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AN ASSESSMENT OF WATER QUALITY AND BIODIVERSITY OF THE MATANIKO CATCHMENT, SOLOMON ISLANDS

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AN ASSESSMENT OF WATER QUALITY AND BIODIVERSITY OF THE MATANIKO CATCHMENT, SOLOMON ISLANDS

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ABBREVIATIONS

MECDM	Ministry of Environment, Climate Change, Disaster Management and Meteorology
MoFR	Ministry of Forestry and Research
MHMS	Ministry of Health and Medical Services
HCC	Honiara City Council
MLHS	Ministry of Lands, Housing and Survey
NAPA	National Adaptation Program of Action
IPCC	International Panel on Climate Change
BOM	Bureau of Meteorology, Melbourne
CSIRO	Commonwealth Scientific and Industrial Research Organisation
WWF	World Web Fund
UNESCO	United Nations Educational, Scientific and Cultural Organisation
IUCN	International
EBA	Ecosystem Based Approach
MNR	Ministry of Natural Resources
SIEA	Solomon Islands Electrics Authority
SIWA	Solomon Islands Water Authority
SOPAC	South Pacific Applied Geoscience Commission
SMEC	Snowy Mountains Engineering Corporation
HYCOS	Hydrological Cycle Observation System
m3	Cubic Meter
m3/s	Cubic seconds (or Cumecs)
EIA	Environment Impact Assessment
ESIA	Environment Social Impact Assessment
TRHDP	Tina River Hydro Development Project
WHO	World Health Organisation
ATTZ	Aquatic Terrestrial Transitional Zone
mg/l	Milligrams per Litre
pH	Power or measure of hydrogen ion concentration
DO	Dissolved Oxygen
NTU	Neophelometric Turbidity Unit
FTU	Formazin Turbidity Unit
MAL	Ministry of Agriculture and Livestock
ECD	Environment and Conservation Division

EXECUTIVE SUMMARY

This report presents the results of an assessment of water quality and biodiversity in the Mataniko River Catchment. This report is mainly focusing on literature reviews and on-site field visits and consultations with stakeholders and communities living and benefitting from goods and services of the Mataniko River. The report describes the physical environment, presents the review findings relative to water quality and ecology status of the Mataniko Catchment.

Several recommendations provide useful contributions in the preparation of Mataniko Integrated Catchment Management Plan. The ongoing monitoring of relevant parameters of water quality and other biodiversity indicators is important to ensure a robust, achievable, and measurable management plan for the Mataniko river.

Accordingly, the Mataniko River Catchment is contaminated with dangerously high levels of faecal coliforms and municipal or industrial wastes discharging into the river. The total coliform and *E. coli* levels increases downstream particularly in areas of high population density. These high readings of total coliform and *E. coli* indicates that the river system is contaminated by untreated sewage and direct fecal contamination.

Mataniko River catchment ecology is still intact at the upper catchment whilst decreases in flora and fauna composition downstream. Due to the environment being impacted by human and city expansion, more tolerable species of plants and animals are present in the mid-lower reaches. Water quality is generally poor from the upper catchment to the lower reaches. This is not good for humans due to the presence of pathogenic organisms. There is a possibility that waterborne disease such as cholera, diarrhoea, malaria, and skin diseases like scabies, will become more prevalent in the catchment soon.

Along the riverside, human settlements are expanding and growing with the unmanaged disposition wastes into the river. At the upper catchment, gardening, farming, and milling of timber is obvious and changing of landscape and the same with human settlements have been increasing. All these activities cause stress to ecosystem goods and services of the Mataniko catchment, which are diminishing relatively fast.

The report adopts the participatory approach that involve and empower communities living and benefitting from ecosystem goods and services to protect and manage the Mataniko river. The communities can also contribute by identifying strategic actions to be included in the Mataniko Integrated Management Plan. Empowering communities will use a gender and socially inclusive approach to ensure that men, women, youth, and all sectors of communities are engaged in all consultations and interventions that involve them. This will be a collaborated effort where state authorities will be leading this forward through participatory approaches.

1. INTRODUCTION

The report presents the water quality status, hydrological and ecology baseline of the Mataniko River Catchment. The baseline information is based on literature reviews and on-site fieldwork at Mataniko River Catchment.

Generally, the Mataniko river is prone to natural disasters and human encroachment and activities along the river catchment. In April 2014, strong wind and heavy rain caused the river to break its banks with flooding that result in extensive damages to properties including several deaths. The disaster had cost the government and the private sector millions of dollars. This flood is the worst ever happened to the river with rainfall data recording 481mm of rain within 48 hours, which is the highest ever recorded in the Solomon Islands. The recovery process is still underway, but disaster and environmental disasters are expected to become more common in the future due to climate change and its association with anthropogenic activities.

This report provides useful contributions in the development of the Mataniko Integrated Management Plan, which ensures the proper management and rehabilitation of the Mataniko River Catchment in respect of human rights, gender, and social structures. It is the intention of the R2R program in the Solomon Islands and the Pacific region to ensure human rights, gender and socially inclusive approaches are considered for all community engagements, which includes the Mataniko River Catchment watershed communities.

