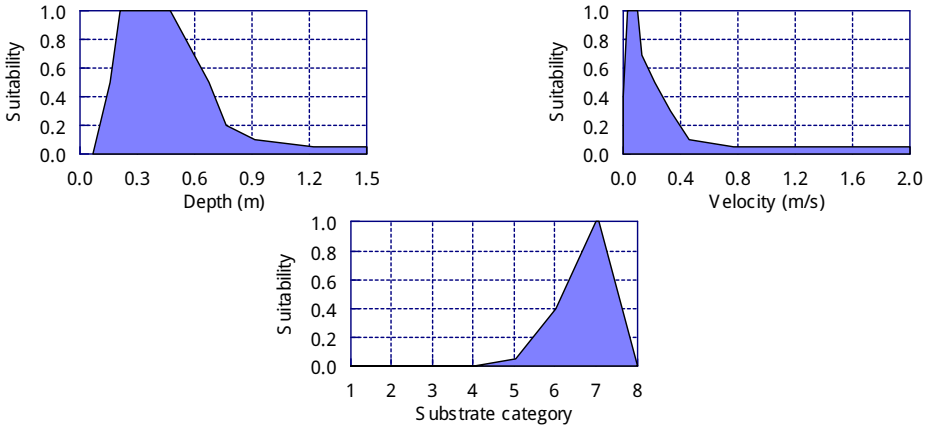


Figure 7-5: Habitat suitability curves for goby species from Guam and Hawaii from Thomas R Payne & associates. The substrate categories are 1= vegetation, 2=mud/silt, 3=sand,4=fine gravel, 5=gravel, 6=cobble,7=boulder, 8=bedrock.

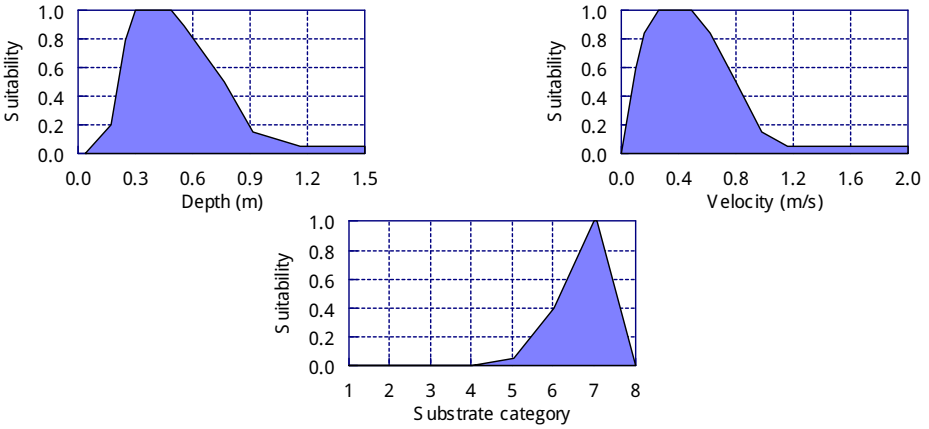
Stiphodon elegans



Awaous stamineus



Sicyopterus stimpsoni



7.6 INVASIVE, RARE, ENDANGERED, ENDEMIC AND THREATENED SPECIES

This sub-section describes observed species that are deemed ecologically important because of their migratory patterns, endemic status, threatened and protected status, and water dependence. These include migratory species, Guadalcanal island endemics species, species included by IUCN as red listed (Vulnerable, Endangered or Critically Endangered), species protected by CITES, and those that are dependent on the river water system.

Although Polhemus, et al. (2008), surveyed many islands in the Solomon Islands archipelago for aquatic insects, and compiled results in the report entitled `Freshwater Biotas of the Solomon Islands: Analysis of Richness, Endemism and Threats¸ there is a lack of literature regarding specific life cycles, and breeding and feeding habits of most fauna in the Solomon Islands. Therefore, due to limited scientific data and limited previous surveys, there is only partial knowledge regarding the extent of impacts that TRHDP activities may have on terrestrial species.

7.6.1 Endemic Aquatic Insect Species

Guadalcanal is rich in aquatic insect diversity. Polhemus surveyed many islands in Solomon Islands for aquatic insects, including nine locations in Guadalcanal, four of which were in the TRHDP study area. These four stations are presented on the map in Figure 6-1. Surveys were carried out between 2004 and 2005. The table in Annex 7 of the Annex Report shows sampling results from Polhemus et al. (2008), aquatic insects observed by the ESIA team were added to the table.

Among the aquatic insect species of the Sub Order Heteroptera (true bugs), 12 species occur on Guadalcanal, 4 of which are endemic across Solomon Islands, and 8 of which are endemic to Guadalcanal.

Among the aquatic insect species of the Sub Order Odonata (dragonflies and damselflies), 15 species occur on Guadalcanal, 8 species of which are endemic across Solomon Islands, and 7 species of which are endemic to Guadalcanal.

Among the aquatic insect species of the Sub Order Coleoptera (beetles), 7 species occur on Guadalcanal, 1 species of which is endemic across Solomon Islands, and 6 species of which are endemic to Guadalcanal.

This richness in aquatic insect species is primarily threatened by logging activities, which can lead to stream degradation, obstruction and siltation from tree falling. Logging also creates openings in the canopy leading to an increase of stream temperatures, which affects habitat requirements of many aquatic species. Oil palm plantations also pose a threat to aquatic insects, due to runoff of water containing of fertilizers and pesticides. Finally, mining activities can cause siltation and introduce chemicals to the streams.

7.6.2 Invasive Aquatic Species

Two major invasive aquatic species, Mozambique tilapia (Oreochromis mossambicus) and mosquito fish (Gambusia holbrooki) can become very numerous in the lower reaches of Guadalcanal rivers. O. mossambicus was recorded at Ngalimbiu River bridge (Golder Associates, 2009) and in a billabong near the Tina Village during the scoping study (PHCG, 2010). The species was not observed during the 2013 fish survey, though its presence was confirmed by interviews with local fishermen, and by observations made during the rainy season.

The dynamics of these two invasive species are believed to be low in the Tina-Ngalimbiu River, due to dominant rheophilic conditions (fast moving water), and to the flow pulse in a short period of time. Tilapia is definitely not a species adapted to rheophilic conditions found in the middle/upper Tina River. This ESIA considers that this species will not colonize the upper Tina River catchment, and will not have consequences on local fish biodiversity. The species has already been present in the lentic environment of the Ngalimbiu River for many years, and has not invaded middle/upper Tina River.

7.6.3 Endemicity and IUCN Status

The endemicity rate of freshwater fish in Solomon Islands has been assumed to be low, compared to other taxa like aquatic insects (Polhemus et al, 2008), although recent detailed studies have revealed a level of freshwater fish endemism in the Solomon Islands that was not previously appreciated (Keith et al. 2017).

According to Polhemus et al (2008):

> . . . interestingly, although freshwater fishes show notable endemism on both New Guinea and Fiji which bracket the SI region, there were no locally endemic genera or species of freshwater fishes previously recorded from the SI archipelago, nor were any unequivocally discovered during the present surveys, although there is a possibility that a few sicydiine gobies collected may prove to be regionally endemic.

In contrast, the aquatic insect biota is represented by many endemic species often confined to single islands, with an endemic rate of 44% to 90%, depending on the taxa, and 32 species new to science.

Fish surveys on Tetepare Island, Western Province (Jenkins and Boseto, 2007) show that most species have a wide geographical distribution range in the Indo-Pacific area. Though, 15% of the fish fauna is either restricted to the Melanesian archipelagoes (5%) or only known from Solomon Islands (10%). Regarding the latter, five un-described species were identified.

The Tina River and other Guadalcanal rivers are likely to present the same range of species, with a few restricted range species, especially in genus Schismatogobius, Stiphodon, Sicyopterus and Lentipes. Endemicity at the Tina/Ngalimbiu watershed level is very unlikely, given the above mentioned scientific results.

For all recorded species, IUCN status is given as least concern or not evaluated / unknown. No native vulnerable, or near threatened, or endangered, fish species have been found in the Tina/Ngalimbiu River system. Some species are rare, according to local communities, and have been identified as such in Table 4-13.

7.7 Fisheries in the Tina-Ngalimbiu River

Along the river, fishing activities were recorded at all surveyed stations. The remote areas at and upstream of the dam location are fished very occasionally, and only on particular occasions, due to difficult access. Further downstream, in inhabited areas along the lower Tina River and upper Ngalimbiu River, subsistence fishing is a continuous activity, practiced either by adults or children, using mainly snorkelling and spear fishing gear. From interviews with local fishermen, fisheries activities have increased with growth of human population, especially for younger people. During

the field survey conducted near Horohotu, a fisherman exhibited a catch of 6 specimens of considerable sizes (mullet and rock-sucker gobies) caught with a spear.

The shore along the mouth of the Ngalimbiu River is a very bountiful fishing location due to the concentration of adult and juvenile fish of different species entering into the lower river. About 30 fishermen from Komporo and other coastal villages are working at the mouth of the river during both daytime and night time, either for subsistence or commercial fishing, using canoe, gill nets, and mosquito seine nets. According to fishermen that were interviewed, a single fisherman can earn SBD 1,500 by selling the catch. Goby larvae are very appreciated and sell for SDB 5 per cup. The catch with 50-70 test fishing lines is very high (e.g., 40 fish per 20 minutes was mentioned) and even higher with 1_ mesh gill nets.

At a monthly frequency, when full moon and sun meet at the dawning of a day, the fishers await massive migrations of juvenile fish entering into the river. In the upstream reach, increased catches have been observed during these periods. Apart from juveniles, migration of large specimens of marine forms and eels reaching maturity, are targeted in the upper reaches.

7.8 TINA RIVER UPPER CATCHMENT, A CRITICAL NATURAL HABITAT?

This sub-section discusses the significance of the upper Tina River catchment solely on an aquatic ecology basis, since it is the main upstream component that will be modified due to the Project. However, the upper Tina River catchment is also an important terrestrial habitat, since it is covered by a significant area of Montane forest, and is the location for many high peaks of Guadalcanal.

7.8.1 Critical Habitat

As defined by World Bank Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources, critical habitats are `areas with high biodiversity value, including:

(i) habitat of significant importance to Critically Endangered and/or Endangered species (IUCN classification);

(ii) habitat of significant importance to endemic and/or restricted-range species;

(iii) habitat supporting globally significant concentrations of migratory species and/or congregating species;

(iv) highly threatened and/or unique ecosystems; and/or

(v) areas associated with key evolutionary processes_.

Unlike the forests in the upper catchment, the Tina River itself does not meet the critical habitat definition. It does not shelter endangered fish species (see table of fish species for definitions).. Although all fishes are migratory within the Tina River catchment, fishes in Solomon Islands do not show homing behaviour, meaning that juveniles can colonize any river, rather than just their natal stream, and do not depend on a particular river for support.

The upper Tina River also does not satisfy the definition with respect to endemic or range-restricted insect species in the groups that were sampled for the ESIA or in the literature. All

identified endemic insect species have also been identified as present in a number of other river catchments within Guadalcanal outside of the study area and well outside of the area of impact for the Project. Polhemus's account of the biogeography of Solomon Islands aquatic insects suggest that catchment-specific impacts of the Project are unlikely to have wider impacts on species populations.[49]

7.8.2 Value Of The Upper Tina River Catchment

7.8.2.1 Important in Fish Life Cycle

The upper Tina River and its tributaries are a significant spawning ground for most amphidromous species, and a rearing / maturing location for many catadromous species, due largely to the high water quality, the richness in habitats in tributary rivers, and food availability. In addition, the length of rivers within the catchment allows for many habitats to shelter a significant number of fishes. However, the length of rivers in the Tina River catchment is not a factor that increases fish lifespan or fertility, since these factors are determined genetically and environmentally. Some environmental signals trigger fish to migrate, to spawn and die, regardless of the length of the river system.

The absence of human settlement is the upper Tina River catchment also allows fish to thrive without significant harvest pressure. The large area of intact forest adds value to the river catchment, since leaf detritus, flowers and fallen fruits provide nutrients to the river system. In addition, the local topography, with its high peaks brings cool, rapid and well-oxygenated water to the catchment, attracts fish. The water temperature gradient found along the Tina River is an important environmental cue suspected of being a trigger for fish migration. Many Tina River tributaries originate at elevations of between 1000masl and 1600masl, bringing cool water to the system. Flash floods can be very powerful in the upper catchment, contributing rich nutrients that support biomass productivity, and provide connectivity for larvae to migrate to the ocean.

