Mamara New Capital City Development Phase 1 Environment Impact Statement (EIS)

Chapter 7: Marine and Coastal Assessment

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1.0 INTRODUCTION

In the tropics most natural beach and coral reef systems are in dynamic equilibrium state. However changes to their equilibrium conditions over time are caused by cyclic weather patterns and biological conditions, usually with large natural changes or by human interventions such as coastal structures and development that usually disrupts the natural balance (*Gillie, D. R 1997*).

Globally Coastal development has put entire ecosystems at risks, as and when during construction to extend artificial shorelines by land reclamation. Reclamation and seawalls activities are common causes to disruptions of equilibrium state of beach dynamics and coral reef system. Development along marine coastal zones usually leads to loss of biological diversity, change coastal morphology, mangrove and coral reef deterioration, extinct of animals and plants and also generates pollutants that pollutes marine environment from reclamation materials during reclamation and construction activities (*Pyriyandes and Majid 2009*). In addition, high energy impacts of waves cause changes to coral reefs, shoreline, and beaches disappear and cannot restore its ecological and environmental impacts that affect fisheries (*Yu and Zhang 2011*).

Coastal development, overfishing, demands for resources and land-based pollution are already impacting coastal habitat condition, with indirect impacts on the reef fish and invertebrates that depend on these habitats. Fishing effort is high due to rapidly growing human populations. Currently, impacts from targeting spawning aggregations and destructive fishing practices and gears, are greater than impacts from climate change (*CEFAS 2018*)

2.0 BACKGROUND AND CONTEXT OF SOLOMON ISLANDS AND GUADALCANAL PROVINCE

2.1 Solomon Islands

Solomon Islands is in the Southwest Pacific about 1,900 km northeast of Australia and the archipelago form approximately 990 islands with a total land area of more than 28,000 square km (*Bennett 2000; Grover 1968*).The Solomon Islands is a young and dynamic country where more than 85% of our population dwell in rural communities. The people depend heavily on the land for gardening, clean streams, and rivers for clean life-giving water, on healthy forest for abundance resources, the sea, coral reefs and mangroves for daily livelihood and sustenance (*2004 Marine Assessment*). These same natural resources are also income sources for many communities to pay for essentials such as school fees, fuel, health expenses

and trade goods. As we are still entirely reliant on our environment for many of our life needs, thus is important to manage our biological and natural resources wisely and sustainably

The Solomon Islands has a total of 494 species of corals recorded and known to be one of the highest diversities of corals anywhere in the world. With a total of 1019 species of fish recorded, it is also one of the countries with the richest concentration of reef fish in the world (*2004 Marine Assessment).*

The coastlines are dominated by reefs exposed to high energy wave action, barrier reefs of different types. Others with extensive mangrove forest along coastline, sea grass meadows and soft substrate.

Figure 1: Map of Solomon Islands showing different Provinces (Parks Vol 20.1 March 2014)

2.2 Guadalcanal Province

Guadalcanal is the largest Island and lies in the southern half Solomon Islands Archipelago between 9º 15'S, 159ºE and 10º 30'S, 160ºE .It has a total land mass of 5310km² with the highest peak being Popomanaseu and Makarakomburu with 2330m and 2450m respectively (Roe 1993). Guadalcanal adopted the matrilineal system of Governance and is known to have 19 languages across the island.

According to 2009 national census, the total enumerated population of Guadalcanal stood at 93,613. Compared to the 1999 population census, this is an increase of 33,338 persons. Guadalcanal's population has a relatively young age structure, with 42% of the population

younger than 15 years of age; 54% are in the so-called working age groups 15-59, and 4% were older than 60 years (*Census 2009: Guadalcanal profile*).

In 1999 Tandai itself has population of 5,970 and rockets up to 14,914 in 2009. This ward is the most developed urban areas in Guadalcanal Province, where most of the major development of Solomon Islands occur and is hosted.