1.1 Mataniko River Catchment vicinity

Mataniko Catchment stretches from *Mamana Water* (Renlau) Community and Lord Howe Settlement at the coast and extends inland Northwest into the Guadalcanal Mountain range measuring a total length of approximately 15-20km^2 and covers a total area of 25,704 ha. The Mataniko River Catchment includes the residential areas, village settlements, business facilities within China Town.

Lowland, ridge top forest type, and riparian plants are distributed randomly along the riverbanks in the upper Mataniko River catchment. There is distinctive vegetation along the catchment's river banks, steep gorges, and ridge tops connecting to the upper grasslands. Tall trees which make up the top canopy layers, only reach a height of about 20 meters. Medium size trees, shrubs, herbs ferns, and orchids are among the many plant types found. Due to this ecosystem, vertebrate assemblage is relatively rich.

Solid wastes originating from human settlements along the river, residential areas and shops operating and living adjacent to the river have polluted the river heavily. During flooding, most of this waste ended up in the Honiara seafront causing a nuisance to the coastal resident and foreshore developments.

1.2 Terms of Reference

This review was made possible by the SPC/GEF International Waters Ridge to Reef (R2R) Project in the Solomon Islands in collaboration with the Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM) and various international, regional, and local stakeholders.

The focus of the International Water Ridge to Reef (IW R2R) is on reducing environmental stress by improving and strengthening governance for watershed catchment management and sustainable land use. The IW SI R2R commissioned the Ecological Solution Solomon Islands (ESSI) to prepare the Mataniko Integrated Management Plan, which includes preparing of several technical reviews and reports covering water quality assessment, diagnostic analysis and ecosystem goods and services valuation. The ESSI carried these tasks by initiating a planning exercise involving desktop review of available literatures, and public knowledge through research and stakeholder consultation.

This review builds on the policy planning initiative to understand the Water Quality and Ecological State of the Mataniko River Catchment that will contribute to the development of a robust and integrated management plan. A team was selected to assess and provide dialogue, review, and develop a management plan for the management and rehabilitation of Mataniko River Catchment.

2. STUDY APPROACH

The objective of this report is to assess the status of the Mataniko River Catchment environmental conditions and to provide a basis for evaluating environmental impacts and mitigation related instruments that will help rehabilitate the Mataniko River Catchment.

2.1 Objective of this review

This report is to ensure that a robust management plan is set for the rehabilitation and management of Mataniko River Catchment in relation to the plans imposed and implemented by the Honiara City Council (HCC), the Ministry of Health and Medical Services (MHMS), the Ministry of Lands, Housing and Survey (MLHS) and the Ministry of Forestry and Research (MoFR) and other stakeholders.

This review focuses on the following:

- Describing the physical environment of the Mataniko River Catchment
- Water Quality and ecological conditions of Mataniko River Catchment
- Formulating recommendations for the development of a management plan for the rehabilitation of Mataniko River Catchment.

2.2 Surface Water baseline field review

The surface water quality of Mataniko Catchment involves the work done by consultants in 2018 and progressive monitoring results by the MECDM. These tests are mainly on the following:

- *E.coli* and Coliform bacteria
- Heavy Metal
- Cation
- Anion (Chlorine, Sulphate and Alkalinity)
- Nutrients: Phosphorus (P), nitrate (NO3-N) and Ammonium Nitrate (NH4-P)
- Physical parameters: Temperature, pH, Oxygen reduction potential, Dissolved Oxygen, conductivity, turbidity, Total dissolved solids, and salinity.

2.3 The Ecological Assessment

The ecological assessment review involves looking at past and present reports defining the state of the freshwater biodiversity in the area. This includes the report produced by Telios Cooperate Consultancy Services in 2018.

This review will be focusing on:

- Describing the physical environment of the area which will includes the different types of vegetation, climate, geology, demography, and economics and, land and river use.
- The Freshwater biodiversity flora and fauna; and
- The Terrestrial flora and fauna

3. EXISTING ENVIRONMENTAL VALUE IN THE AREA

3.1 Sites monitored in 2019 by the MECDM

Figure 1 clearly depicts the sites observed and sampled by MECDM in 2019 and need to continue monitoring annually. Trends of improvements or worsening help inform policy decisions on the impact of policy interventions particularly those set out in the Mataniko Integrated Management Plan. The consistency of using the same sites provide for more useful comparison spatio-temporally.

Figure 1 shows the sites observed and sampled in 2019 by the MECDM

3.2 Physical Environment

3.2.1 Topography, Soil and Geology of Mataniko River Catchment

Guadalcanal Island is about 150 km in length, about 45 km wide and approximately 6,000 km^2 in area, where the central rugged range of high peaks and deep valleys from the east to west direction along the southern section of the island which accounts for majority of island's north coastal plain drainage of rivers with smaller drainage systems to the south (Hansel et al., 1976). High peaks in the central range of Guadalcanal's Island includes Mt. Popomaneseu (2,310m) and Mt. Tanareirei as the highest peak of the island.

3.2.2. The Geology of "Naghoniara[1]" or Honiara

Honiara comprises of quaternary, calcareous sediments overlayered with sandstone and conglomerates of late tertiary at the upper Lungga beds. Generally, throughout the sequence, pure limestone, and coralline limestone (former fringing reefs) commonly occupy the outer edge of these terraces with calcareous sandstones and coarser lagoonal deposits on the inland margins (Hansel et al., 1976).