It is, however, important when comparing the value of habitat to mention that the mouth of the river is more `critical_ to the life cycle of fishes, than the upper catchment. This is because the river mouth is the unique entry point for all migratory fishes when at the fragile juvenile stage of their lives. Disturbances at the mouth of the Tina/Ngalimbiu River can have greater adverse impacts on juveniles, than disturbances to the upper reaches of the river system have on adult fishes.

7.8.2.2 Tina River Uniqueness

Assessing the value of the upper Tina River catchment is rather difficult, since little scientific data exists regarding other river catchments with which to compare the Tina River. Prior to the Gold Ridge mine development, Chovohio River and Tinahulu River catchments (Matepono) were likely similar to the Tina River catchment, where 45 species of fish were identified (Golder and Associates, 2009). Likewise, the Tetepare catchment had 60 identified species of fish (Jenkins and Boseto, 2006). By looking at these two other catchments, the Tina River's fish biodiversity appears to follow the general trend in Guadalcanal. Other than its relatively large catchment area, based on

[49] Polhemus (2008) p. 105. Polhemus in discussing hydropower projects notes that `ŭ their impacts would be confined to the mid- and terminal reaches of a few individual river catchments. Given the short, discrete nature of many Solomon Islands drainage basins, and the sharp topographical divides separating them, the environmental changes caused by any one dam, although locally dramatic, would have little overall effect on the aquatic biota of a given island, and would not serve to endanger any endemic species in a global sense._

the limited knowledge of its fish biodiversity, the, Tina River catchment does not appear to represent unique habitat within the Guadalcanal context. Moreover, within the South Pacific region, catadromous and anadromous fish do not present a homing behaviour. Juveniles are able to colonize any river, rather than just their natal stream.

Notwithstanding, all of the fish surveys conducted to date have been based on qualitative, rather than quantitative methodologies. Therefore, it is difficult to determine the quantity of fish that the Tina River system is able to produce, compared with other catchments. Several factors could be having a positive influence on fish biodiversity, productivity and abundance, and contribute to the uniqueness of the Tina River, including:

- Its large catchment area, the majority of which is undisturbed forest;
- It is among the few rivers that drain mountain peaks that reach to 2000masl in altitude. The topography also makes the area less accessible to human related disturbances.
- The length of the river network provides a variety of aquatic habitats for catadromous and amphidromous fishes, enabling them to thrive without human pressure.

The Tina River is among the few rivers that possess all these features, thereby making it a distinctive river in terms of its physical characteristics.

7.9 Conclusions on Fish and Aquatic Environment

Although the upper Tina River catchment plays an important role in the life cycle of various fish species, it is not a critical role since:

- Fishes do not show homing behavior, meaning that juveniles will colonize any rivers, rather than only their natal stream;
- The mouth of the Ngalimbiu River is more critical to the life cycle of fish species found within the system, than upstream areas, as the mouth of the river is the only point between the river and the ocean that all species of fish must cross at some point in their live histories.

Based on current knowledge, the waters of the upper Tina River are a highly valued aquatic habitat, but not critical habitat .

8. SOCIO-ECONOMIC / SOCIO-COMMUNITY BASELINE

8.1 SOCIAL ENVIRONMENT

8.1.1 Meeting at Hill Top

Prior to commencing the social assessment, a meeting was held at Hill Top with Bahomea Chiefs, members of the TRHDP PO team and the ESIA team. The objective of the meeting was to present the ESIA process to the Chiefs, taking note of Chiefs˘ grievances, and to get their blessing prior to commencing fieldwork.

Table 8-1 lists the persons involved in the meeting:

Table 8-1 List of attendance at Hill top meeting

Name	Title	Name	Title
Timus Matthew	Chief	Aldin Roger	
Mahlon Dasi	Teller	Japan Chaku	
Kapini Sosimo	Chief	Deresa	Chief
Michael Meki	Chief	Riskiy Rongo	
Gilbert Avai	Elder	Zimiri Launi	
Daniel Garusi	Chief	Oscar Billy	
Alfred Ilala	Chief	Jonathan Beho	Chief
Adam Singi	Elder	Areson Handila	
Rex Ata	LOC	James kaputi	
Albert Ringo		Pastor Kedimiel Lauri	Pastor
Hudson Solo	Chief	Michael Litany	
Timothy Suigi		Peter Rocky	Paramount Chief
Richard Anisie	Chief	Mahlon Maeni	Chief
Masioth Rere		David Tapitoa	
Peter Lakale	Chief	Jabeth Lati	
Dohlan Gisi	Chief	Crystal Frenda	
Penuel Pore	Chief	Bethsaida Neka	
Enoch Mark	Chief	Dorcus Pesini	
Malcolm Rino		Eric Gorapava	TRHDP PO
Hipo Suhara		Brally Tavalia	TRHDP PO

Name	Title	Name	Title
Absuah Zapaniah		Julian Maka'a	TRHDP PO
Wickham Kesi		Daniel Una	Chief
Madrush Welmah		Eric Deneut	ESIA Team
Julia Jackie		Fred Patison Siho	ESIA Team
Lovelyn Hema			

Minutes of the meeting are included in Annex 4 of the Annex Report.

8.1.2 Social Assessment Methods

8.1.2.1 Staff Involved

The Social studies were led by Gerard Fitzgerald, Sociologist. He was accompanied by a team of National experts, including:

- Lawrence Foana'ota, National Cultural Heritage consultant; and
- Kellington Simeon, National social assessment assistant.

Additional assistance was provided by the following:

- Sharon Tabea-Para, an indigenous woman from the area, who also acted as a project Community Liaison Assistant (CLA). Ms. Tabea-Para is an independent Sociologist with independent local knowledge about local protocols, custom, village populations, kinship relations, natural resources, and the local environment. She facilitated culturally-safe access to local women and provided the team with local indigenous language translation skills.
- Zimri Laoni and Rex Ata, TRHDP office community liaison assistance (CLAs) from Bahomea, who provided liaison with local leaders and groups in the Bahomea communities.
- Community Liaison Assistants (CLAs) from Malango and Ghaobata.
- An officer of the Guadalcanal Provincial Government, who assisted in organising meetings with downstream communities.

Several observers attended village meetings during the fieldwork, including:

- Real Courcelles, an international expert in project benefits sharing, who attended at Marava
- Brally Tavalia, the TRHDP PO Community Liaison Officer.
- Fred Patison, who attended workshops at Mataruka and Ado villages in the Malango area.

8.1.2.2 Dates of Surveys

Field surveys were carried out from 29 August to 25 September 2013.

8.1.2.3 Location of Surveys

The program of fieldwork was developed by the ESIA team in consultation with Project officers, the project CLAs, and the environmental assessment team. The aim was to concentrate most of the fieldwork effort on the indigenous communities likely to be most directly affected by the proposed development options, while also allowing time and resources for input to be provided by

communities, and stakeholders, not likely to be immediately or directly affected by the project's construction or operation.

Table 8-2 shows the extent of social science fieldwork carried out by the team.

Table 8-2 Village fieldwork schedule and locations

Date	Core Venue	Target hamlets/stakeholders	Grouping	Ward
2-Sep-13	Marava	Marava, Vatupaua, Rate CHS, Ngongoti	Bahomea	Malango
3-Sep-13	Haimane,	Vuramali, Haimane, Horohutu 2, Katihana	Bahomea	Malango
4-Sep-13	Tina	Tina, Valebebe, Valebarik, Valemaota, Tahurasa	Bahomea	Malango
5-Sep-13	Antioch	Antioch, Valesala, Komeo	Bahomea	Malango
9-Sep-13	Senge	Senge, Koropa, Choro	Bahomea upstream	Malango
10-Sep-13	Pachuki	Habusi, Pachuki, Veraloka	Bahomea	Malango
11-Sep-13	Office	Fieldwork team & assistants		
12-Sep-13	Verakuji	Mangakiki, Verakuji	Bahomea	Malango
13-Sep-13	Namopila	Namopila, Komureo, Valekocha, Vatunadi	Bahomea	Malango
17-Sep-13	Mataruka Ado	Malango (Mataruka 1, 2, 3, & 4) Belaha communities	Bahomea	Malango
18-Sep-13	Vera ̆ande Horohutu 1	Vera ̆ande, Verakweli, Niumahata, Horohutu 1(settlers)	Settlers	West Ghaobata
19-Sep-13	Ravu	Ravu area hamlets (Ghaobata plains communities)	Ghaobata - downstream	West Ghaobata
20-Sep-13	Verakabikabi Old Selwyn	Settler communities, lower roadside Ghaobata plains communities	Settlers Ghaobata - downstream	West Ghaobata West Ghaobata
23-Sep-13	Honiara	Team workshop with assistants & project team		
24-Sep-13	Honiara	Institutional stakeholders	Government and non-government organisations	

8.1.2.4 Community and Stakeholder Participation

International ESIA practice guidelines specify participation by project-affected persons (PAPs), and other stakeholders in the planning of a project, and in the social impact assessment process. Such participation provides the opportunity for project planners and assessors to learn directly about local social conditions, ways of life, and existing issues among local people and communities. It also provides the opportunity for people and communities to help shape proposals that directly affect their present and future social and economic conditions. Consultation and other activities for engaging people are, therefore, normally initiated in the early stages of a project, rather than after key decisions have been made.

Current good international industry practice (GIIP) attempts to move beyond simply providing information. Rather, GIIP requires two-way dialogue to develop partnerships and empower people and communities, to enable themselves to play an active role in shaping developments to meet their own needs[50]. There is a considerable body of literature on how to achieve participation in development projects, especially by vulnerable groups. Participatory methods (such as those offered by Participatory Learning and Action (PLA)) are increasingly used in developing countries for project and programme identification, planning, assessment, and implementation.

The TRHDP PO, which is embedded within MMERE, is a well-organized, and comparatively well-resourced organization, with an explicit mandate. The TRHDP PO has planned and implemented an ongoing program of stakeholder, community, and indigenous leader engagement. The program has included, among other things:

- awareness raising activities, including suitably crafted multi-channel information dissemination.
- the creation of appropriate forums for discussion and negotiation, including formulation of access agreements for the project investigations, memoranda of understanding between the TRHDP PO and customary land owners and their leaders and an agreement for the acquisition of the Core Land with the five landowning tribes.
- establishment of a network of trained community-based liaison assistants to aid communication between villagers and the project office.
- public meetings, conferences, participatory workshops, and small group and individual discussions.
- study tours to hydropower facilities elsewhere in the Pacific.

Ongoing consultation activities implemented by the TRHDP PO have been reported in project newsletters, media releases, and on the project website http://tina-hydro.com.

8.1.2.5 Methods

GIIP recognises that community and stakeholder participation is integral to ESIA, and most professional organisations, such as the International Association for Impact Assessment (IAIA)[51], stress that the outcomes of consultation/participation should be incorporated into the project design, and into the assessment, management, mitigation and monitoring of social and other impacts.

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[50] See a recent (2014) description of landholder involvement in the TRHDP by Roughan, at http://www.stakeholderforum.org/sf/outreach/index.php/previous-editions/sids/sids-day-7-water-food-and-waste/11724-the-tina-river-experience-power-only-through-partnership

[51] The international professional body for impact assessment professionals: See www.iaia.org.

The TRHDP ESIA work itself was specifically designed and implemented to achieve active participation by project affected people (PAPs), local residents, downstream, residents, other stakeholders, project planners, and environmental technical specialists. The participatory focus workshop process, combined with face-to-face interviews and direct observation with local communities was chosen to enable active participation and interaction between the assessment team and the stakeholders. The details are outlined below in the description of the ESIA fieldwork.

Prior to conducting field visits, information was gathered from various stakeholders, including the MECDM, MHMS, Guadalcanal Provincial Office, and the Census Office. Information was obtained from personal communications with these sources. The main stakeholders consulted during the course of the assignment included the TRHDP PO, MECDM, MHMS, Guadalcanal Provincial Office, National Census Office, other international consultants and TRHDP CLAs and environmental experts working on the ESIA. Issues pertaining to the project location and settings were discussed with the TRHDP PO and its CLAs. Governance issues relating to the Project, were discussed with the MECDM and Guadalcanal Province. Health issues were discussed with the MHMS. Other relevant topics of discussion, such as benefit sharing, were discussed with other international consultants engaged by the World Bank as advisors to the Project.

A key output of the planning stage was a program schedule for the village workshops. The schedule took into consideration the amount of time available for the social studies, the size of the project area, and the impact of weather on accessibility. As part of the schedule, key focal villages were identified as optimum locations for conducting workshops and face-to-face interviews, since it was recognized that it would be difficult to carry out workshops in each and every village within the project area.