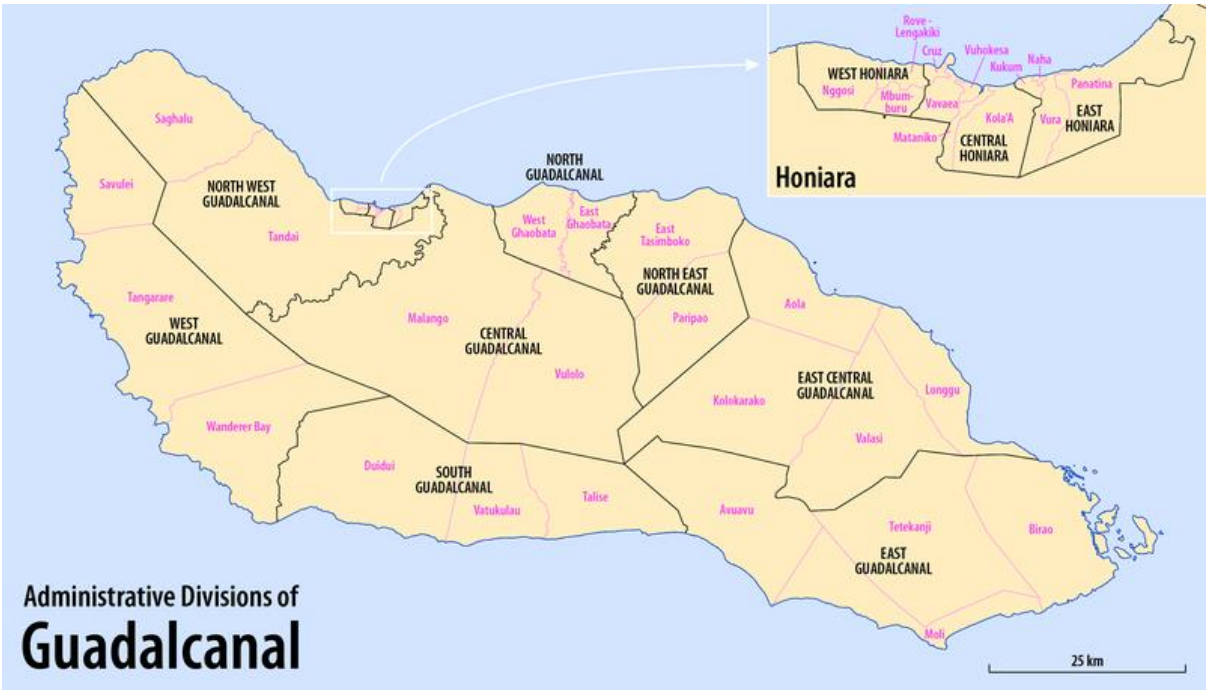


*Figure 2. Map showing the administrative divisions of Guadalcanal Province (*https://commons.wikimedia.org/)

2.2.1 Climate

Honiara is situated on Guadalcanal Island, thus the climate described for Honiara on average similar to Mamara site, since the vicinity of the project site is closer to Honiara, and most of the Honiara climate data covers the Mamara New Capital City project site. Below is some average weather data collected from historical climate data. On average, the temperatures are always high, and the warmest month is January with an average maximum temperature of 31°C (87°F) (Figure 3)

The coldest month is July with an average maximum temperature of 30°C (86°F).

March is the wettest month while August is the driest month (figure 4). A lot of rain (rainy season) falls in the month of January, February, March, April, May, July, October, November and December and On average, March is the most rainy while September has the least rainy days (Figure 5) The average annual amount of rainy days is: 197.0 day