[1] A Guadalcanal dialect for the region that faces the wind. It is later pronounced as Honiara.

Due to the built-up, progressive coalescing of clays and coarse gravels from inland mountains, the alluvial plains expand northwards causing rivers to move and bifurcating within their main deltas. This is typical for Lungga and Mataniko Rivers. Such rivers contain gravel beds within their channels consisting of 70% volcanic materials and 30% limestone materials.

The formation has been exposed, warped, and eroded into three or four terraces. Three major terraces in Honiara includes Vavae, Mt Austin and Barana terraces which are covered by grass with populated residential areas in their valleys. These areas are also prime sites for subsistence farming due to soil formation and fertility. This causes drastic erosion and runoffs draining down these ridges, however, they are blocked by the developments creating back swamp areas, for example, the King George areas and Burns Creek.

The fragility of these areas influenced by anthropogenic activities and associated with natural shifts of the geomorphology of rivers had caused improved fertility and production of root crops such as cassava, potatoes, and cabbages. The crops support residents of Honiara and surrounding communities into cash economy permitting an increase of farming and production. The rich nutrient erodes and seeps into the gales, through the streams and rivers and eventually to the Honiara coastline.

3.3 Climate Condition

Guadalcanal has a tropical climate but varies over altitude. Seasonally prevailing winds exists with the dry and wet season of the Solomon Islands. Southeast trade winds occur on drier season between May and October and northeast winds during the wet season between January and March where tropical depression and cyclones can be felt also. According to the report by the Institute of Hydrology (1993), it states that more rain occurs in the south or at the weather coast side than on the northern side with an average rainfall of 5,000mm/year.

In terms of natural disasters, Guadalcanal is prone to tropical cyclones associated with heavy rains and flooding. One of the latest phenomena was the April 2014 flooding which left a trail of loss and destruction across the country: damages to infrastructure, homes and even deaths. This event suggests possible detrimental floods in the future, and it is essential to develop plans to address and mitigate the growing concern concerning natural disasters.

According to the National Adaptation Program of Action (NAPA), surface air temperatures in Auki from 1962 through to 2007 and Henderson Field from 1975 to 2006 showed a significant increase of 1^0C during these periods.

By adopting the International Panel on Climate Change (IPCC) global assessment the following changes will be expected.

- Due to the thermal expansion of the ocean, sea level is expected to rise by 18 cm to 59 cm by 2100
- There will be more frequent warm swells, heat waves and heavy rainfalls with confidence level of greater than 66%
- There will be an increase in droughts, tropical cyclone, extreme high tides, and storm surges with confidence level of greater than 66%

Tropical cyclone in the Solomon Islands is typically between November and April. In the period from 1969 to 2010, 42 tropical cyclones passed within 400km of Honiara (BOM and CSIRO, 2011).

3.4 Terrestrial Biodiversity

3.4.1 Flora

Various published works like Hancock and Henderson (1988), WWF (2005), and McClatchey et al (2005) have put the Solomon Islands archipelago floral species between 4500-5000 species. One of the renowned publications by Hancock and Henderson (1988) identifies about 3,210 species of vascular plants belonging to 205 plant families, however, with recent research this is increasing. UNESCO (2008) mention that 50% of palm and orchid species and 75% of climbing pandanus species are endemic to the Solomon Islands.

The Solomon Islands has been enlisted within the top 200 eco-region in the Pacific given the structural and species compositions similarities over the region. The IUCN (1993) Environmental synopsis mentions that over 60 commercial species identified within larger islands rainforest where 12 common species comprised forming the upper canopy of lowland rainforest. This includes *Callophylum kajeweskii, C.vitensis, Campnosperma brevipetiolata, Dillenia samomonesis, Elasocarpus shaericus, Endospermum medullosum, Gmelina moluccana, Maranthes corymbosa, Parinari salomonensis, Pometia pinnata,Schizomeria serrate* and *Terminalia calamansanai.* According to EBA status, based on the high levels of endemism, at least seven endemic genera and 90 endemic species and these includes animals and plants which are found only in the Solomon Islands.

Guadalcanal Islands is one of the largest low-lying island groups in the Solomon Islands where its eastern part is linked by chains of mountains that elongates to the southern side of the island. This had influenced the distribution and occurrence of unique complex layers of vegetation type from the mountainous regions, valleys and gullies beside rivers and streams, plains, and coastal regions.

Vegetation types in Guadalcanal Islands include:

i. Low land primary tropical vegetation forest which consists of trees commonly associated with climbers and epiphytes up to 45 meters in height. This vegetation increases into the montane forest.

ii. Secondary forest where the forest is being disturbed either naturally or by humans induced clearing for gardening and farming. This area is characterized by thick shrubs, ferns, and vines.

iii. Montane forest is found on an elevation of 1000 meters above sea level which is associated with the cloudy forest with a lower canopy of 6-12 meters and characterized by stunted growth trees draped with ferns and mosses.

iv. Open heath with ferns and shrubs and a few species trees where this vegetation is associated with ultramafic rocks.

v. Grass-covered areas are mainly visible on the plains and the northern foot of hills from Mt. Austin, Poha ridges at the west of the Honiara. The grassland is burned frequently and grows back over time. It is one of the few places where you can study the regeneration and succession of this vegetation type.