The social research fieldwork required 4 weeks to obtain primary data for the social profile and for the assessment of impacts. All members of the social assessment team were involved in the detailed planning of the fieldwork program and selection of methods, assisted by TRHDP PO project officers and CLAs - the latter serving as the main points of contact and logistics organizers within the study communities.

The social scope for the assessment, as specified by the study terms of reference (TOR), covered:

- the above geographical areas, and within them the:
  - Teha speaking customary landowning residents, including leaders, general public, groups, kinship groups, women, and youth.
  - The _settler_ residents (that is, people originating from elsewhere in Guadalcanal, but residing locally as _guests_ of the landowners.
- users of the Tina River in general.
- other stakeholders, including customary landowners who do not regularly reside within the project area, and environmental and community NGOs.

To ensure that the various stakeholders specified in the TOR were covered by the fieldwork investigations, the Tina River catchment area was divided into four areas or zones, based on the proposed project, - each with a different set of issues to be investigated, as follows:

1. Any communities located in the Direct Impact Area, that is, the lands required for the construction and operation of the proposed dam, storage reservoir, headrace tunnel, and powerhouse, as well as any borrow areas, set down areas, and yards, etc (Core Area) and any communities located in the 50 metre wide access road and transmission line corridor (Infrastructure Corridor). No communities or residences were identified in this area or in the Upstream Area above the reservoir.

2. The people and communities likely to be mainly affected by changes in the river water quality, volume, or availability during the construction or operation of the hydro scheme ¯downstream of the power station site. This area was designated as the Downstream Area. Within this group, the Senge Community are the villages located closest to the Direct Impact Area.

3. The people and communities likely to be mainly affected by modifications to, and use of, the existing or new access road/s, and transmission line corridor but who are not located within the Direct Impact Area. These areas were designated as the Infrastructure Area.

4. The people and communities who use or have ownership rights to land and resources in the project area and downstream, but do not necessarily reside in the Tina-Ngalimbiu River valley. These were designated as belonging to the Wider Impact Area (WIA).

These various groupings are generally consistent with the communities˘geographical distance from the Core Area. Groups 1 to 3 could also be affected by loss of access to livelihoods and resources upstream of the proposed dam, and by the potential presence of a construction workforce. All groups could benefit from employment or contracting opportunities during construction and operation of the scheme.

Using this classification, the villages and hamlets in each of the different project impact areas were identified, as shown in Table 8-3.

Table 8-3 Classification of Tina Catchment settlements by potential project affect

Impact area	Customary landowning communities	Non-customary communities
Direct Impact Area (DIA) and Upstream Area Settlements	None.	
Downstream Area Settlements	In Bahomea district: Senge Community (proximate to the reduced flow reach): Choro, Koropa, Senge Other Bahomea: Habusi, Pachuki, Namopila, Komureo, Vatunadi, Tahaurasa, Tina, Valebebe 1 & 2, Vuramali, Haimane, Valebariki, Horohutu2 In Ghaobata area (plains): Popolo 1 & 2, Old Selwyn, Ngalimera, Selaghoghoro, Pokasou, Siroigha, Kadavu, Ravu area, villages on Tenakaro Road, and	Horohutu1 New Birao GPPOL village,

Impact area	Customary landowning communities	Non-customary communities
	riverside road to Tetere between main road and the mouth of Ngalimbiu River .	
Infrastructure Area settlements	Bahomea District Mangakiki/Verakuji, Pachuki, Marava area, Vera ̃ande/Grassy	Verakabikabi, Namanu area
Wider Impact Area (WIA) settlements	In Malango district Communities of Malango area and Belaha area	

The social studies in the communities consisted of the following:

- Structured community workshops designed to collect information in each village area about a) the local way of life, social organization, history of settlement, resources, and livelihoods, and b) views on potential project impacts. Each meeting brought together several associated hamlets. The meetings typically took approximately 4 hours and followed a standard format. Discussions were conducted in Solomon Islands pidgin and occasionally in the local indigenous language (Teha), and were aided by the use of large format maps, printed satellite imagery, and sketched diagrams. Where necessary, additional explanation of the hydro scheme components and operation (as known at the time) was provided by the team. Attendance sheets were completed for each meeting. Fifteen such village workshops were held covering the residents of 40 villages and hamlets. Total attendance was at least 511 men, woman, youths, and children.
- A questionnaire survey of a random selection of female householders from each of the hamlets represented at the community meeting. This questionnaire covered household nutrition, health, gender and age division of labour, resources and income, and anticipated project impacts. Approximately 50 such interviews were conducted, each taking approximately 30 minutes.
- Individual interviews with village and tribal chiefs and older men about sacred and important cultural sites and issues. These were conducted by the team's national cultural impact specialist.
- Where time permitted, transect walks were carried out through village and garden areas, complemented by photography and recording.

The social baseline studies were carried out by both on-site social surveys and bibliographical data. Photographs in Figures 8-1 and 8-2 illustrate engagement activities at three of the villages located within the project area. The methods used to undertake the social surveys are presented in the following sections.

Figure 8-1 Verakambikambi Village; men, women and children participating in the discussion

Figure 8-2 Discussion at Segue and Tina Village

8.1.2.6 Recording People's Responses

The members of these communities were given the opportunity to inform the ESIA team of their specific communities' interests, and concerns regarding the construction and operation impacts of the proposed hydropower project. These were recorded on a white board, and detailed notes were also made. The responses to the questions and the concerns raised are presented in this report (also see Annex 15 in the Annex Report).

Time was provided in the fieldwork program for consolidation of fieldwork notes and photographs between the team members, and for reviewing and completing questionnaire forms, when necessary.

8.1.3 Summary of Results

Using the fieldwork program schedule as the reference, and with the aid of the local field assistant and CLAs, the Social research workshops were conducted in 15 focal villages, within four main districts (Bahomea/Tina, Malango/Belaha, Mid-Catchment and Roadside, and Plains).

Residents of more than 45 village communities attended the focus workshop meetings. Participants included tribal chiefs, village chiefs, youth, men, women and children. Overall, a total of 511 people attended the meetings.

Table 8-4 lists the focal villages and some of the communities that attended the workshops, including the number of participants. Figure 8-3 is a map that identifies the surveyed communities.

Results of the social assessment studies are discussed in the next sections.

Table 8-4 Surveyed communities

Date	Venue	Communities	Approx. number of Participants	District
2-Sep-13	Marava	Marava, Vatupaua, Rate CHS, Ngongoti	31	Bahomea (Upstream Communities)
3-Sep-13	Haimane	Horohotu 2, Vuramali, Haimane, Katihana	44	

Date	Venue	Communities	Approx. number of Participants	District
4-Sep-13	Tina	Tina, Valebebe, Valebarik, Valemaota, Tahurasa	38	
5-Sep-13	Antioch	Antioch, Valesala, Komeo	41	
9-Sep-13	Senge	Senge, Koropo, Choro	22	
10-Sep-13	Pachuki	Habusi, Pachuki, Veraloka	43	
12-Sep-13	Verakuji	Mangakiki & Verakuji	80	
13-Sep-13	Namopila	Namopila, Komureo, Valekocha, & Vatunadi	28	
17-Sep-13	Mataruka and Ado	Mataruka 1, 2, 3, 4, Belaha, More than ten villages (2 separate meetings held)	83	Malango/Belaha
18-Sep-13	Veraande & Horohotu 1	Veraande, Verakwele, Konga Horohotu 1, Niumahata (NB: Two separate meetings held)	24	Bahomea Settlements Communities
19-Sep-13	Ravu	(at least 5 communities represented)	19	Gaobata/Plains (Downstream Communites)
20-Sep-13	Verakambikambi Old Selwyn	Verakambikambi Old Selwyn (Popoloi) (NB: Two separate meetings held)	58	

Figure 8-3 Map of communities surveyed within the project area

8.1.4 Social Organization

8.1.4.1 Key Contextual Factors

Based on a review of reports and other secondary information, and fieldwork conducted in Guadalcanal, the following points seem to be crucial considerations for the planning of the TRHDP and the social assessment:

- the system of clan-based customary collective land ownership, coupled with shifting settlement patterns and leadership, and inter-tribal marriage, gives rise to complex claims and conflicts over resource and land rights;
- lack of services and infrastructure, underdevelopment, isolation, and poverty in Guale indigenous rural communities despite their proximity to Honiara;
- the historic settlement, agricultural development, and alienation of large areas of the Guadalcanal plains by colonial administrators and corporations, and their use of migrant labour from Malaita;
- the post-World War II development of Honiara as the modern day capital of the Solomon Islands with its associated multi-island and multi ethnic population located on Guadalcanal, and its on-going sprawl onto adjacent Guale customary land;
- on-going large-scale and unsustainable logging of Guadalcanal's indigenous forests by foreign logging companies with high level political patronage, that provides little apparent material benefit to the majority of indigenous land owners;
- the establishment of the Gold Ridge mine, with on-going grievances regarding distribution of benefits and royalties;
- the recent history of Guale rising up against the central government, the cause of which was a sense of inequity in the distribution of benefits and costs of development, and the associated violent conflict between indigenous people and `settlers_ from Malaita, and other islands and regions. This ethnic tension, and associated civil unrest, was present in the project area and has abated under the authority of the Regional Assistance Mission to Solomon Islands (RAMSI), but has not necessarily been resolved[52].

At the local level, Pacific Horizon Consulting Group (PHCG) note the following are also important to the context for the TRHDP:

- The emergence of the Project Office as the primary identity for the TRHDP, rather than MMERE and its officials.
- The emergence of various groups and organizations for interacting with the Project and government, including the Bahomea House of Chiefs, the Malango House of Chiefs, the more recently formed Tina River Hydro Landowner Council (with 27 representative groups `purporting to represent a district clan within the Ghaobata and Malango areas_), along with area-based groupings of villages within the project affected area (e.g., the Upper River Catchment Community centered on Namopila)

[52] For example, during the ESIA fieldwork in September 2013, a group of intoxicated Malango youths from the Tina village area attacked a Weather Coast settler and destroyed their roadside stall/shop at the corner of the Namanu Road in the hope of evicting them. Some of the settlers are occupying `alienated_/government land.

The following sections provide a detailed description of the people and communities of the proposed project area and their socio-economic condition.

8.1.4.2 Settlement Patterns

The TRHDP study area consists of over 30 villages and hamlets of mainly indigenous people originating from the central Guadalcanal mountain lands, and several official `settler_ villages made up of people originating from South Guadalcanal/Weather Coast.

The Bahomea villages and their component hamlets are mainly distributed adjacent to the Ngalimbiu River and lower-mid sections of the Tina River, and are often only hundreds of meters apart. In some cases it is hard to distinguish where one hamlet ends and another begins (e.g. Antioch and Valesala). Most hamlets in the study area are connected together by walking tracks and in some cases by dirt roads, which are prone to becoming impassable during wet weather. In recent years, settlements have been established along the main Bahomea access road and logging track that run up the ridge that marks the left side of the Tina Valley.

Settlements range in size from two-house hamlets with one extended family, up to villages with dozens of houses and over a hundred residents. These larger villages tend to be arranged around a village square/green with a substantial church, and perhaps a meeting-house and other facilities. The details of the various villages are provided in subsequent sections.

Roughan et al (2011) and Entura (2012) both provide a history of the settlement of the Tina River area, and while the accounts differ in some respects, they agree on the following key aspects:

- the present-day indigenous inhabitants of Malango Ward, and in particular the proposed project area, are closely related and have common ancestors.
- the originating communities lay at the base of Mount Popomanaseu, and were variously named Sasahakama, Belana, Tuhurutolu, and Malukuna.
- Since World War II and the establishment of Honiara city, there have been successive waves (or chains) of migration down from the villages of the central mountains to the foothills to the north, so that people could be closer to modern services and employment, to be safer from landslides and other natural disasters, and to protect clan lands from intrusion inland by squatters and others.
- In these moves, people from different originating Malango villages stayed together and settled in different areas. The people from Belana and Tuhurutolu settled in the Tina river/Bahomea area. The people from Malukuna settled in the Malango area, and people from Sasahakama settled in the Gold Ridge area and on the Toni River.
- There has been some subsequent movement from the north back up the main ridges of Malango Ward, as areas have been opened up by logging roads, and possibly to avoid exposure to ethnic conflict.
- Mixed in with the indigenous Malango-speaking communities are more recent arrivals of people from the Weather Coast who sought refuge locally from natural disasters, poverty, and conflict, and who moved to find employment in the plantations and foreign owned resource industries.
- Since the 1980s there has also been unauthorised settlement on Malango lands by migrants from Malaita, and elsewhere, that were drawn to Honiara for employment.