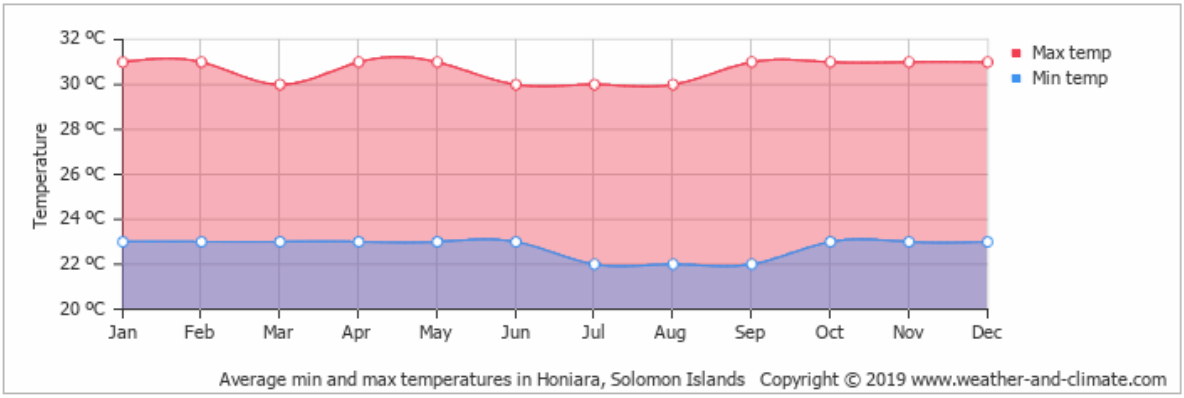


Figure 3: Average minimum and maximum temperature over the years

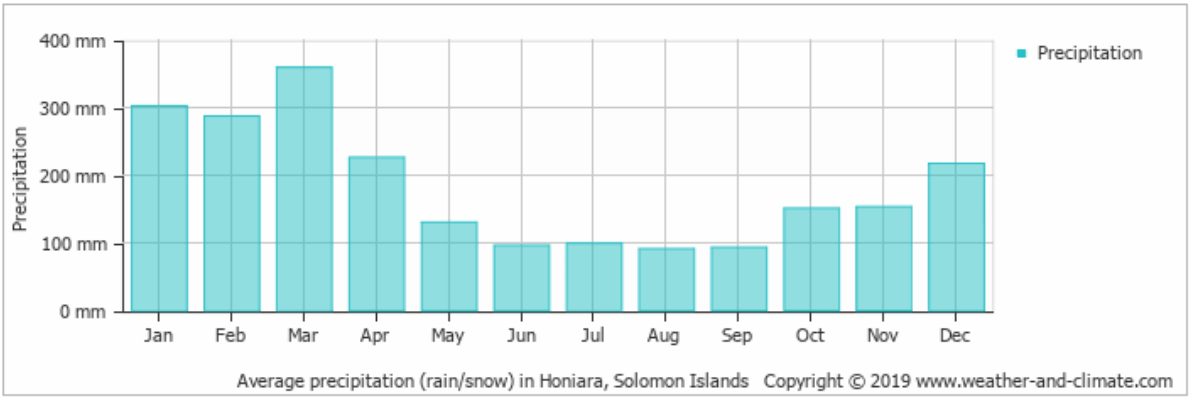


Figure 4: Average monthly rainfall over the years

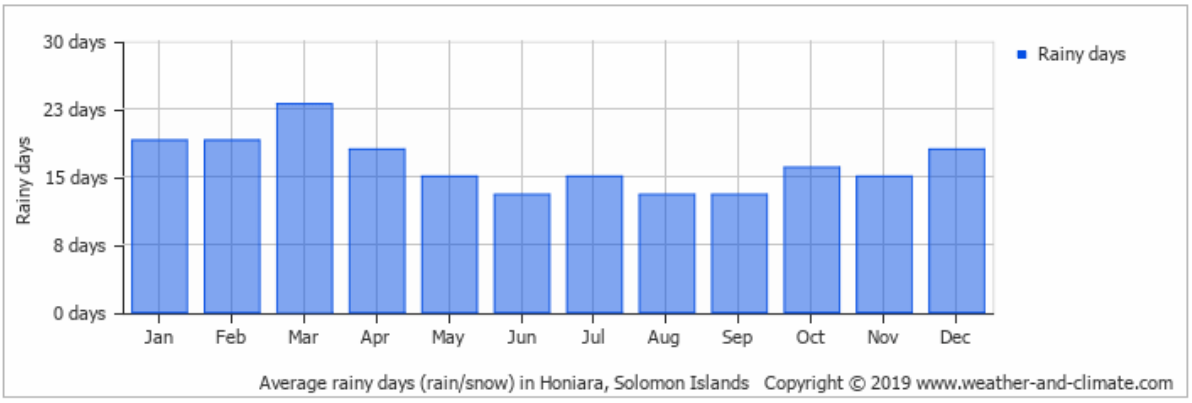


Figure 5: Average monthly rainy days over the years

3.0 THE PURPOSE OF THE MARINE SURVEY AND ASSESSMENT

This report has been prepared for Metropolis Mamara Development Ltd as part of the Environment Impact Statement (EIS) for the Construction and Operation of Development of Solomon Mamara "New Capital City" Project on Mamara area West of Honiara, Guadalcanal Province. The overall objectives of this marine survey assessment report between Poha River and Mamara River are to:

- describe and characterise the existing marine fauna aquatic environment, get a record of baseline of the marine, coastal and fisheries flora and fauna occurring that will be or has potential to be affected by the zone of influence of the project.
- Discuss the potential direct and indirect construction and operation phase impacts of the project to the marine and coral reef ecosystem
- Describe proposed mitigation and or management measures for protecting or reducing the impacts to the values of the marine ecology.

4.0 EQUIPMENT USED

The equipment's used for the Marine Survey and Assessment was as follows:

1. 50m Tape measure
2. Goggles, fin, and mask.
3. Underwater paper data sheets
4. Pencil
5. Clipboard
6. GPS
7. Camera

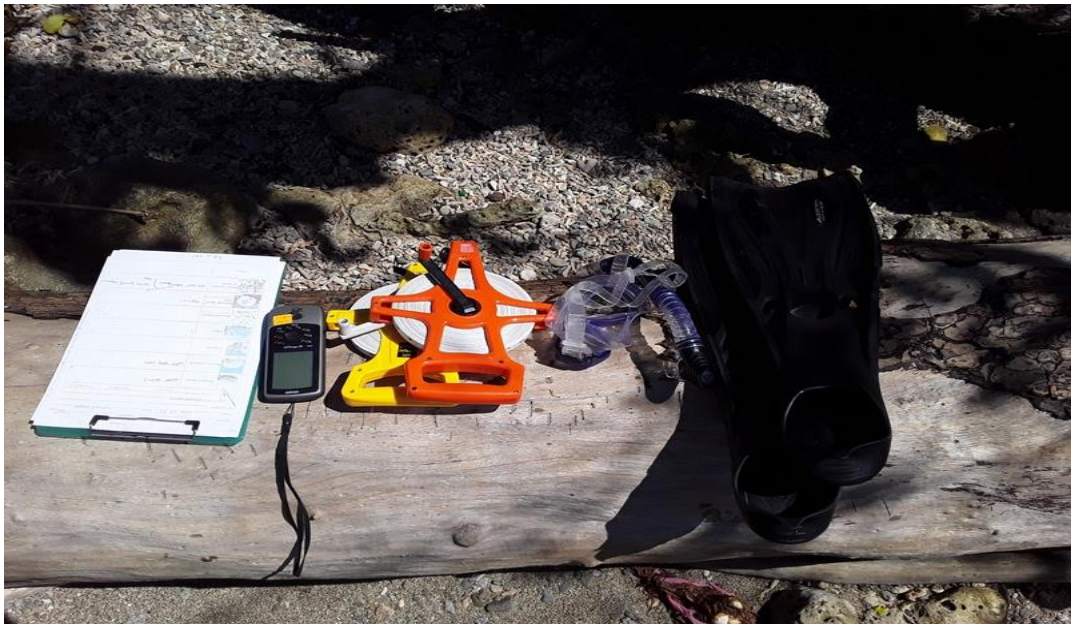


Figure 6. Showing the equipment used for the marine survey

5.0 DESCRIPTION OF PROJECT AREA

The project area is located towards northwest of the capital city, 7 kilometres away from the city administrative centre and 15 kilometres away from Honiara International Airport. The project site extends from southeast to northwest along the coastline, with a coastline of 8km. There are hills, streams, and several small bays in the area, with beautiful ocean view and sky scenery. In addition, there are also WWII shipwrecks of Japanese and American naval ships in the area. The marine area surveyed and assessed was between Poha and Mamara River which was designated as Phase 1 of the overall project (Figure 7)

Figure 7. Map showing the coastal area of influence for phase one development that is from Poha river mouth to Mamara river mouth.

6.0 FIELD SURVEY METHOD

The Marine survey and baseline assessment included the following

- Coral community substrate cover
- Fish size and abundance
- Benthic invertebrates
- Coastal Morphology
- Habitat Characterization
- Water Column and Bottom Characterisation
- Ocean Circulation
- Fisheries and Coastal resources

Random interviews were also undertaken to gain understanding of the local marine fisheries to supplement the field observation. Desktop review of publications, books, previous studies,

and websites were also consulted for background and other relevant information for this assessment.

The Location of the marine site surveyed and assessed along the Mamara area is shown in map of figure 8

Figure 8: Picture showing the site surveyed (arrow) and two sites Coastal marine area from Poha River to Mamara.