3.4.2 Fauna

The Solomon Islands fauna is remarkable with some island groups showing visible continuous evolution of certain species. It is obvious by studies that there is a form of islands linkage from the Northeast down to the southwest of the Solomon Islands and these islands include San Cristobal (Markira Islands), Guadalcanal, New Georgia and the western Solomon's that shows significance of endemism of species occurrence.

Rats, bats, and opossums make up the remainder of the mammal diversity, with a large number distributed and mobile in a wide range of areas. As recorded, there are 34 species of bats which 19 are endemic and, 3 are critically endangered namely Spechts mosaic tailed rat (*Melomys specti*), Poncelet's giant rats (*Solomys ponceleti*) and Emperor rat (*Uromys imperator*).

Birds are well studied in the Solomon Islands. According to International BirdLife (2014), the Solomon Islands have the highest number of restricted bird species than any other birds inhabiting the lowland forest and low montane region below 1,500 meters above sea level.

The studied area from the 2018 study recorded 67 species which is derived from 28 families of birds found occurring at low-land and beside rivers and streams. According to the study, if it reaches the high elevations of mountainous regions, it is likely to discover new species.

As stated by Adler et al. (1995), 34 species of skinks in the Solomon Islands, of which 10 were believed to derive from continental and 5 from within the Pacific and 19 are endemic to the Solomon Islands. Shenomorphus skink genus has 9 endemics species while the Corcia genus is endemic.

There are 9 families of reptiles found in the Guadalcanal Islands, Agamidae, Gekkonidae, Scincidae, Varanidae, Typholophidae, Boidae, Acrochordidae, Colubdridae and Elapidae (McCoy (2006)).

Snakes have two endemic genus Loveridgelaps which is found only in the Solomon Islands and the Solomonenlaps which is endemic to Bougainville and Solomon Islands. Saltwater crocodiles (*Crocodylus porosus*) are widespread throughout the islands.

As of 2008, the number of amphibian species had increased to 21 species but with other studies lately, the number is expected to increase following expeditions into the high elevated areas of montane forests. Insects and snails are the least researched group of organisms although a recent study report by Marinov and Pikacha (2013) states 64 species of dragonfly in the Solomon Islands where 6 were endemic. Land snails account for over 100 species of the families Placostylidaey, Camaenidae and Trochomorphidae. Insects are estimated to have reached almost 50,000 species of which 130 species of butterflies (which may include bird-wing butterfly) of which 35 species are endemic.

Aquatic fauna survey team member in Ngoti stream carrying hand net

3.5 Freshwater Biodiversity

3.5.1 Hydrology of Mataniko River Catchment

There were six reports in relevance been studied for Guadalcanal Province in the years since 1988 till recently 2009. The reports include:

- Asian Development Bank (1988). Komarindi Hydropower Project. Draft Report. Prepared by Tonkin and Taylor International Limited
- Institute of Hydrology (1993). An Investigation into the relationships between altitude and rainfall on Guadalcanal, the Solomon Islands, Report No. 93/10.
- Government of Solomon Islands MNR (1999). Lunga Hydroelectric Project Consolidation Report. Prepared by SMEC Developments Australia Pty Limited.
- Japan International Cooperation Agency (2001). Master Plan Study Power Development in Solomon Islands, Final Report for MNR and SIEA Solomon Islands.
- Hydro Tasmania Consulting (2007). Solomon Islands Sustainable Energy Project Hydropower Component Final Report, Report No. 202438-01
- Pacific Hycos, SOPAC (2009). HYCOS Mission Report to Solomon Islands, 27th October to 3rd November 2009. Pacific Islands Applied Geoscience Commission.

The report shows that rainfall is linked to altitude, affecting the mid to lower reaches of river sections, which shifts over time during and after heavy rains. Thus, rivers and streams depend on the hydro-cycle due to elevation or topography, catchment area and terrain.

The Guadalcanal Rivers apparently, descends to the coastal plains in a north-easterly direction following a fault fracture in the upper sections which are typically steep and torrential. Rivers in the coastal plains form a meandering pattern with channel banks that decrease in height as it approaches the coast causing damage to roads and bridge infrastructure.

River discharges are higher during wet seasons and lower during dry seasons. River flows start to increase in October, peaking from December to March (Solomon Islands' cyclone period) and remaining visible until May. In general, low flow below $29m^3/s$ can occur at any time of year, with the lowest being less than $5m^3/s$ in August where Mataniko River is of such kind.

In the case of some rivers on Guadalcanal Island, such as the Poha River, extreme seasons in 2014 exposed 99.5% of the river's dry. Rivers and streams dry p during these dry seasons, however, there were no sediment profiling done in Guadalcanal to map the effect of sediment with dry seas and dry seasons.