- The ethnic tensions of the late 1990s and early 2000's displaced the non-indigenous settlers, including many hundreds working in the (now GPPOL) palm plantation, and squatters, resulting in a major reduction in the population of the Malango and West Ghaobata wards.
- With the subsidence of the ethnic tensions, people from the Weather Coast have returned to the Bahomea area, and squatters are again moving onto the government and alienated lands within Malango Ward.

At present, the mountainous interior of Malango Ward is essentially unpopulated, apart from periodic expeditions by the traditional owners for hunting and camping, and to reconnect with customary 'homelands'. The indigenous people of the Tina River area are, therefore, aware of the locations of their key originating villages and important cultural sites. Since membership of particular clans is claimed through kinship connection with people from successive historic settlements and originating places, knowledge of such places is crucially important for establishing identity and land and resource rights.

Original migrants from these upland villages can be still found among the older residents of the TRHDP study area, and they have knowledge of the sequence of migration and village creation within the Tina catchment. A number of stories of such movements were recorded during the social impact assessment fieldwork. The sequence of movement is represented in Table 8-5.

Table 8-5 The settlement history of villages in the TRHDP area

Villages/ hamlets	Impact area	Year of establishment (approx.)	Origin notes
Senge Choro Koropa	Downstream	1970 1990s 2003	Originating place was Reiloto. Senge originally started in 1930s. In 1940s-50s moved to Marava, Vuramali, Mangakiki and Koropa. Some stayed. Senge destroyed by Cyclone Namu in 1986. Reoccupied and rebuilt in 1990s.
Verakuji Mangakiki	Infrastructure	c1984 c1987	Originally from Tangilagila/Hamilake, then Marava, then Mangakiki, and Verakuji and Verakila (1990s). From Turutolu/Malukuna, then to Tangikala, then Mangakiki.
Pachuki Habusi	Downstream	1996 Post 1986	Originally from Turutolu. Villagers moved in 1966 to Vatunandi & Valebungana, then Valekocha , then Valesala after Cyclone Namu in 1986, then Pachuki and Habusi
Namopila Komureo Vatunadi Valekocha	Downstream	2007 2004 1990 2008	Originally from Valevungana (est 1967). Cyclone Namu (1986) moved to Valekocha, then Valesala. Then dispersed to Choro, Vatunadi, Koropa, Komureo, and Valekocha
Antioch	Downstream	c 1970	

Villages/ hamlets	Impact area	Year of establishment (approx.)	Origin notes
Valesala Kolanji Komeo		1986	Movement from the hill & forests began in 1960s. Came from Kolohaji, then Talamu and Turutolu, then Vatunandi, Valekocha, and then Antioch etc
Tina Valebarik Valebebe Tahurasa Valemaota	Downstream	1950 1980 1998 1999 2006	The first village in the lower part of the Tina River valley. Originally from Belana and Vurutolu. The other villages in the community were established to cope with local population growth
Marava Ngongoti Vatupaua Rate school	Infrastructure	1962	Moved from hills & forest. Other villages are spin off communities. Rate established by government as a district school campus, with teacher housing.
Vuramali Haimane Horohutu 2 Vuvamali	Downstream	1986 c 1970 c 1960 -	
Horohutu 1	Downstream	c1980	Moved from Weather Coast of Guadalcanal to Konga in 1974 while founding family working for Foxwood Timber Milling Co. Started the settlement at Horohotu 1. Cyclone Namu struck in 1986. Other villages established subsequently.
Vera'ande Verakweli New Mahata	Infrastructure	2000 1968	Moved from Tina to Vera ̆ande in 2000 to take up a cocoa blocks on clan land left by Levers. Verakweli established by families from Veravolia. New Mahata established by families from the Weather Coast
Verakabikabi	Infrastructure	c1965	From Weather Coast. More settlers in 1970. Acquired custom rights to occupancy and use from indigenous land owners.

Traditionally, Guadalcanal villages were periodically moved so they could be located closer to newly cleared gardens, to move away from bad spiritual influences, or because of natural disasters. Such natural disasters feature prominently in the history of settlement of the Tina River Valley. Cyclone Namu, which hit the region in 1986, is probably the most significant event in terms

of destruction and relocation of villages. Settlers from the Weather Coast also came north as refugees from floods, earthquakes, and landslides. Some of the early upland settlement areas of the Malango people were also badly affected by natural disasters[53]. Nowadays, various factors encourage villages to be permanently located, such as the building of permanent churches and houses using more durable building materials, the availability of services, roads and other infrastructure, and perennial cash crops. Reasons for relocation given by villagers who participated in the community workshops include:

- as resettlement after landslides, flooding and cyclones, especially Cyclone Namu in 1986;
- better access to employment and, therefore, the opportunity to improve living standards;
- better access to services and facilities, including health, education, transport, markets, and churches;
- to get better access to quality gardening land;
- over-crowding and shortage of resources, for example, land for a house or water supply;
- to escape influence of the Moro Movement (see description of Moro Movement in Section 8.2.5);
- to provide greater protection to clan land, especially from migrant labour squatters; and
- family disagreements or feuds.

Internal migration and the formation of new village communities are only possible because of kinship networks and clan membership, which provides access to land and livelihoods throughout the Bahomea/Malango area.

Downstream of the Tina River, where the Ngalimbu River joins the Guadalcanal plains, there are larger villages and hamlets made up of the indigenous coastal people, referred to as the Ghaobata. The plains and coastal area also contain hamlets of settlers from elsewhere, including `squatters_ who have (re) occupied `vacant_ marginal, or abandoned plantation land on the plains, which had been vacated during the Ethnic Tensions. The current makeup of the squatter hamlets is said to be predominantly Malaitan peoples drawn to the Honiara area for work, but this was not confirmed. It is clear from village discussions that the Bahomea and Ghaobata peoples regard the presence of these non-indigenous outsiders as a threat to their land and resource rights, and is an ongoing potential source of conflict.

8.1.4.3 The People of the Project Area

LANGUAGE GROUP

The indigenous people of the TRHDP area are often referred to as the Malango, and speak the Malango language (also known as Teha). They are hill peoples who once occupied hamlets around the central mountains of Guadalcanal, including Mt Popomanaseu, the highest point in the Solomon Islands. Up to the 1950s or so, the hill people of central-north Guadalcanal largely lived in isolated hamlets, rather than centralized larger villages that are evident today.

According to Lynch, Ross, & Crowley (2002), the Malango language belongs in the Bugotu¯Gela¯Guadalcanal family of languages within the overall Southeast Solomonic group, itself part of the Oceanic group within the larger Malayo-Polynesian set of languages. Other languages in

[53] Note that in early April 2014, subsequent to the ESIA fieldwork and reporting, a major flood in north and central Guadalcanal appears to have damaged the villages of Habusi, Pachuki and Namophila. The local effects of the flood are unknown.

Guadalcanal family of languages are Birao, Ghari, and Talise. According to Ethnologue (the Internet reference site for the world's languages), in 1999 there were an estimated 4,140 native speakers of Malango/Teha. The downstream neighbours of the Bahomea-Malango people of the Tina River valley, the Ghaobata people, are indigenous speakers of the Longgu language.

The Malango people are largely resident in the modern-day administrative Malango Ward of central-northern Guadalcanal, and have a population of 10,500, 95% of whom are Melanesian. The proposed TRHDP lies within the Bahomea district, and is centered on the Tina River and associated ridge/s running from the mountainous interior north towards the Guadalcanal Plains. The people of Bahomea district are kinsmen of the peoples of Malango to the west, and to those of the Gold Ridge area to the east. The Ghaobata people live on the plains, and are largely located in two administrative Wards ¯ West Ghaobata and East Ghaobata. The Ngalimbiu River runs through West Ghaobata Ward to the sea (see the map in Figure 5-3).

KINSHIP AND TRIBAL STRUCTURE

Guadalcanal societies are known for their matrilineal descent systems, that is, where descent and inheritance are traced through the mother's line. Normally in matrilineal systems women marry outside their own kin group into a nearby community and reside with their husband's people after marriage. A woman's sons take up land from their mother's brother upon reaching adulthood. Adoption may also be used to provide matrilineages with heirs to land (Schoeffel, Fitzgerald et al, 1994). The most common pattern is for marriage partners to be chosen from a different clan, so in matrilineal systems one may not marry one's mother's kin, because they are members of the same descent group as oneself. However, one might be able to marry one's father's kin, since they are not of one's own descent group. Several matrilineal kinship systems are found on Guadalcanal.

Hogbin, in his 1930s studies of Guadalcanal societies[54], found that that the hill tribes of North Central Guadalcanal (Including the Malango people) are organized into a pair of exogenous matrilineal moieties, each with their respective custom origin stories. These moieties are known as the Manulava [55](the eagle or `big bird_) and Manukiki (the hawk, or `small bird_). Every indigenous person belongs to one or other of these moieties. Hogbin also records that each moiety consists of a number of matrilineal clans/sub-tribes each of which carries the name of a different species of bird, and each clan has primary rights over blocks of land scattered /patch-worked across the tribal landscape, `with no piece of ground un-owned_ (1964:17). That is, land and resource ownership is based on clan membership. This remains the situation today among the Malango people of the TRHDP area. In their review of the `Indigenous Terrain_, Roughan et al (2011) confirmed that the matrilineal clans (mamata) of the study area `are the sole authorities vested with authority over territory_ (p. 29).

Previous studies have noted that regardless of the decent system, in the Solomon Islands women tend to move to their husband's village after marriage (known as virilocal residence). In a matrilineal descent system, this means that women will be living away from their own land, which will be under the control of their brothers. As people living in villages where they are not members of its land-owning groups, they are, therefore, outsiders when it comes to local-level decision-making, particularly about land and resource use[56]. Women are far more likely to be in this

[54] For example, Hogbin, I. 1964 A Guadalcanal society: the kaoka speakers. London, Holt,. Rinehart and. Winston.

[55] Known to the Malango/Teha speaking people of the Project area Manukama

[56] Schoeffel, P., Fitzgerald, G, and Loveridge, A. 1994. Solomon Islands Forestry Inventory Project Working paper 19: Forest utilisation in the Solomon Islands: social aspects and issues

situation than men. This tends to be the case in the communities of the TRHDP area, although there is a degree of variation in marital residence.

Figure 8-4 represents the kinship structure of Malango society as revealed by an informant in the Bahomea area. Note that terminology varies for the types of groupings at different levels, and there is a range of spelling for names of the different groups/units. This diagram suggests that there are 29 clans within the Tribe, though the exact number is contentious. For example, Roughan et al (2011), in their work on indigenous terrain mapping, identified 13 named clans in Bahomea, and 14 in Malango (27 in all), along with their chiefly representatives (see Table 8-6).

In 2010, SIG, through intermediaries, identified 27 tribal sub groups as having a stake in the TRHDP, and they became signatories to the original access agreement with SIG to allow the project feasibility studies to proceed. Subsequently, in consultation with local leaders, the TRHDP PO identified 10 `communities_ and their component villages, along with the list of clans found in each community - giving a total of 21 locally resident clans.

Not all of the clans identified by our informant are present in the project area, or necessarily represented by either of the Houses of Chiefs (HOCs) as described in project documents. Further clarification on clans in the area is provided by the :land identification˘process undertaken by the Bahomea Land Identification Committee comprised of Bahomea story tellers, a Paramount Chief, a church leader and tribal chiefs (TRHDP, 2013).