The red line arrow was the site the transect line was laid and survey was done (Figure 8). The yellow stars are sites that rapid visual observation was carried out to find out the coral communities and the type of substrate and habitat characters along the coastal stretch of coral substrate (Figure 8)

6.1 Coral Reef Substrate survey method

A 50m x 3 transect line was laid along the coral site was extended along part of the coral reef between 1- 3 metres. Identify what is directly under each metre mark. If tape stretches over a hole, try to see what is at the bottom and record on the datasheet. Three sets of transect was used per site surveyed. For a site, coral percentage composition cover of the following categories was estimated:

- Massive coral
- Branching coral
- Soft coral
- Algae
- Bleached coral
- Recently dead
- Rock, sand, or rubble

6.2 Benthic Invertebrates survey method

Snorkelling at a depth of 1-3m along a 50m transect tape, identifying and recording the sizes within 2m on either side of transect tape. The list of invertebrate's species is those important commercially and as indicator to coral reef health. For a site, the mean size and abundance of the following invertebrates were to be calculated:

- Trochus shell
- Crown of thorns
- Crayfish
- Clams
- Diadema Urchin
- Blacklip
- Triton
- Sea cucumber species

6.3 Fish survey method

Snorkelling along the 50m transect tape and recording the different types of fish and estimated sizes observed within 2m on either side of the transect.

As you observe any fish that are on the list, estimate its length in centimetres, from the tip of its mouth to the tip of its tail and estimate the fish population. Any fish that is below 4cm is not recorded.

The fish species list are important food fish for food and commercial and some indicator species that can help identify the health of the coral reef system.

The fish species on list for survey and included for assessment were:

- Parrot fish
- Groupers

- Emperors
- Sweetlips
- Wrasse
- Rabbit fish
- Snapper
- Surgeon fish
- Butterfly fish
- Trigger fish

7.0 FIELD SURVEY TIMING

The survey was conducted between 10:15am to 12:00 noon on the 27th of June 2020. Follow up snorkelling; observation and assessment were carried out from time to time thereafter for 3 other times.

Coral cover composition, Benthic invertebrates, Fish size and abundance were recorded using the marine monitoring survey method protocol developed by Solomon Islands Locally Managed Marine Area (SILMMA) known as Underwater Visual Census (UVC) combined with photography as a guide to survey and monitor the different categories of marine resources present and the substrate types.

8.0 MARINE AND COASTAL ENVIRONMENT ASSESSMENT RESULT AND DISCUSSION

8.1 Biological Survey Results and Discussion

The results of the biological baseline survey and assessment was analysed and are discussed below. These were Percentage of coral cover, fish abundance and size in cm and Benthic invertebrate abundance and size in cm on the site surveyed.

8.1.1 Coral Reef

The substrate cover along the coast showed that Rock, rubble and sand has the highest percentage cover (40%) followed by recently dead corals (20%), followed by live corals of both massive and branching coral (sub massive) and finally algae (10%). The result indicated that the coral reef is deteriorating, and from general observation of diving on two selected sites indicated by the star (figure 8) and further 50m from where the transect line stopped; the

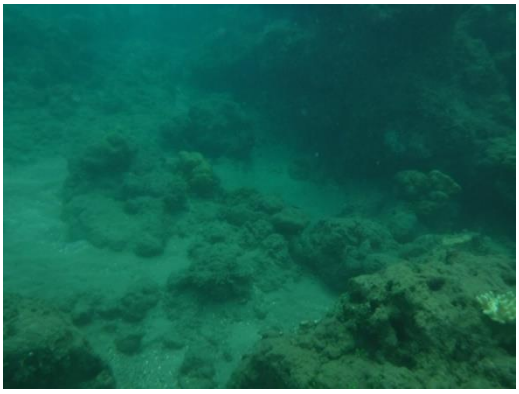
general reef characters was deteriorating (figure 9 c,d). It is obvious that massive coral boulders after they died were covered by brown algae growth. When reefs are dominated by algae and soft corals, it is a sign that the quality of water is getting worse and, they do not provide quality habitat for fish. (Albert S 2013)). The area above the Mamara river mouth surveying towards Poha river mouth direction within an area of 300metre square has better substrate cover compared to the rest of the reef system within the area of influence. Generally, the reef condition is not that healthy along the coast towards the Coastal bay East ward to Poha river direction. The cause for such condition could be increase in sea temperature, exposure to high energy wave action during bad weather , exposure to direct heat during low tide, crown of thorns (COT) starfish (*Acanthaster planci*) effects and human intervention by using the coral boulders for seawall and lime for chewing betel nut.

At the national level in comparison to the country coral reef system, Guadalcanal appears to have no coral patches along the main island. Long barrier and expansive intertidal reef flats are uncommon (*SOE report 2012*)

In Guadalcanal only in Marau has extensive reef system, while most areas with minimal size reef system. With Mamara much of the intertidal coral is dead, at Poha coast at lower eulittoral for stratum of Acropora and Montipora (figure 9 c, d) rubbles characters of intertidal zone (*Roe 1993)* and less diversity of fish as well, as shown in the survey .The fish that dominates the healthier part of the coral reef Figure 10 a,b) is mainly black surgeon fish , butterfly and other small fish (sp). Inverts observed during survey were only 2 sea cucumber and 1 tridacna *sp* were sighted.

a

b

c d

Figure 9 (a, b, c, d) showing the different types of coral cover along the Mamara to Poha river mouth

8.1.2 Fish

The fish list surveyed is important food fish, commercial species, and coral reef health indicators. This does not mean that other fish species are not present. This result showed and reflects only one site of 50m x 3 transect tape from Mamara river mouth going east towards Poha river mouth direction (Figure 8). Other two sites marked star in figure 8 are sites where reef observations are done without using transect due to the high energy wave actions and high turbidity with very low visibility. As we recorded and analysed, most food fish and commercially important fish are not found, and those present the fish sizes were small. This is may be due to the coral reef system area is within the reach of Honiara population for night diving and netting and deteriorating status of substrate habitat.