3.5.2. Freshwater biodiversity of Solomon Islands notably Guadalcanal

Unlike the terrestrial and marine ecology studies, few freshwater ecologies and freshwater fish studies have been conducted in the Solomon Islands. The first published work on freshwater in the Solomon Islands was by Gray (1974) on the Guadalcanal brackish waters. Later, studies were conducted for the Environment Social Impact Assessment (ESIA) of two of the Solomon Islands Government (SIG) National Projects; the Gold Ridge Area, Central Guadalcanal mining development Project and the Tina River Hydro Development Project (TRHDP). These occurred in 1990, 1995, 2003 and 2006, Tina River System by Entura in 2010 and the TRHDP ESIA report in 2015 and 2017.

In 2011 an expedition was conducted at the Kovi-Kongolai catchment and biodiversity funded by the Keidanren Nature Conservation Fund through the IUCN Oceania Regional Office. The catchment defines the limestone landscape in North Guadalcanal notably Mt Austen area, Kongolai and Mataniko River Catchment. Boseto (2011) stated that only 1% of the 47 species found on Guadalcanal were recorded.

Other recent studies involve assessing Guadalcanal mountainous region in 2015 for the headwater catchments of Tina River/Naglimbiu River. In 2016, an extraordinary study at Gold Ridge, Central Guadalcanal, was published as baseline to this work, which was followed by a rapid survey of the Mataniko River Catchment in 2018.

(Polhemus *et al* (2008) and Gray (1974) have updated record of 47 fish species from 39 genera and 23 families found on Guadalcanal Island which represents 70% of all freshwater fish species found in the Solomon Islands. The majority (46.8%) of Guadalcanal fish species are edible to the local community and can be found at elevations of 30-200 meters above sea level (masl) .

Some rapid surveys were conducted in some of the major islands in the Solomons such as West Baoro, in Makira Island, Tetepare Island's freshwater system in the Western Islands, Choiseul, and Mt Maetambe.

According to these studies, there are 138 freshwater native species in the Solomon Islands from 61 genera and 30 families. Three introduced species; *Oreochromis mossambicus* (Freshwater Tilapia)*, Gambusia affinis* (Mosquito fish), *Gambusia holbrooki* (Guppies) from two families (Cichlidae and Poeciliidae) were found in the Solomon Islands. Two endemic fish species were also recorded from the genus *Lentipes* which was described and documented by Polhemus *et al* (2008) and Jenkins *et al* (2008). A second endemic species of genus *Lentipes* was documented in the headwaters of the Tina River, Guadalcanal Island, and Choisel (Kolobangara Island) in 2015. It was later described and published in 2016.

Freshwater systems in the Solomon Islands are commonly dominated by Gobiidae fishes (Jenkins and Boseto, (2007) and Polhemus *et al* (2008)). This family comprises over 1600 species throughout the Indo-Pacific, Africa, Asia, and Americas (Berra (2001) and Nelson (2006). This family of fishes is also the most structurally diverse and numerically abundant (Miller (1986)), inhabiting a wide range of habitats in both marine and freshwater systems. Gobiidae fish species are cryptic and benthic, burrowing in soft mud, coral reef crevices, seagrass beds, mangroves, rapid waters, and above high waterfalls (Ryan (1991), Nelson et al (1997) and Marquest & Mary (1999)).

The Sicydiinae, a sub-family of the Gobiidae is common in tropical island streams due to their amphidromous life history (Kieth (2003, Keith & Lord (2011)). Adult gobies live and breed in freshwater, laying eggs on the underside of rocks in the upper reaches of rivers and streams where the larvae are later hatched and transported by high flows to the ocean to live as pelagic/oceanic marine larvae before returning to freshwater to complete their cycles (McDowall (1993) and Keith (2003). The duration of the oceanic phase varies among species and seasons (Bell et al (1995).

3.5.3 Types of freshwater habitat

There are 5 main habitats in the Mataniko River Catchment by which fish depends for survival, in terms of feeding, spawning, security and home.

1. Pools (>2m depth) where oxygen high with nutrients, high light exposure, rich with micro-crustaceans (decapods) and migration took place for smaller fish of the species*; Khulia sp, Mesoprestis sp, Anguilla marmorata, Mugil sp.*
2. Under boulders, cobbles and pebbles creates a micro-habitat for the "sucker" fish. This area varies in depth from 0.5 to 1.5 meters. Nutrient level is relatively high plus place for security. Fish common in this area includes *Sicyopterus sp*, *Macrobrachium sp*, prawns and shrimps and freshwater crabs.
3. Running and riffle areas were shallow with depths less than 1.5 to 0.2 meters. Velocity increase from 1.5 to 3 m/s in some areas. Temperature changes due to the degree of exposure to sunlight and vegetation coverage. Most species are of the Gobiidae/Sycniidae families of *Sicyopterus sp*, *Rhyacichthys aspro* and *Stiphodon sp*.
4. Stream confluence where most of exchange and mixing of nutrients from the land or gullies happened. This area is rich in nutrients and dissolved oxygen due to the terrestrial and network of streams. Most fish found in this area includes *Stiphodon sp*, *Sicyopterus sp*, *Khulia sp*, *Anguilla marmorata* and *Sicyopus sp*. Streams confluence increases upstream due to the stiffness, gorges and slopes increases upstream.
5. Aquatic Terrestrial Transition Zone (ATTZ) is the plain area that buffers the terrestrial and aquatic environment. This area is rich in nutrients and oxygen and is dominated by micro-crustaceans (decapods, prawns, and shrimps). Tree frogs, tadpoles, spiders, fish juveniles of gobies are present. In gorge areas ATTZ is absent.