Figure 8-4 Tribal Structure of the Malango people

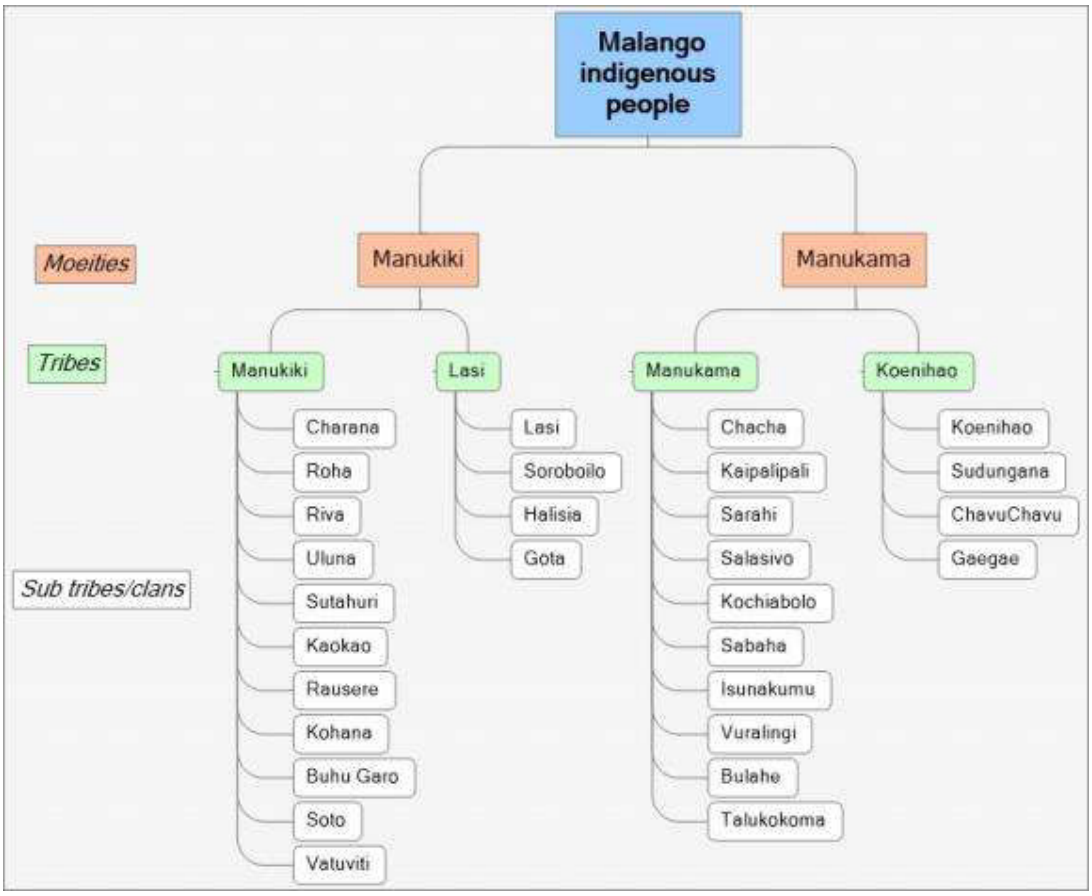


Table 8-6 Clans/sub-tribes represented in Houses of Chiefs (Roughan et al, 2011)

Clans in the Bahomea House of Chiefs	Clans in the Malango House of Chiefs
Charana	Barahau
Chavuchavu	Bolahe
Kaipalipali	Buhu/Garo
Kochiabolo	Chacha
Lango	Halisia
Rausere	Kaokao
Salasivo	Koenihao
Sarahi	Kohana
Soroboilo	Ngaengae
Sudungana	Riva
Sunakomu	Roha
Sutahuri	Sabaha
Uluna	Soto

Clans in the Bahomea House of Chiefs	Clans in the Malango House of Chiefs
	Vuraligi

According to Hogbin (1964), the tribes occupying the northern and eastern coastal area of Guadalcanal, between Point Cruz and Longgu, including the Ghaobata people who neighbour the project area, are divided into five exogamous matrilineal tribes named Hambata, Lasi Naokama, Thimbo, and Thonggo. Of these, Hogbin noted in the 1960s that:

> The chief importance of the clan organisation is its application to land rightsŭ Land is cut into named blocks of varying acreage, some 2 or 3, others 50 or 60 acres large. These are grouped into series each of which is bound up with a clan. By virtue of his birth into a clan, an individual acquires the inalienable right to select sites for his house and cultivation on the territory of that clan (1964:5- emphasis added).

Roughan et al (2011)[57] suggest that the tribal structure of the people of the Bahomea area is similar to that for the Ghaobata and other coastal people. They suggest there are 5 named tribes (or kema) in the project area, that is, Lathi, Thimbo, Negama, Thongo, and Gaobata (also known as Garavu and Hambata), and these are divided into land owning and rights-holding subunits called mamata (clans). However, this is not quite consistent with what local informants have suggested is the situation for the Malango people, and what Hogbin noted during his anthropological studies.

LOCAL COMMUNITIES

As noted above, the TRHDP PO identified various `communities_ and their associated clans. The basis for `community_, which according to Roughan et al (2011), is one of the key elements of the cultural landscape and is dynamic, is not clear from the Table 8-6. However, the available information indicates that there is a mix of clans present in any particular village or geographical community. In practice, Guadalcanal communities are dynamic, and sometimes ephemeral.

As noted above, new villages are formed in response to the need for services, as a new start after natural disasters, resource scarcity and availability, spiritual threat, and internal conflict. Overlapping with communities of place, communities of interest may be formed or dissolve according to peoplesˇ affiliation with particular interest or group (e.g., religion or issues-based grouping). Again, overlapping with both place and interest, communities of identity are based around kinship and ethnic affiliation, which can shift or be reinvented over time, e.g., the assertion of an `Isatabu_ (indigenous Guadalcanal) identity by the Moro movement in the post-war period, at the time of independence in the 1970s, and during The Ethnic Tensions.

From the social assessment fieldwork data it would seem that the groupings are based on a combination of geographical location, kinship, and religious affiliation, although this is not entirely consistent. For example, Senge Village is said to be associated with Namopila Village, but in practice the families located at Senge are closely related to those at Marava, from whom they split in the 1970s, or so. The extended family at Koropa (founded in 2003) is closely affiliated to Namopila through kinship.

During the fieldwork, it was common to hear people say that all of the people in the Malango area are related to one another, and that `we are all really one family_. It is not clear, however, to what extent these bonds extend to resource or residential rights.

[57] in the PHCG `Indigenous Terrain Mapping Report_ prepared for the project

Table 8-7 lists the communities in the TRHDP study area and their tribal affiliations.

Table 8-7 Communities of the TRHDP study area and their tribal composition

Communities	Villages	Est. Pop. 2010	Paramount Chiefs	Subtribe / clan Chiefs	Village leaders/ chiefs	Sub tribes/clans In the community
Namopila community	Namopila, Choro, Senge, Habusi, Pachuki, Komureo,	300+			5	Sutahuri, Kaokao, Uluna, Koenihao, Kochiabolo, Sabaha
Antioch community	Antioch, Valesala, Valekocha, Vatunandi	150+		3	2	Kochiabolo, Lasi, Kaipalipali, Kaokao, Charana, Roha, Koenihao, Sutahuri, Uluna
Verakuchi community	Mangakiki, Verakuji, Hanilake	200+		3	3	Kochiabolo, Charana, Kaipalipali, Roha, Sarahi
Tina community	Tina, Valebarik, Valebebe, Tahurasa, Valemaota,	300+	1	6	3	Sarahi, Riva, Chavuchavu, Rausere, Sudungana,
Marava community	Marava, Ngongati, Rate CHS, Vera'ande, Verakwele, New Mahata	200+		1	3	Charana, Kochiabolo, Kaipalipali, Sabaha
Katihana community	Katihana	150+	1	*	2	Chavuchavu, Uluna, Kaokao, Halisia, Rausere, Chacha, Kochiabolo
Vuramali community	Vuramali	100+	1	1	2	Kochiabolo, Koenihao, Charana, Uluna, Soroboilo, Salasivo
Haimane community	Haimane	150+	1		2	Koenihao, Lango, Sutahuri, Uluna
Horohotu	Horohutu 2 & 3, Valele'e	100+			2	Chavuchavu, Salasivo, Kaipalipali, Charana, Sarahi, Koenihao
Settler communities	Horohutu 1, Verakabikabi, New Birao, Namanu, Vatupaua	120+			4	from Guadalcanal Weather Coast clans

Source: TRHDP PO community liaison team

POLITICAL ORGANIZATION

The Malango people are divided into two administrative groups: the Bahomea House of Chiefs (BHOC) and the Malango. According to a local informant (a member of the Bahomea House of Chiefs) the BHOC is a legally constituted body, and consists of the four Paramount (tribal) Chiefs

plus the subtribe/clan chiefs and local village chiefs, along with other representatives and elected officers (see Figure 8-5). The chairman is elected by and from the members. The Houses of Chiefs seem to exist primarily to determine resource and land rights, resolve disputes, settle matters of custom and breaches thereof, and to represent local indigenous people in dealings with outside organisations. Houses of Chiefs are a relatively new institution, and while their internal governance is unregulated modern government has given them a role in providing an initial determination of land disputes under the Local Courts Act.

Much has been written about the process by which leaders[58] emerge from within Melanesian societies. As elsewhere, local leaders /chiefs do not acquire their positions or authority by inheritance, although they do draw on their relationships with kin, neighbours, and fellow churchmen and with other networks (i.e., local social capital) to build a base for leadership. Despite fieldwork and the available project reports, it is unclear how the leaders are selected within the Bahomea area. From observation, clan leaders appear mainly to be elderly males who have the best knowledge of the history and customs of their clan, including the land and resources to which they have primary rights. This is crucial, since the clan is the primary land-owning group. Village leaders /chiefs appear often to be younger and show more of the characteristics of `Big Men¿ i.e., they appear to have above average ability, seem able to organise and sponsor projects and events, are active in various economic and church activities and can rally both human networks and natural resources for economic and sociocultural purposes. For example, a paramount chief is also the Pastor of the South Seas Evangelical Church (SSEC) church at Tina Village; the village chief at Verakuchi is the sponsor/funder of the new local SSEC church; and a chief at Marava was the sponsor/funder of a new pre-school at Verakuchi.

More traditional `big men¿ activities still occur in local communities. For example, a traditional pig feast gathering took place in September 2013 at Habusi, which involved large numbers of local people and featured the distribution of pigs and other produce among the participating clans and communities.

Regarding modern politics and leadership, Malango Ward is a political unit of the Guadalcanal Provincial Government, and is currently represented on the Provincial Assembly by Mr. Amaziah Robo. It also lies within the national Parliament¨s Central Guadalcanal constituency, currently represented by Hon. Peter Shanel Agovaka.

VILLAGE AND COMMUNITY ORGANIZATIONS

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. As noted, villages in the TRHDP area are often made up of several related hamlets, and sometimes these have different religious affiliations. As observed above, local clan and village leaders may also be religious leaders.

Some villages have formally structured administrations. For example, at Marava, which has a population of 180 or so, there is a central community board which has six committees covering different areas of community life and development, including: education and training; women, children and youth; culture tourism; health and sanitation; agriculture and forestry; and projects.

There are also five church groups represented locally, and each church has its own groups, such as a woman¨s groups, sports groups, singing bands, and youth clubs. Also located at Marava is a community house belonging to the Malango Council of Women (MCOW), one of a network of

[58] most often referred to as "big men".

groups organised by the Guadalcanal provincial government. MCOW has a woman's community house which is used as a meeting and educational centre (see Figure 8-6).

Figure 8-5 Women's centre at Marava

Most villages in the project area, especially the smaller ones, do not have this level of organisation or formal structure, hence most activity is organised through the churches and in association with village chiefs.

8.1.4.4 Ethnic Tension

Roughan et al (2011) note that Guadalcanal has been structured and patterned more than any other island in the Solomons, by the location of national projects, and the reactions to them. These projects have led to a broad discourse of grievance in which TRHDP specific concerns need to be understood.[59] This experience has been politically articulated by the people of Guadalcanal through various textual and bureaucratic means since the 1970s[60], with the main elements of this narrative centering on:[61]

- The widespread and longstanding alienation of lands from the late 19th century onwards, exacerbated by their subsequent continuous habitation and evident employment in significant articles of national infrastructure, most notable of which is the capital city of Honiara
- The economic productivity of major investment projects emplaced on Guadalcanal, and their historically perceived lack of lasting positive effect on either the peoples whose territory has been host, or on the people of Guadalcanal as a whole. Chief amongst these have been SIPL (now GPPOL) and the Gold Ridge mine.

[59] Roughan et al (2011)

[60] See Kabutaulaka, T.T. (2002) A weak state and the Solomon Islands Peace Process. East-West Center Working Paper No. 14. Honolulu: East-West Center and Bennett, J (2002) Roots of conflict in Solomon Islands. RSPAS Discussion Paper 2002/5. Canberra: Australian National University for overviews of this history.

[61] Roughan et al (2011)

¿ Invasion of cultural and social space of the Guadalcanal people by settlers from other islands and provinces. This has been recognised as a form of structural violence, taking the form of disregard and disrespect for Guadalcanal cultural forms and norms, and actual violence perpetrated on indigenous Guadalcanal persons in the shape of murder and physical assaults.

Over time, a lack of comprehensive action in relation to these concerns has been apprehended as structural unresponsiveness, something which has itself been additional basis for grievance.