The most dominant fish recorded were black surgeon fish. The fish resources are depleting in this zone also due to the status of the coral reef habitat and the exposure to high energy wave action most of the time with high turbidity. Secondly this area is exposed to high population influx for recreation from Honiara thus the pressure to reef fish resources.

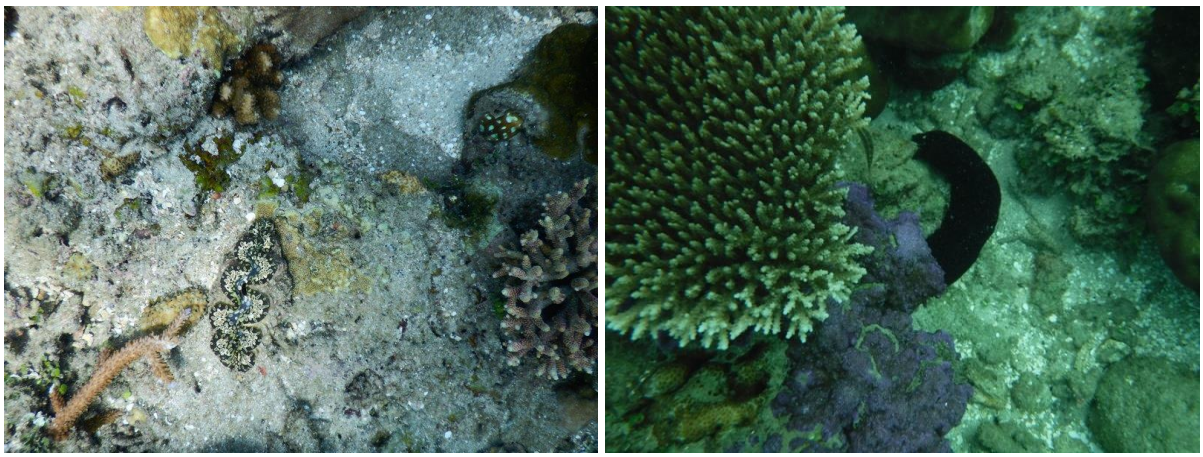
a b

Figure 10 (a, b). Showing the reef fish swimming along the coral reef system

8.1.3 Benthic invertebrates

As recorded during the invertebrate survey there was very low, almost no population of invertebrates' present. Only one tridacna clam shell (*Tridacna maxima)*, one sea cucumber (*Holothuria atra)* which is important for food and commercial species respectively were found (figure 11 a, b). Blue Starfish (*Linckia laevigata)* and diadema urchin (*Diadema antillarum)* also present on the site that was surveyed.

The high exposure of the reef system to Honiara residents, as it was used for public recreation and settlers along the area is one of the reason for the depletion of the important invertebrate for food and commercial uses and also the nature of the substrate and exposure to high energy wave action is not conducive for some of these important invertebrate species.



a b

Figure 11 (a, b). Showing the tridacna clam shell and sea cucumber found during the survey

9.0 PHYSICAL ENVIRONMENT

9.1 Ocean Circulation

Solomon Islands ocean surface currents circulation moves over a uniform movement. In relation to Guadalcanal and Mamara area, experience current direction movement coming in from Malaita passed Gela and swept over passed Guadalcanal.

Amongst ocean circulation, upwelling is an important process because water below at depth is often rich in nutrients needed by marine organism for growth and food chain continuity.

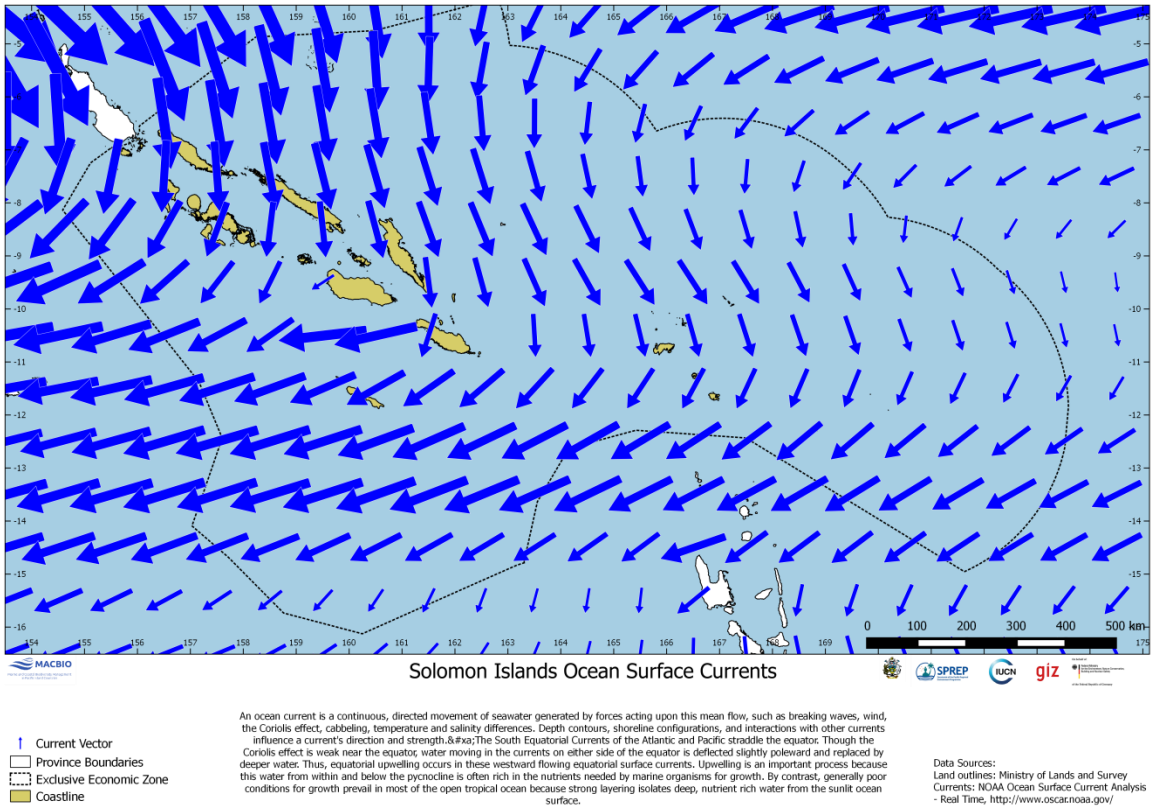


Figure 12: Showing ocean surface currents of Solomon Islands

The impacts of climate change are generating acute stresses within communities across the Pacific region

Globally, the ocean has absorbed more than 90% of the additional heat from human-caused global warming, leading to an increase in sea temperature.