The areas described above defines the types of areas that make Mataniko River Catchment unique to in its ability to inhabit a wide range of biodiversity. These habitats were equally distributed from upper reaches, mid-reaches to the lower reaches eventually to the coastline of the river. The upper catchment is conducive for spawning of the Gobiidae/Synciidae fish species.

The threat to these areas is the increasing encroaching of human settlements, wastes disposition and activities that will reshape the natural ecosystem of the area. If the river connectivity is disturbed by reclamation or river developments, it could result in a lack of diversity among fish species.

3.5.4 River use

Lack of management measures, high population density and loss of river pools due to upper catchment clearance and milling practices have led to the depletion of all rivers edible fish and plant species. It was revealed on the survey in 2018 that only juvenile specimens were noticed, and informants all agreed that this had been the trend for the past 30 years.

Almost of the residents and informants agree that the river was used for washing clothes by women and girls and that the river was also used for bathing and recreation at times.

Most women and children can participate in hunting for fish at the mid to lower reaches of the river, thus their use of the river for laundry and other purposes has an impact on fishing. At the Lord Howe settlement, local fishermen confirm that during nighttime diving is common especially at the lower reaches (brackish water) of the river. Trevally, Mackerel and Chubs were among the fish targeted.

Bed nets and gill nets were used at the mid to the lower reaches of Mataniko River. Bed nets were used during post-larvae migration of gobies upstream at the coastline. These post-larvae are caught and sold in most cases.

Poisonous substances used for malaria control and widely used by farmers as pesticides are used for catching fish. A massive catch is expected when a milliliter of such substances is used. Catches include fish and crustaceans (such as prawns and shrimps). As the number of catches decreases, such extensive methods will be obvious throughout the catchment. It was noted that those involved are mainly mid-youths who have learned from their parents.

It is notable that extensive reliance on the river for multiple uses has caused a considerate effect on the localized biotic carry capacity of the river. Given the many different uses and reliance on the river system for fish, the introduction of fishery management requires a wider consultation and collaboration from all levels of the community and sectors, business houses, and individuals regardless of gender, age, social position, ethnicity, and background.

3.6 Waste management system

3.6.1 Mode of occurrence of waste in Mataniko River Catchment

The uncontrolled, unmanaged, and unregulated expansion of human encroachment into areas in Honiara had put pressure on state authorities to deliver services. One of which is waste management services. Waste management in the Mataniko River Catchment is highly common due to human settlements, residential areas, state infrastructures, and business facilities or centers. Waste management intervention to target all sectors and members of the community is paramount to ensure effectiveness and commitment in managing waste in Mataniko River Catchment.

According to the Mataniko Environment Baseline Report (2018), it depicts that majority of wastes were mainly solid waste due to unsatisfactory disposal methods and approaches. The study does not capture organic waste from decaying leaves assuming that land use activities at the upper catchment including subsistence farming might exacerbate their occurrence.

Rubbish dump on coastline at Kukum

Generally, wastes increase towards the coast and is factored with the wet and dry season in the country.

In 1990 a waste characterization was conducted by Sinclair Knight Mez (SKM) purposely to establish mechanisms, approaches, and methods to tackle the alarming rate of waste in Honiara City. The report highlights the following:

- Plastic waste or solid wastes is high
- Only a few returnable bottles reach landfills due to the recycling scheme at that time was working
- Aluminum was collected for recycling before it can be collected to reach the landfill
- Metals a seen to till reach landfill
- Organic wastes or biodegradable materials is very high at 65% of total wastes to the landfill

The report showed a waste generation rate of 0.62 kilograms per person per day. With the population of 48,000 at the time, the total waste generated annually would be over 10,862 tons.

Another study was conducted by Dr Melchior Mataki as part of his PhD dissertation focusing on the Honiara Central Market and household waste. The study shows a relatively but significant result that a person waste generation rate per day is 0.87 kilograms in urban areas.

So, for a total population of 64,600 people at that time, total waste generation would be 20,516 tons annually. This shows that in just 20 years, the amount of waste in Honiara has increased by threefold.

In the same year (2011), the Honiara City Council (HCC) also conducted another waste characterization study reporting a waste generation rate of 0.86 kilograms per person per day which annually equivalence to generating as 20,277 tons/year.

The studies all show that the largest proportion and component of waste is organic or biodegradable waste. The response to this is the development of the Solomon Islands National Waste Management and Pollution Control Strategy 2017-2026, which ensures a whole country-driven and –owned approach to address, manage and control waste from the source.

3.6.2 Sources of wastes

Most wastes were mainly from municipal and animal/human sources triggered by irresponsible behaviors and attitudes within the communities. One of the main issues is the lack of knowledge about waste management with respect to the aquatic/marine environment as a habitat that can support lives as well. Municipal wastes are increasing at an alarming rate downstream which requires state policy planning and legislative enforcement in collaboration with the community.