These grievances took most obvious shape in the initiation and evolution of the :ethnic tension˘of 1998-2003 characterised by widespread violence and militancy across Guadalcanal and other provinces and the eventual functional collapse of major state institutions including those mandated with ensuring law and order.[62]

During this time the northern plains area incorporating GPPOL, and central Guadalcanal, including the Gold Ridge area, witnessed extensive Eghting involving armed militants, police and civilians.

The initial stage of the unrest generally consisted of intimidation and violence against Malaitian settlers in Guadalcanal, including those working on Gold Ridge and oil palm plantations in Central Guadalcanal (Evans)[63]. The placement of a (largely Malaitan) police force to secure Gold Ridge mine may have escalated the violence. According to Evans the Eghting was linked largely to Malaitan¯Guadalcanal differences related to issues of cultural respect, perceived inequitable revenue distributions, and Malaitans securing jobs on Guadalcanal. By May 2000, Malaitans working on the Gold Ridge mine were evacuated. It is estimated that by the end of 1999, 24,000 largely malaitan settlers had been evicted from Guadalcanal.[64]

Fighting was initially centered between the Isatabu Freedom Movement (also known as the Guadalcanal Revolutionary Army) and later the Malaita Eagle Force (as well as the Marau Eagle Force). In October 2000 the Solomon Islands Government signed a peace agreement with these groups or elements of these groups, known as the Townsville Peace Agreement. The Agreement led to a fracturing of Guadalcanal militants between those that supported the peace process and those that did not. This fracture led to an era of intra-ethnic warfare including further fighting in the Central Guadalcanal area, and with fighting spreading to the Weather Coast.

Warfare largely ceased after the arrival of Australian and Pacific Island police and soldiers under the Regional Assistance Mission to Solomon Islands (RAMSI) in July 2003.

8.1.5 Socio-Economic Profile of the Communities of the Project Areas

8.1.5.1 Data Sources

The most reliable data for assembling a profile of communities associated with a proposed development usually comes from an official Census of population and dwellings. However this is not always available. For the most part, the only statistical data that are available for constructing a profile of the TRHDP study area are population estimates for the various villages, made by local

62 Roughan et al (2011)

63 Evans, D, :Tensions at the Gold Ridge mine, Guadalcanal, Solomon Islands˘, Pacific Economic Bulletin Volume 25 Number 3 ø 2010 The Australian National University

64 Fraenkel, J, The Manipulation of Custom: from uprising to intervention in the Solomon Islands, 2004, Victoria University Press/Pandanus Books, Canberra

chiefs for the TRHDP PO, and those data gathered in the community workshops and from householder interviews conducted by the ESIA field team.

8.1.5.2 Population

The communities potentially affected by the TRHDP all fall within the Malango and West Ghaobata Wards. The population counts of the TRHDP areas and villages within Bahomea made during the ESIA field studies in 2013 are presented in Table 8-8, along with the available census data.

Previous local estimates put the population of the TRHDP area at approximately 2000, with half of these having `direct access_ to the Tina/Ngalimbu River (Entura, 2012:32). The counts made during the ESIA fieldwork put the Bahomea/Tina population at about 1800, divided among approximately 362 households.

The villages of the project area have an average population of approximately 56 people, and an average of 11 households. Settlement sizes vary from 4 persons for Choro (the isolated occupation site in the upper Tina River), to 219 for the settler community of Verakabikabi. Nearly half the surveyed settlements had 5 households or fewer, and only 11 of the 32 villages had 20 households or more. The largest indigenous villages (with 100 people or more) are Tina, Antioch, Valebebe, Haimane, Mangakiki, and Marava. Komeo near Antioch, was abandoned at the time of the survey, while the settlement at Choro appeared to be occupied sporadically by an elderly couple, and seems mainly used as a shelter during times of garden cultivation of clan lands in the upper Tina River catchment.

The average household size in the TRHDP area is 5 persons, compared with 5.9 for the whole of Malango Ward in 2009. Households of the Senge Community average 5.1 persons, 4.6 in the other Bahomea downstream villages, and 5.6 in the households in the infrastructure impacts area. Based on the limited data available, the downstream Ghaobata households are of a similar size to those in the Bahomea area and to the rest of West Ghaobata Ward. In 2009, Solomon Islands households had an average of 5.3 persons.

While having a significantly larger population than its coastal neighbours, at 19 persons per km^2 Malango Ward has a low settlement density compared to West Ghaobata (60 persons per km^2) - reflecting the very different terrain of each group of people. West Ghaobata and East Ghaobata wards have the highest settlement densities of all wards in Guadalcanal Province.

Table 8-8 Population counts of the TRHDP areas and villages within Bahomea

Communities & affiliation	Villages/ hamlets	Impact area	2013 households (approx.)	2013 population (approx.)	2009 census	1999 census	1986 census
Senge Community - Bahomea							
Senge community	Senge	Direct	3	16			
Bahomea	Choro		1	4			
	Koropa		3	19			
Total			7	39			
Downstream Area - Bahomea							
Pachuki community	Pachuki	Downstream	14	65			
Bahomea	Habusi		6	33			

Communities & affiliation	Villages/ hamlets	Impact area	2013 households (approx.)	2013 population (approx.)	2009 census	1999 census	1986 census
Namopila comm.	Namopila	Downstream	5	27			
Bahomea	Komureo		6	28			
	Vatunadi		1	5			
	Valekocha		5	26			49
Antioch community	Antioch	Downstream	23	110			
Bahomea	Valesala		20	105			
	Kolanji		2	10			
	Komeo		0	0			
Tina community	Tina	Downstream	23	104			109
Bahomea	Valebarik		6	22			
	Valebebe		22	104			
	Tahurasa		5	15			
	Valemaota		4	12			
Vuramali comm.	Vuramali	Downstream	18	70			18
Bahomea	Haimane		26	111			
	Horohotu 2		17	84			46
	Vuvamali		16	77			
Horohutu comm.	Horohotu 1	Downstream	12	60			51
Settlers							
Total			231	1068			
Infrastructure Area (area affected by Infrastructure Corridor) ¯Bahomea							
Verakuji community	Verakuji	Infrastructure	11	56			
Bahomea	Mangakiki		21	111			5
Marava community	Marava	Infrastructure	28	168			54
Bahomea	Ngongoti		1	20			
	Vatupaua		5	50			31
	Rate school		?	?			4
Vera¯ande community	Vera'ande	Infrastructure	6	30			78
Bahomea	Verakweli		6	24			
	New Mahata		2	15			51
Verakabikabi comm.	Verakabikabi	Infrastructure	44	219			54
Settlers							
Total			124	693			

Communities & affiliation	Villages/ hamlets	Impact area	2013 households (approx.)	2013 population (approx.)	2009 census	1999 census	1986 census
Bahomea Total			362	1800			
Malango Ward					10532	4105	6094
West Ghaobata Ward					4515	2601	4239*

* Did not exist in 1986 ¯ Was part of the former West Tasimboko Ward

8.1.5.3 Population Trends

Little reliable data is available from which to determine population trends for the TRHDP area. Even where village level figures from 1986 are available, it is almost impossible to interpret the data without access to the census boundary maps of the time.

From the available data, its seems that Tina village has about the same population as in 1986, Marava š population has trebled, Horohutu 2 has almost doubled, and Vera ăande has decreased by more than half. The populations of the Weather Coast settler communities of Horohutu 1 and Verakabikabi have increased after having been significantly depopulated during the Ethnic Tensions. Verakabikabi appears to be about 4 times larger than in 1986. This may be because the villagers, being settlers residing in the area under a customary arrangement with the local indigenous chiefs, do not have their own local land rights outside of this area, which might enable them to spread out and establish new hamlets.

On a broader scale, census counts for Malango Ward show the socially disruptive depopulation effects of the Ethnic Tensions, and the post-tension rapid repopulation and growth: that is, from 6,094 people in 1986, to 4,105 in 1999 at the height of the tensions, and 10,532 in 2009. The population of Malango Ward is now 2.5 larger than it was in 1999. Over the same 10-year period, the population of neighbouring West Ghaobata (downstream of Bahomea) went from 2,601 to 4,962, making it almost twice the size it was in 1999.

By comparison, the population of Guadalcanal Province (excluding Honiara City) increased by 55% between 1999 and 2009, while the population of the Solomon Islands as a whole increased by 26%. Guadalcanal Province has the fastest growing population of all the provinces. Natural growth is high due to high birth rates and declining death rates, but this has been obscured in recent years by internal migration.

Fraenkel (2004), drawing on results of the 1999 census, records that 4,098 people (or 16.7% of the population at the time) were evicted or fled from Malango Ward and became displaced persons in 1998-99, as a result of the Guale uprising. In West Ghaobata 2,808 people were displaced (11.4% of the population), and in East Ghaobata 1,549 people (6.5% of the population were displaced). Most of those driven out the district were Malaitan and fled initially to Honiara.

The project is therefore taking place in a local context of considerable former social disruption and post-conflict population growth ¯ with its associated demand for residential and garden land, natural resources, and social services.

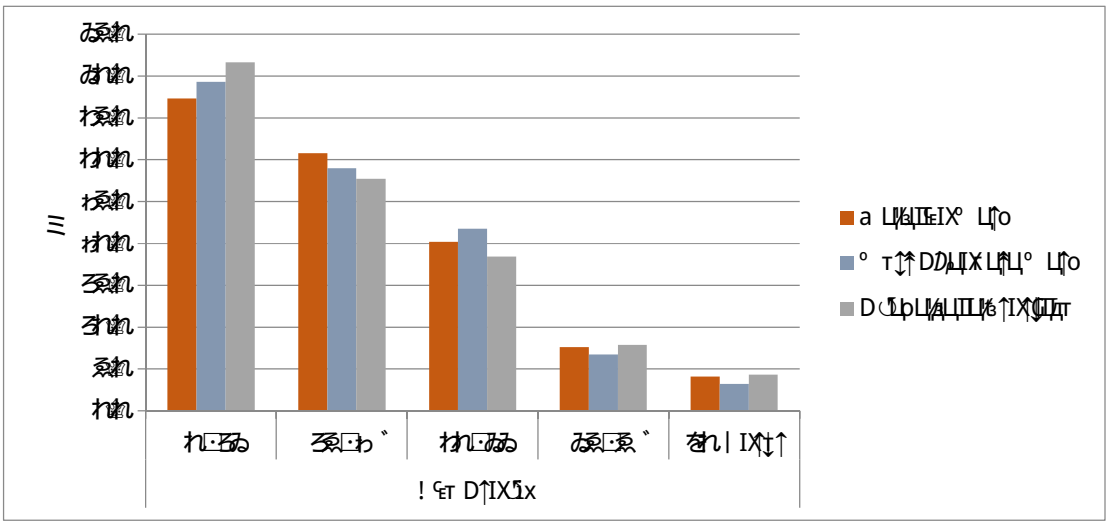
8.1.5.4 Sex and Age Structure

Figure 8-7 shows the age structure of the population of the relevant wards compared with Guadalcanal Province in 2009. The populations of Malango and West Ghaobata have very similar age structures and are generally consistent with the rest of the Province. That is, they have very

large proportions and numbers of infants and young children (aged 0-14 years), and very few elderly people, the latter of which are the repositories of traditional knowledge and customs. The high proportion of children is consistent with observations in the villages surveyed for this study, where the large number of potentially vulnerable teenage mothers and infants is very evident. However, there is some evidence that the Malango population is aging. For example in 2009, 37% of the population was aged 14 and under, compared with 45% in 1986.

Across each of the groups in the Malango and West Ghaobata ward populations, males outnumber females. Males make up 53% of the total Malango population, and 52% of West Ghaobata. In Malango Ward the gender imbalance is most evident in the 45-59 year old group, and may reflect a greater longevity among local males, compared with women.

Figure 8-6 Age Structure of Malango Population, 2009



8.1.5.5 Ethnicity

The population of Malango Ward is 95.4% Melanesian, although the available census data does not distinguish between people who are from Malango, and those from elsewhere in the Solomon Islands. This compares with 97.8% Melanesian in West Ghaobata, and 98.5% for Guadalcanal as a whole.

As noted elsewhere, there are groups of Weather Coast settlers residing legitimately in the Tina-Ngalimbiu area. In these cases, the settlers have formal customary agreements with the land owning clan and its chiefs. Through exchanges of pigs, produce and custom money (chupu), they have been granted rights to use local land for residences and gardens, but ownership is retained by the customary landowning clan. These agreements reportedly need to be renewed periodically. One of the challenges for the customary landowning peoples of North-central Guadalcanal, since the 1970s, has been the unsanctioned occupation of their land by people from Malaita and elsewhere, who have come to Guadalcanal to work in the city, in the plantations, and the resource extraction industries.