Ocean acidification has the potential to significantly impact marine ecosystems and the services they provide, particularly through combined impacts of sea temperature rise and coral

bleaching. Any reduction in coral reef health could have serious consequences for public amenity, food security, tourism, and economic development

9.2 Coastal Morphology

The coastal area of the project site at Mamara is a bay with mostly white fine sandy beach and coastal vegetation of vine known as morning glory (*Ipomoea pes-caprae spp*) and coastal tree shrubs and other coastal vegetation land wards. The coastal site is with high wave energy and showed indication of coastal erosion (*Figure 13 b, c).*

Outlets from Poha River caused high sedimentation and siltation as a result there is high turbidity and very low visibility along the coastal waters. There was evidence of solid waste disposals coming out from both Poha and Mamara river outlets and ended up in the coral reef system

The mouth of the Mamara River down towards the sea was hard rock with live coral reef system at the depth between 1-4 metres. As you move from Mamara river mouth towards east side along the coast, the surface changes from live substrate with most of the reef fish to mostly fine sandy beach and patches of mixture of live and dead coral boulders along the sea coast. There is not much healthy branching and Acropora coral species due to the exposure to very high energy wave action and high temperature during low tide most of the time.

a

b

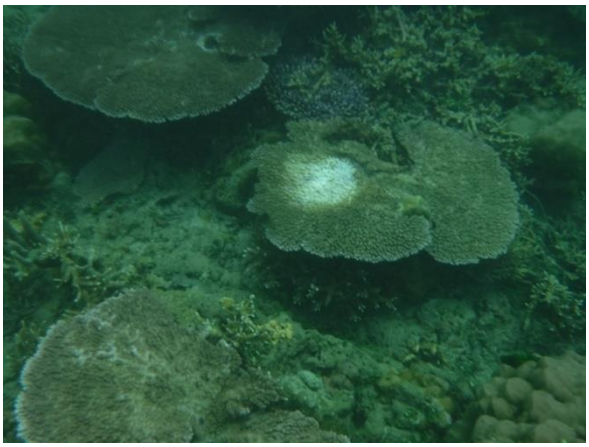
c d

Figure 13 (a, b, c, d): Showing the types of characters along the Mamara coastal sites

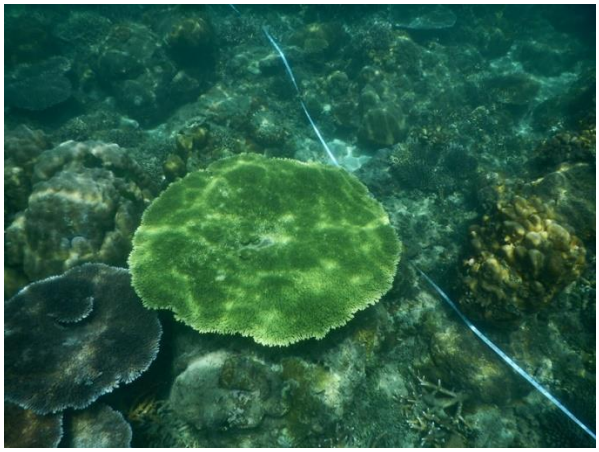
9.3 Habitat Characterization

From Mamara river mouth, the reef is mostly covered with live coral boulders, tabular corals, few branching corals and mixture of dead corals, rubbles, and sand. As you move 200 meters towards the east, there is mostly sand and dead corals and patches of live coral boulders exposing mostly to high energy wave actions. The corals are habitat to some of the coral reef fish found in that area. Amongst the coral reef habitat system, there are indications of bleached tabular corals along the Mamara river mouth coral reef system. This could be due to exposure to low light visibility and exposure to high temperature during low tide

Along the white sandy seabed along the bay, there are also some fish species that graze around this habitat mostly small reef fish species. Living species or live corals can withstand the harsh condition and exposure to high heat during very low tide. Dead rock flat with few individual reef and stones and patches of sand covers the zone of influence.



a b



c d

Figure 13 (a, b, c, d): Showing the types of habitat along the coastal zone of the marine site

9.4 Water Column and bottom characterization

The water along the area of influence is clear when the weather is good, and the sea is calm. When there are windy and high wave actions, the bottom sediments and rubbles caused the movement of particles that results in high turbidity with very low visibility of water along the coast.

Exposure to high energy wave movement during strong wind can cause high turbidity affecting local sand bottom. The bottom has high sediments once there is high wave energy and water movement. If there is low energy wave or water movement, then with less sediment movement and so water quality improves.

The Mamara and Poha site has the following nutrient level, sulphate is 107.0 mg/l and 120.0mg/l. potassium 35.3 mg/l and 33.9 mg/l, nitrate 15.57 mg/l and 17.85,mg/l, Ammonium Nitrate 0.21 mg/l and 0.21 mg/l, phosphate 0.13 mg/l and 0.80 mg/l respectively.

While the water quality tests of Mamara river and Poha are as follows, temperature is 30.05ºc and 30.19, pH is 8.34 and 8.34, dissolved oxygen is 26.78ppm and 28.75ppm, turbidity is 14 FNU and 10 FNU, salinity is 44.67 and 44.59 respectively.