Sewages in the rivers were from untreated and direct discharge sewage into the Mataniko River. The construction of comfort rooms, pig and chicken fences over riverbanks has resulted in an increase in bacteria and water-borne diseases in the river system. Most settlers and landowners have no access to toilets thus the river is used as toilets. Foreign products including plastic bags were common in the river and were believed to be from the Chinese shops in Honiara.

3.7 Water quality review since 2018

Water quality is a significant determinant of health for humans. It is critical for management or decision-making purposes to use the water quality indicators or parameters mentioned in this section as a measure of fit or unfit for human exposure. This includes the chemical, physical, biological, and radiological characteristics of water. The quality of surface water varies greatly depending on the environment, ecosystem, and human uses. The WHO standards are used as a comparison point in the Solomon Islands' water quality standards. The ToR was used to review and use the Water Quality parameters in the report.

3.7.1 E coli and Coliform bacteria

Due to humans accessing the Mataniko River Catchment for swimming, recreational, fishing, transport and food and water, it is crucial to prevent diseases and infection. A key indicator is to test for the bacteriological quality of the water for traces of *Escherichia Coli* (*E. Coli*) levels. *E.Coli* is a dominant bacterial organism in animals and especially in human faeces. (Steblin (2007)). *E. coli* indicates the presences of pathogens in the water column that is poses risk to human health. Total coliforms are also an indicator of pathogens that can cause acute and chronic health effects.

According to the World Health Organization (WHO) Guidelines for Drinking Water Quality (4^{th} Edition), the levels for safe drinking water is 0/100ml and 200MPN/100ml for water used for recreational purposes. Thus, as expected, *E.coli* and total coliforms are high due to human activities, wastes and untreated sewage.

The reports obtain for this review indicates that the Mataniko River Catchment total coliform and *E.coli* increases downstream although there are high indicated levels of these parameter. These high readings of total coliform and *E.coli* indicates that the river system is contaminated by untreated sewage and direct fecal contamination.

3.7.2 Heavy Metals

Heavy metal natural constituent of the environment but presents in traces or small amounts, however, several metals originate from anthropogenic sources due to increasing mechanical technologies and sourced metal materials as a result of industrial activities or unmitigated attitudes of humans to expose or dispose of such metal sourced wastes. When detected it is difficult to remove from the environment. Long-term exposure to heavy metals may lead to carcinogenic acute and chronic health effects.

Weathering of sedimentary deposits derived from volcanic rocks on Mataniko River Catchment may source heavy metals like Arsenic and Chromium. With the increasing trend of human settlements along the Mataniko River Catchment, the possibility of domestic and industrial effluents which finding their way into the river contributing to the water column pollutants is increasing.

During the tests for Cadmium, Chromium, Lead and Mercury in 2018, studies showed that concentrations were found to be below the detection limits. Other trace such as Copper, which is found in the upper reaches, indicate their natural occurrence. Other trace metals indicate the disposition of sourced heavy metals into the river especially mid to downstream and to the coast from various activities and developments

3.7.3 Cat-ions

The measure of the water's ability to react with soap, leaving deposits of precipitate white foams above water, is known as water hardness. Hard water needs a considerable amount of soap to produce lather caused by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cat-ions, other cat-ions that includes; aluminum, barium, iron, manganese, strontium, and zinc.

Cat-ion is expressed as milligrams of calcium carbonate per liter. Calcium Carbonate concentration below 60milligrams per liter (mg/l) is considered soft water, 60-120mg/l moderately hard, 120-180mg/l as hard and more than 180mg/l as very hard (WHO (2011b)). Sources of Calcium and Magnesium in Mataniko River Catchment would be from sedimentary rocks namely limestone, seepage, and runoffs from soil.

Potassium-based water softeners are common to remove minerals such as calcium and magnesium ions from hard water to replace them with potassium and sodium ions. Potassium is an essential element in animals and plants for their tissues. Potassium and Sodium can cause health effects that are susceptible to animals but are not harmful if consumed. Sodium is commonly leached from the terrestrial environment to groundwater and surface water (WHO 2011a). Sewage effluents due to unmanaged treatment facilities can source sodium and potassium into the river.

3.7.4 Anions (Chlorine, Sulphate and Alkalinity)

Chlorine is used as disinfectants and bleach for domestic and industrial purposes and used for water treatment as disinfect drinking water to control bacteria levels. By reacting with water, it produces hypochlorous acid and hypochlorite. According to WHO guideline, the level considered for safe drinking water is 5mg/l.

Sulphate is discharged into water columns from industrial wastes and through atmospheric deposition. Most sulphate occurs in groundwater and from natural sources, and if ingested at higher levels/concentrations may result in gastrointestinal effects (WHO (2011a)).

Alkalinity is determined by the geological composition of soil and bedrock that water passes through. Carbonate, bicarbonate, and hydroxide compounds are sources of natural alkalinity. This parameter is important to aquatic life because it creates buffers against rapid pH shifts. High alkalinity means the water column is acidified and may be harmful to aquatic life. (WHO (2011a))

Chloride has a higher indication near to the coastline or estuary although it varies, thus associated with residential expansion and settlements. Unlike the upper catchment, chloride indication is relatively low. Higher chloride indicates pollution.