The main ethnic minorities in Malango Ward are Polynesians and Micronesians (relocated Gilbertese), possibly associated with the St Joseph's boarding school at Tenaru, and with settlements along the main road and/or close to Henderson.

The Project needs to comply with the WB Performance Standards as previously mentioned. Based on discussions with the World Bank about Performance Standard 7 and Operational Policy 4.10, both of which address Indigenous Peoples, all groups resident in the area are considered Indigenous people regardless of their status and origin in the Solomon Islands (landowner, squatters, settlers, people from Guadalcanal, Malaita or other islands), which ensures that all communities are consulted in compliance with this standard and Policy. More information on this is provided in Section 3.6 WB Performance Standards.

8.1.6 Local Peoples˘ Sources of Livelihood

8.1.6.1 Framework

The proposed TRHDP could have a significant effect on local people˘s livelihoods. Therefore, both the ESIA and householder surveys gathered background information on current livelihoods in each of the communities. This is presented below in terms of the elements of the Department for International Development˘s (DFID) :sustainable livelihoods framework˘: that is, the range of livelihood strategies employed by local people, the livelihood capitals they deploy or utilize, the various constraining and enabling factors at play, and the various risks and vulnerabilities that people must manage to obtain the things they need to make a living, are outlined.

8.1.6.2 Livelihoods Strategies

The main livelihood goals of the people and households of the project area appear to be daily food security, and protection of the family from risks of climate and loss of resources. With a paucity of financial capital, local people use a range of 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 typically include one or several of the following:
  - household-scale cash crop production, with the produce sold in the central market in Honiara
  - small-scale timber milling for local and Honiara markets
  - local day laboring, for example in timber milling, garden clearing, house building, etc.
  - running a small home-based business, such as home baking, natural materials handicrafts, a local shop-canteen selling small items, vehicle hire, etc.
  - full or part time employment for a government agency or large company ¯ typically the Gold Ridge Mining Company (GRMC) (when operational), GPPOL, Earthmovers Logging Company, market gardens.
  - Fishery at the River mouth.

These strategies, therefore, mostly rely on having good access to:

- local natural capital such as land, forests, river, gravel and forest products
- household human capital, including traditional and formal skills and knowledge, and labour power
- 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.

The following sections outline the situation regarding livelihoods in households and communities of the TRHDP area.

8.1.6.3 Household Income and Expenditures

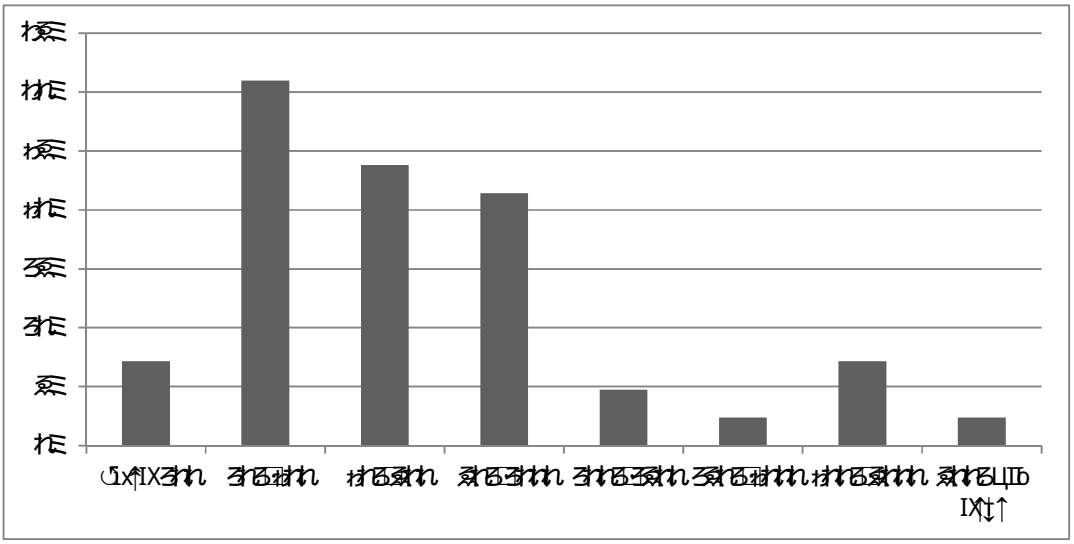
The 2006 National Household Income and Expenditure Survey (HIES) calculated that 56% of all income to rural households in the Solomon Islands (and to households in Guadalcanal province) comes from home production of goods and services. That is, they are produced by the household and predominantly consumed by the same household. Next most important for Guadalcanal households is self-employment (13.5% cf 9% nationally), and wages and salaries (12%, both provincially and nationally).

People in the TRHDP area rely on both cash and non-cash income and, increasingly, they are being drawn into the cash economy to meet their needs. Most households have some level of subsistence production, though the current annual value of this subsistence production is not known.

The survey of householders in the project area indicates that the average weekly cash income for households is approximately SBD 870 [65], and the median income is SBD 500. However, the range of weekly cash incomes as reported to the social team (Figure 8-8) is very wide, ranging from SBD 100 to SBD 6000.

In addition to income generating activities of various kinds, some members of the communities of the project area received periodic payments of royalties from the Gold Ridge Mine when it was operational and/or receive royalties from logging on customary land. This tends to be treated as windfall income and is used to purchase major items, if possible. Hence, it is not surprising that only a weak correlation was found between the number of appliances and pieces of equipment that a household owns, and the weekly income of that household.

Figure 8-7 Weekly cash incomes in Solomon Islands Dollars (SBD) for the sampled households in the study area



No data on local household expenditure were collected in the social survey. National data from the 2006 HIES indicates that average annual household expenditure in rural areas of Solomon Islands was SBD 23,366 for an average household of 6.0 persons, giving an average per capita

[65] Approximately $121 US.

expenditure of SBD 3,894. On average, 66% of this expenditure was on food, 11% on housing, 5% on transport, and 14.5% on miscellaneous goods and services.

8.1.7 Human Capital

8.1.7.1 Introduction

Human capital refers to the knowledge, skills, and experience on which individuals and households can draw to generate a livelihood, and the labour/work power or energy available to them. The latter depends on peoples overall health and well-being. These various aspects of human capital are discussed below.

The people of the project area rely heavily on specialist, customary, and detailed technical knowledge, skills and abilities in a number of areas:

- knowledge of the land and geography of the Tina River catchment, including the location of particular natural resources, natural hazards, tracks, and places where they have ownership and use rights;
- knowledge of the trees, plants and animals found in the catchment, along with their characteristics, uses, and seasonal availability;
- knowledge of garden plants and other domesticated species and the skills to manage them;
- marketing and selling skills;
- carpentry and house building skills;
- numeracy and literacy; and
- knowledge and skills in hand and power tool and machinery use.

They also require the ability to resist a range of endemic diseases, which could reduce their ability to support themselves, and knowledge of basic health care necessary for family wellbeing. All of these are complemented by knowledge of local customs and social mores and, increasingly, knowledge of how to deal with bureaucracies and commercial organisations.

An important strength of the residents of the project area is the depth of their traditional knowledge and skills and ability to live in a largely natural environment, and to acquire a livelihood from it. Such skills, abilities, and qualities are acquired in the course of growing up in rural areas and participating in village life, where traditional knowledge is passed down by parents and elders through `learning by doing_. This is complemented by formal education in the government and/or private school system, if it is accessible and affordable. Increasingly, people are required to interact with urban communities and conditions, and with a monetised economy that requires a different range of skills and experience, which are not always locally available.

These various aspects of human capital are dealt with separately in the following discussion on work, employment, education and health, using the official and survey data that was available.

8.1.7.2 Work

The Solomon Islands Census gathers information for each person aged 12 and over on whether they worked during the previous week, and the `type of work/activity they usually do_. Respondents are offered a choice of one of the following:

- Work for pay as an employee of government or private sector, as an employer, or as self-employed;
- Producing goods for sale;

- Producing goods for own consumption;
- Voluntary work; and
- Unpaid family work.

The implied assumption in the Census question is that people have one main or dominant kind of `work¸ rather than being involved in perhaps equally important multiple activities. Taking the data for Malango Ward at face value, almost 35% of the 4,266 people of working age recorded in the 2009 census for Malango Ward were in paid employment, 10% were self-employed or employing other people, and a further 15% were producing goods for sale, for example, garden produce. This implies that 59% or so were engaged in the cash economy in some way.

The level of participation in the cash economy among people in West Ghaobata is similar (55%), but somewhat higher than for Guadalcanal as a whole (41%).

The 2009 census records that only 17% in Malango, and 24% in West Ghaobata, were engaged principally in subsistence food production, which is low in comparison to the whole of Guadalcanal province (38%). Malango and West Ghaobata may be at an advantage compared to other rural residents of Guadalcanal, since they are both located relatively close to Honiara city. Honiara has an active labour market and several large produce markets, including the Honiara central market, where most produce is sold and bought.

Importantly, the Census data show that there is a major difference in work between males and females in Malango Ward. For example, in 2009 only 471 of the 1,872 (i.e., 25%) involved in paid jobs were woman, whereas women made up 64% of those engaged in subsistence production, 53% of those producing goods for sale, and 72% of those doing unpaid family work. Apart from income from selling small volumes of cash food crops, home baking, and craft items locally and at the Honiara market, women typically have little direct access to cash.

8.1.7.3 Paid Employment

The village workshops attempted to gather information on the extent of paid employment in the communities of the TRHDP area. Table 8-9 summarizes the data.

Table 8-9 Employment in the communities of the TRHDP area

Community & affiliation	Villages/ hamlets	In paid employment	Types/sources of paid employment	Main types of self-employment
Downstream Area - Senge Community				
Senge community	Senge Choro Koropa	1?	Public service	Chainsaw timber milling, ecotourism, market gardening
Total		1?		
Downstream Area ¯ Other Bahomea				
Pachuki community	Pachuki	2		

Community & affiliation	Villages/ hamlets	In paid employment	Types/sources of paid employment	Main types of self-employment
Namopila comm.	Habusi		GRML, Earthmovers	Timber milling, market gardening, livestock, equipment hire
	Namopila Komureo Vatunadi Valekocha	0		Timber milling, market gardening, gravel extraction
Antioch community	Antioch Valesala Kolanji Komeo	11	Public service, Earthmovers, GRML, GPPOL, church	Timber milling, firewood, market gardening, crafts, bush food marketing
Tina community	Tina Valebarik Valebebe Tahurasa Valemaota	20	GRML, GPPOL, Public Service,	Timber milling, market gardening,
Vuramali comm.	Vuramali Haimane Horohotu 2 Vuvamali	15	GRML, Public service, CBSI, Ports Company, Fisheries,	Timber milling, market gardening, copra, cocoa, canteen, handcrafts,
Horohutu (settlers) Settlers	Horohotu 1	12	GPPOL, GRML, NGO, public service, logging company	Vehicle hire, market gardening,
Total		60+		
Infrastructure impacts area				
Verakuji community	Verakuji Mangakiki	6	Public service, GRML, Earthmovers, Church,	Timber milling, market gardening, bush products marketing, vehicle hire

Community & affiliation	Villages/ hamlets	In paid employment	Types/sources of paid employment	Main types of self-employment
Marava community	Marava Ngongoti Vatupaua Rate school	4	GRML	Timber milling & marketing, handicrafts, market gardening, canteen, firewood
Vera ̆ande community	Vera'ande Verakweli New Mahata	19	GRML, GPPOL, QQQ farms,	Timber milling, market gardening, bakery, bush products,
Verakabikabi (settlers)	Verakabikabi	?	GRML,	Gold panning (artisanal mining), market gardening, vehicle hire
Total		29+		
Downstream Ghaobata communities		?		

8.1.7.4 Household Production and Self-Employment

The importance of multiple activities as a livelihoods strategy among the people of the greater TRHDP area is evident in the 2009, Census data on `household money earning activities_(see Table 8-10). For example, while 646 Malango residents said in 2009 that their main economic activity was producing goods for sale, 77% of households reported that they earned some money from the production and sale of crops and/or other products, such as vegetables and fruits, betel and other edible nuts, coconuts and related products, cocoa, cut flowers and wild plants, milled timber, and craft items (Table 8-11). Compared with their Ghaobata neighbours, the people of Malango are more involved in the production of flowers and timber but much less involved in coconut products and cocoa. This reflects the accessibility to Ghaobata people of established (and perhaps abandoned) commercial plantations on the Guadalcanal plains, downstream of the Tina River.