9.5 Fauna Identification

There is a community of different individuals within the coral reef ecosystem along the reef system between Poha River and Mamara River. There are individuals of blue star fish (*Linckia laevigata*), sea cucumber (*Holothuria atra*), sea urchins (*Diadema antillarum*), tridacna clam

shell (*Tridacna maxima*), varieties of reef fish of which surgeon fish (*Acanthurus bahianus*) is the majority and a number of butterfly fish (*Chaetodon vagabundus*) and corals species such as tabular coral (*Acropora hyacinthus*) branching corals (*Acropora digitifera*, *acropora millepora*). The area is less diverse with regards to fish species and invertebrates. However, there are a community of live corals and fish in area opposite and along the Mamara river mouth. Along the coast towards Poha River, 70% of the coral reefs are dead and deteriorating due to exposure to high temperature and high energy wave actions and high temperature.

10.0 MARINE, COASTAL AND FRESHWATER FISHERIES

10.1 Fisheries

Fisheries and marine resources are the second largest source of export income after forestry and it plays a critical role in the national economy. The Solomon Islands fisheries are divided into four major sectors: offshore, inshore (coastal), inland freshwater and aquaculture (*SI National Fisheries Policy 2019-2029*).

10.2 Inshore Fisheries (Coastal)

A mosaic of habitats form from coral reefs, sea grass and mangroves sustain a great diversity of life, and abundant fish productivity. These coastal and marine supports a diversity of species that support variety of industries such as fisheries and tourism and simultaneously effectively protect coastlines against erosion and storms (*CEFAS 2018*).

Human pressures from coastal developments, pollution and over-fishing threatened the biological diversity and health of coastal and marine ecosystem. Resilience to Climate change is critical by reducing these pressures (*CEFAS 2018*)

Climate change is the cause of coral reefs degradation and thought to be threat to coastal fisheries.

In Solomon Islands marine Fish and invertebrate species are harvested for subsistence, sale at local markets and/or export.

Marine and coastal ecosystem services are core to the livelihoods and well-being of a large portion of Solomon Island communities and economies. Marine and coastal ecosystem resilience needs to be enhanced by improving water quality, reducing coastal development pressures, and sustainably managing fisheries resources *(SPREP ESRAM 2018).*

Along the Mamara coastal waters, there was evidence of line fishing activities by locals for subsistence purposes. Women and children spend time to fish either standing along the beach and throw their lines out into the sea or use traditional canoe to fish. Based on information gained from people that settle along the coast and individual interview from Borosughu village, that fishing along the Mamara coastal waters are for subsistence and not commercial, however they sale should there be a surplus of catch. Also, night diving is not frequent overtime, as the area is also accessible to Population in Honiara and settlers living along the Mamara coast.

Figure 14: A female standing beside her canoe after returning from fishing along the coastal waters.

10.3 Inland freshwater ecosystem

Freshwater ecosystems provide essential services to many Solomon Islands households. The key anthropogenic threats to freshwater ecosystems are an increase in sedimentation of stream and river systems from logging and land-clearing practices, pollution of water catchments from inappropriate solid waste and sanitation practices, rapid population growth, and urbanisation (*SPREP ESRAM 2018*) The key climate threats to freshwater ecosystem services are an increase in extreme rainfall events and sea-level rise. The key ecosystem

services most vulnerable and in need of protection, restoration, and enhancement to build their resilience under future climate conditions are;

- Provision of water supply (for drinking, domestic and irrigation purposes) provided by groundwater, rivers, streams, and lakes;
- Provision of food for both subsistence and commercial purposes (eels and other fish, molluscs, crustaceans, etc.) provided by rivers, streams, lakes, wetlands, and swamps
- habitat provision provided by streams, rivers, wetlands, lakes, and swamps;
- income generation (fisheries, aquaculture, and bottled water) provided by streams, rivers, wetlands, lakes, and groundwater;
- provision of recreational activities (swimming) provided by streams and rivers; and

Mamara inland freshwater system is pristine and has supported community livelihood over the past years. The freshwater habitat has fish, shells and other freshwater plants that present along the river. The valuable freshwater ecosystem is untouched and undisturbed. Watercress an important source of income for the surrounding community is farmed at upper stream of the Mamara River. The sale of this product supports the family with school fees, medical fees, and other basic needs. Downstream, the people use it to swim, wash clothes, cars, and other household items. Varieties of plants and animals use the Mamara River as habitat.

a

b

c d

Figure 15 (a, b, c, d): Showing the freshwater flora, fauna, habitat, and ecosystem of the river.

11.0 POTENTIAL IMPACTS AND MITIGATION MEASURES

11.1 Potential impacts

Project construction and operation activities will have an impact to the marine ecosystems as follows:

1. Increase turbidity as a result of Sedimentation due to excavation and reclamation, pile driving, spoil handling and clearing and road construction and the steep topography of the project site with increase rainfall caused soil erosion in turbidity that will have a negative impact to the marine life. This impact occurs in the first phase of the project which is during gravel extraction, reclamation and back filling the site

2. Run-off from construction of water way crossings, vegetation clearing, and earthworks due to road construction affects corals as they are sensitive to turbidity and high sedimentation. Low turbidity reduces sunlight penetration to the corals that affects photosynthesis of algae in coral tissue known as Zooxanthellae (*Rogers 1990*)

   Coral communities' reef front along coast for the Mamara and Poha River will be affected by high turbidity and freshwater run-off that will reduce the penetration of sunlight through the water column. High turbidity water may attract most small fish to hide from their predators. This impact will occur during the first phase of the project plan.

3. Spills of hydrocarbons (fuels) and other potential contaminants from vehicles in operation, or oil spillage in event of any grounded vessel will impact the marine system. This impact is likely to occur in phase one, phase two which are roads, drainage building and road construction phase.

4. Increase in litter and solid waste into marine water will also degrade the water quality and negatively impact marine mammals. There is all high risk of entanglement in debris threatens marine life such as turtles and other important mammals.

   Household solid waste such as plastics, empty cans and rugged clothes will conduit through rivers into the coral reef systems. Thus, will smother the corals and as a result will kill them. Such impact will become worse during the second and the third phase.

5. Increase in Nutrient enrichment due to storm water run-off from wastewater (sewage) affects water quality. Increase in nutrients can lead to algal bloom takin hold as it dissolves oxygen which decrease DO and affects marine life. Increase in algae can reduce intake of sunlight by corals and can smother them to death (Lapointe 1997). This impact will occur and really affect the marine system during the third stage if not monitored and addressed properly

6. Direct/permanent loss to marine flora and fauna due to land reclamation and dredging should there be any. Loss of corals reefs will affect fisheries. Direct loss of corals should there be reclamation of land areas along the coast. Such impact will affect the marine system during the second phase of the project.

7. Increase in noise vibration during excavation, reclamation and construction that threatens marine and coastal biodiversity such as coastal birds, dugongs, and turtles.

8. Increase in fishing pressure.

There will be an increase in population surrounding the city as there is huge residential population in the new city and the pressure that they will have on the surrounding coastal fisheries will be huge. The already deteriorating reef system will experience greater pressure over time and will really have a negative impact to the coastal and coral reef ecosystem.

9. Invasive species

The introduction of exotic marine flora and fauna can threaten the natural communities that are present. The introduction of the marine species through ballast water has been identified globally. Introduce species could possibly compete with the local species and could alter the reef system ecology

11.2 Mitigation Measures/Management Actions

The table below discusses the potential impacts and recommends Mitigation actions or measures to address some of the potential impacts discussed above

Development Phase	Potential Impacts/Risks (respective fields) e.g. climate change or water quality	Mitigation Measures (corrective actions that can be taken to minimise or reduce impacts or risk
Development Phase 1 – Gravel Extraction and Reclamation Phase	1. Increase turbidity as a result of Sedimentation due to excavation and reclamation 2.Run-off from construction of water way crossings, vegetation clearing, and earthworks 3. Spills of hydrocarbons (fuels) and other potential contaminants from vehicles in operation, oil spillage 4. Increase in noise vibration and human activity during excavation, and reclamation, noise during construction that might chase away the coastal birds, dugongs and even any other terrestrial or coastal fauna	1. Apply standard best practise and erosion/sediment management control measures 2. Prepare Standard best practices for Erosion and sediment control. Develop water management plan for the new city. 3. Fuel, oil, and chemical handling to be undertaken in accordance with standard best practises for stockpile and runoff handling and implement spill management 4. Enforce speed limit at vicinity of new city and nearby areas. Also use soundproof materials on strategic areas to reduce noise
Development Phase 2 – Roads, Drainage and Building Construction	1.Spills of hydrocarbons (fuels) and other potential contaminants from vehicles in operation or vessels during anchorage	1 Fuel, oil, and chemical handling to be undertaken in accordance with standard best practises for stockpile and runoff handling and

	2.Increase in litter and solid waste into marine water 3. Direct/permanent loss to marine flora and fauna due to land reclamation and dredging should there be any 4. Increase in noise vibration during excavation and reclamation will have an impact on marine and coastal biodiversity 5. Introduction of invasive species through ballast water during transportation of building materials	implement spill management 2. Must have standard best practice for waste disposal and storage 3. Avoid sensitive and critical marine habitats where possible during construction phase 4. Enforce speed limit at vicinity of new city and nearby areas. Also use soundproof materials on strategic areas to reduce noise 5.Follow best practise for the water ballast management and treatment protocol
Development Phase 3 - Operational phase, Residential, commercial and Supporting Utilities	1.Spills of hydrocarbons (fuels) and other potential contaminant during the operations e.g. Waste oil/fuel from powerhouse generator etc 2. Increase in litter and solid waste into marine water 3. Increase in Nutrient enrichment due to storm water run-off from wastewater (sewage) affects water quality 4. Increase in noise vibration and human activity during excavation, reclamation, and construction that might chase away the coastal birds, dugongs, even any other terrestrial or coastal fauna	1 Fuel, oil, and chemical handling to be undertaken in accordance with standard best practises for stockpile and runoff handling and implement spill management 2. Must have standard best practice for waste disposal and storage 3. Prepare Standard best practices for Erosion and sediment control. Develop water management plan for the new city**.** 4**.** Enforce speed limit at vicinity of new city and nearby areas. Also use soundproof materials on strategic areas to reduce noise

	5. Increase in fishing pressure	5. Manage and apply restrictions measures fishing activities in different zones along the coastal area

12.0 CONCLUSION

The proposed project site marine and coastal environment has gone through years of human and natural disturbances. Thus, the Coral reef ecosystem and the coastal environment have changed, adapted, and are still adapting and coping with both the anthropogenic and natural impacts. With that, the baseline description of the characters of the existing marine fauna, aquatic environment, marine, coastal and fisheries flora and fauna was recorded. It has been observed that the marine and coastal environment is highly vulnerable, modified and highly degraded due development over the years.

The reef system just in front of the Mamara river is showing signs of resilience with good coral cover and good fish count observed. However, all fish species expected of a healthy reef have not been observed and the reef is adapting the changing conditions experienced over the years. some keystone species such calms shells and few soft corals have been observed with means that reef has potential to thrive is managed properly.

The report also identified some of the potential impacts to the marine and aquatic environment and the possible mitigation measures that will help manage the impacts to the marine and coastal environment. With those, the developer's adherence to some of the mitigation actions is crucial while in different phases of the New City development project, to avoid the potential negative impacts to the environment.

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