Table 8-10 Households earning cash from sale of produce, 2009

	Number of households			Percentage of households		
	Guadalcanal Province	Malango Ward	West Ghaobata ward	Guadalcanal Province	Malango Ward	West Ghaobata Ward
Food crops	12088	1110	686	70.4%	63.5%	70.3%
Coco./Copra	4518	50	203	26.3%	2.9%	20.8%

Betel Nut	7574	152	215	44.1%	8.7%	22.0%
Cocoa	6392	309	280	37.2%	17.7%	28.7%
Tobacco	1045	35	5	6.1%	2.0%	0.5%
Timber	569	52	6	3.3%	3.0%	0.6%
Flowers	1428	189	52	8.3%	10.8%	5.3%
Other products	816	78	11	4.8%	4.5%	1.1%
none	1977	401	157	11.5%	22.9%	16.1%
Households involved	15186	1348	819	88.5%	77.1%	83.9%
Total households	17163	1749	976			

*Note that households could indicate more than one product type

The 2006 Household Income and Expenditure Survey (HIES) reported that of the Guadalcanal households that were involved in some kind of self-employment, 34% were producing root crops for sale, 31% were producing other vegetables and fruits, 6% were doing livestock farming, 6% were catching and selling fish, 5% were in handicraft production, and 16% were engaged in some other kind of self-employment or small business activity.

In our householder survey, 100% of the respondents indicated their household grew crops of some kind for home consumption, while 70% said they grew or collected produce for sale. This is reasonably consistent with the 2009 Census findings for Malango Ward.

Women of the study area tend to group together to make the weekly trip to Honiara to sell their produce, and to make any necessary household purchases. Different villages seem to favour different days for marketing, though Saturday seems to be the busiest day for the Honiara Central Market. Transport typically costs at least SBD $50 per person each way, plus a market stall fee.

The range of crops grown for consumption and sale is presented in Table 8-11. Relatively few respondents mentioned producing and selling betel nut and tobacco, despite there being an apparent abundance of betel nut in the villages of the study area, and plenty of betel nut chewers. Many indigenous village households are involved in some capacity in sawn timber production. This is discussed below.

Table 8-11 Crops produced for consumption and for sale by the surveyed households

Product	% of households growing for consumption	% of households growing for sale
Banana	90%	31%
Kasava (Manihot esculenta)	74%	19%
Kumara (Ipomoea batatas)	69%	26%

Product	% of households growing for consumption	% of households growing for sale
Beans	57%	31%
Cabbage	57%	19%
Tomato	55%	24%
sugar cane	50%	10%
slippery cabbage (Abelmoschus manihot)	43%	14%
taro (Colocasia sp)	38%	7%
yam (Dioscorea sp.)	38%	10%
Eggplant	36%	14%
Capsicum	29%	17%
pana-yam	23%	7%
potato (Solanum sp)	17%	14%
Pumpkin	17%	10%
Shallot	14%	12%
Pawpaw	12%	14%
Garlic	12%	7%
Pineapple	7%	-
Chinese cabbage (Brassica rapa var.)	9%	9%
Cucumber	7%	7%
Coconut	7%	7%
lemons/citrus	5%	2%
kangkong (Ipomoea aquatic)	5%	0%
betelnut (Areca catechu)	2%	5%
Melon	2%	2%
cutnut (Barringtonia procera)	2%	2%
Corn	2%	2%

Product	% of households growing for consumption	% of households growing for sale
Cocoa		5%
jackfruit (Artocarpus heterophyllus)		2%
sago palm (Metroxylon sp)		2%

In his guide to Solomon Island food crops, French (2011) describes the diversity of crops produced in local gardens, and notes that having a range of cultivated and wild foods available is a proven food security strategy in an uncertain environment. Table 8-11 reveals that that the variety of food produce offered for sale is greater than reportedly produced for home consumption. With home consumption there is a much greater emphasis on staples such as root crops, banana, and cooking vegetables, whereas the cash crops are more likely to include salad (green leaf) vegetables and exotic items. This suggests that there is an established pattern of growing specifically for the market and targeting more high-value food products. Importantly, some domestically and commercially important green vegetables are collected from wetland areas adjacent to the Tina River, and in some cases areas that may be required for the Hydro development.

8.1.7.5 Occupations

Among the 1,872 paid workers in Malango Ward in 2009, the most important occupations are crafts and trades (20%), service and sales (19%), professions (15%), and plant and machinery operation (13%). By comparison the most important occupational groups among those in West Ghaobata are elementary workers or labourers (34%), followed by skilled agricultural and fishing work (23%) ¯ both probably associated with employment at GPPOL, and other nearby plantation operations. No occupational data is available at the village level.

8.1.7.6 Education

Formal education provides a means of building `human capital¸ and especially the skills and knowledge necessary to participate effectively in the modern economy and society.

Nowadays, all children in Solomon Islands are expected to at least attend primary school where it is available. Primary school in Solomon Islands is free, but not compulsory. In the project area and nearby, schools are provided by both central government and by established churches.

Government statistics indicate that the majority of Solomon Islands children attend school between ages 8 and 13, after which attendance rates decline. Nation-wide, 64.5% of rural children aged 6-12 attend school. In general, the levels of female and male educational attainment in rural communities in Solomon Islands are similar.

Census data on educational participation and achievement is only available for the whole of Guadalcanal Province. These data suggests that there are problems of poor school attendance by primary school aged children. For example, in 2009 only 69% of 5-9 years olds were attending school or preschool, 85% of 10-14 year olds were attending, and 61% of 15-19 year olds were attending some kind of schooling/or training. School attendance reportedly falls off from age 13

onwards. The main differences between boys and girls in educational participation emerges in the 15 and over age group, possibly due to the relatively high cost of high school fees for ordinary rural families, which means families favour advancement of sons over daughters in the education system.

From observation in the villages of the TRHDP area, school attendance is relatively low. Interviewees indicated that this was due to the labour needs of the household, low accessibility of the local schools due to lack of school transport, and poor attendance by teachers due to low salaries and/or failure of the government to regularly pay the teachers˘ salaries. Some local villagers volunteered that their young people/teenagers had poor literacy skills, and were not easily employable as a result. This, in turn, leads to early marriage and child bearing among girls, and antisocial activities among boys.

At present, there are approximately seven schools within the TRHDP area (the closest ones shown on the map in Figure 8-10). Local people aspire to have greater access to schools to make it easier and safer for their children to get an education. As a result, communities sometimes use church buildings as alternative classrooms, or resort to building their own classroom using local materials. For example, in Valesala/Antioch, the community has a barely serviceable building that houses the kindergarten (see Figure 8-9) as well as Grades 1-3. However, a new permanent building, located at the intersection of Antioch and Valesala villages, was under construction and will take students from Grades 4-6. This new permanent building, like that constructed at Rate, was being funded by the Ministry of Education as part of a bundle of benefits provided to local communities through the TRHDP planning process. Construction was being done by a builder from the local community. The new school classrooms at Valesala will eliminate the need for local children to walk several kilometers to Rate School. However, high school students will still need to attend Rate Community High School. There is also a school run by the Seventh Day Adventist Church at Namanu.

Children who want to attend higher levels of secondary school often need to leave the area and attend boarding school. The closest such school is at Tenaru (St Josephs). Selwyn College was formerly located near the river in West Ghaobata, but was relocated to West Guadalcanal following massive damage by Cyclone Namu. Tertiary level trade training is available in Henderson at the Don Bosco academy, and in Honiara.

Kindergartens are located at Marava, Ngongoti and Valesala. These take children aged 3 to 5 years old, and are run by local community groups with volunteer help. At the time the social surveys were being conducted, a new community kindergarten was nearing completion at Verakuji. Students from the downstream communities such as Ravu, Popolo, the GPPOL workers village, and other plains communities adjacent to the Ngalimbiu River, attend Ngalimbiu Primary and the High School at Nguvia.

Figure 8-8 Valesala kindergarten and grades 1-3 (left) and grades 4-6 (right)

8.1.7.7 Health and Health Services

Health and wellbeing underpin personal human capital and one's ability to secure the means of existence, and to participate fully in one's society. Depending on location, Solomon Islanders face significant threats to their health and wellbeing, especially:

- diseases associated with the environment and unimproved living conditions, such as: malaria, pneumonia, diarrhea, asthma, and skin diseases; and
- increasingly common diseases and conditions associated with inadequate or modern diets, nutrition, and lifestyle, such as: diabetes, high blood pressure, anemia, (in children) wasting and malnutrition, stress, and problems of protein deficiency.

Based on village workshops and interviews with local people, the principle diseases of concern to residents of the project area are malaria, pneumonia, diarrhea, stress, flu and other respiratory conditions, diabetes, and STDs. Hernia seems to be a problem, especially among men, and is put down to the physically demanding types of work and carrying of heavy loads (e.g., timber). In several village workshops people reported incidences of gonorrhea and dengue fever. Cuts and fractures to limbs appear to be relatively common and relate to peoples' living environment and their way of life, though no data is available on the incidence of serious injuries.

In some communities, people reported that malaria and diarrhea cases are slowly reducing, but pneumonia incidence appears to be increasing. Some of the improvements in sanitation related illnesses have resulted from environmental and sanitation improvement drives within communities (e.g., Tina Village). Respiratory conditions appear to be common among both children and adults, and may be associated with cooking cover open wood fires in closed spaces, and with damp living conditions.

The people who live in the vicinity of the Tina River are constantly interacting with it in the course of their daily lives, especially women and children. Several of the villages in the project area (e.g., Koropa, Choro, Habusi, and Vuramali) are located on the right bank of the Tina/Ngalimbiu River and their residents have to ford the river to access most facilities, and to catch transport to Honiara. This can sometimes be very dangerous, since river conditions are subject to change, sometimes rapidly. Consequently there are occasional drownings or near drownings of children, reportedly about one every two years. The rainy season also brings the threat of major destructive floods which, in the past, have caused many deaths.

The overall rate of accidents and accidental deaths in the communities of the project area is not known.

For women, the main diseases and health issues for which they most often suffer include stress giving birth to premature babies, miscarriage, or death of either the mother, or baby, or both, during the time of delivery. Since there are no health facilities, including no clinics nearby any of these villages, death may occur when women encounter such problems. The other hardship women currently encounter is the lack of easy access to transportation to take them to the clinics in Honiara or the Central Referral Hospital at No. 9 (downtown Honiara) if they encounter problems when giving birth.

According to women, the main causes of stress are husbands spending all the money on alcohol and other women, husbands becoming involved in extramarital affairs, husbands not contributing enough to support the needs at home, young people taking drugs, disobeying their mothers, not doing well in schools and unwanted pregnancy among young girls.

According to the ESIA Scoping Report, in Pachuki, Habusi, Namopila, Tina Village and Antioch, the most common ailments reported were pneumonia, malaria and an observed high incidence of skin conditions, especially among children (Entura, 2012).

8.1.7.8 Child Health

In the 2007 Demographic and Health Survey (DHS), the most common health issues for young children in rural Guadalcanal were associated with poor nutrition and hygiene. These include anemia (55%), stunting of growth (34% nationally), and diarrhea. Poor nutritional status is related to maternal malnutrition, low birth weight, inadequate breastfeeding and weaning diets, and childhood diseases. For children under five years of age, 17% were reported to have had a fever in the two weeks preceding the survey, with children aged 6 to 23 months being the most vulnerable. On Guadalcanal, only 46% of those children who were reported to have had a fever were taken to a health facility for treatment. This is the lowest level of treatment of all of the provinces. In the two weeks preceding the survey, nationally 9% of all children aged less than five years were reported to have had diarrhea. However, 93% received some form of treatment. Poor children˜s health and lack of access to healthcare represent significant threats to the future availability of human capital for rural Guadalcanal communities.

8.1.7.9 Access to Health Services

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. The national 2007 DHS showed that in rural areas only 37% of children less than five years of age with diarrhea in the previous two weeks had access to oral rehydration, and 58% had been taken to a health facility. The incidence of seeking health support for sick children in the project area is not known, although it is not likely to be any better than elsewhere, since the majority of the residents of the project area have to travel considerable distances over rough roads, often on foot, to attend the basic provincial government provided health clinic at Namanu or the health post at GPPOL (Gorou health post). Even when they are able to attend the clinic, local people may not be able to obtain the drugs or treatment necessary. The main national hospital (`Number 9_) in Honiara is not easily accessible by local communities.

Local villagers consider health services within and adjacent to the project area to be inadequate. Given the prevalence of illness and disease, there is clearly a need for a nursing station or a part-time attended health outpost in the Tina River area, possibly at Rate or Antioch.

The infrastructure map in Figure 8-10 indicates the location of schools and health services.