As sulphate is associated with the saltwater environment, the results obtained in 2018 had confirmed higher levels at and near the coastline. From mid-reach to the upper catchment, sulphate levels were below the WHO standard 500mg/l. Sulphate levels in the Mataniko River Catchment is influenced by iron-rich sedimentary layers in the upper catchment gorge.

According to this review, the Mataniko River Catchment alkalinity level is higher in most areas sampled. The Mataniko River's tendency to neutralize acidity increases downstream, and is influenced by rocks, soil, salts, certain plants, and wastewater discharges from settlements along the river catchment (Mataniko Environment Baseline Report (2018)) and (MECDM. (2019)). Alkalinity levels are also affected by saltwater intrusion and sediment composition.

3.7.5 Nutrients - Nitrogen, Nitrate and Nitrite as Nitrogen

Due to the natural occurrence of the nitrogen species in the Mataniko River catchment, soil fertility for farming cannot be disputed, but they are present in reduced form as a result of microbial reduction of nitrate.

The clearance of vegetation causes nitrates to seep into surface water as runoffs and also peculates into groundwater. The recommended value for Nitrate is 50mg/l (11mg/l as nitrate-nitrogen). The nitrate recommended value can change rapidly due to surface runoffs of fertilizers, uptake by phytoplankton and de-nitrification by bacteria. Nitrate and Nitrite are expected to be low on the upper reaches of Mataniko River Catchment due to less microbial reduction activity. Unlike in the densely populated areas downstream, one would expect higher levels of Nitrate and Nitrite due to waste water disposal and seepages from sceptic tanks from the urban areas.

3.7.6 Total Phosphorus

This parameter is an essential nutrient for all living organisms and plays a significant role in biological metabolism. Phosphorus is the least abundant, common nutrient that limits biological productivity. Water bodies of low phosphorus support diverse and abundant aquatic life. High phosphorus concentration adversely affects aquatic ecosystems.

Phosphorus occurs in three forms in aquatic systems namely, inorganic phosphorus, particular organic phosphorus and dissolved (soluble) organic phosphorus. Total phosphorus concentration ranges between 0.01mg/l-0.05mg/l in non-populated water (WHO (2011a)). A significant elevation of total phosphorus may result in algal productivity (algal bloom), rapid plant growth and low dissolved oxygen from the additional decomposition of plant materials in water bodies.

Running surface water consisting of organic matter or bogs can exhibit high total phosphorus concentrations. Unlike low turbulence lakes or rivers, the higher concentration of total phosphorus is associated with sediments and sinks to the bottom. (Canadian Water Quality Guidelines (2004)).

Surface water rich in organic matter or bogs tends to exhibit high total phosphorus concentrations. In lakes or areas of low turbulence in rivers, sediments tend to contain much higher concentrations of total phosphorus. (Canadian Water Quality Guidelines, 2004).

3.7.7 Physical parameters: Temperature, pH, Dissolved Oxygen (DO), conductivity, turbidity, Total dissolved solids, and salinity.

Temperature

The temperature of a water body or column is a property of water that indicates how cold or hot it is. It also defines the movement of molecules in the water body. It is then an important water quality monitoring and assessment indicator for the quality of life in a water body or water column. (Brett (2014)). It also defines the level of toxic substances in the river or water column.

The normal water temperature for a river range between 25^{0}C to 27^{0}C at daytime and 5^{0}C to 3^{0}C during cold nights as it supports life both on land and in water.

Temperature increases downstream, however, they are within the range possible to support lives.

pH

pH is an important water quality monitoring parameter showing the acidity and alkalinity of any water body or river. It is the measure of hydrogen ion (H+) in a sample. The pH scale ranges from 0 to 14, and water is normally at pH 7 which is considered as neutral in this case. Above 7, it is alkaline/ basicity and below 7, it is acidic.

The pH tolerance for aquatic life ranges from 6.5 to 9.0, and drinking water ranges from 6.0 to 8.5, with pH levels outside of these ranges being considered harmful to both aquatic and human lives. (Environmental (2014). At pH 5.5 in Bangladesh mass aquatic species died due to pollutants. (Chandan (2013)).

According to recent studies by the MECDM in 2019, the pH trend decreases downstream towards the coastline. This is due to the high concentration of nutrients and organic wastes within and beside the riverbanks. Since there are more solutes in the water column, this can result in higher conductivity and salinity. However, these values are still within the safe range for a healthy aquatic ecosystem.

Further down the Mataniko River, sewage and diffused wastes from Solomon water's outfall and piggery farms polluted the river. All the diffused wastes transported from upper catchment settles in pools along the meadow areas.

Conductivity

This parameter is the measure of anions and cat-ions' ability to conduct electricity within the river. Conductivity is influenced by temperature, water body, surrounding soil and presence of dissolved solids that consist chemical formula of C Cl-, SO42-, NO3-, PO43- or Na+, Mg2+, Ca2+, Fe2+, Al3+. (MECDM. (2019))

High level readings indicate major discharges or other sources of inorganic dissolved solids in the river. Conductivity within the Mataniko River was noticed to increase at the upper catchment and slight decrease in the mid reaches before escalating more than 5 times the upper catchment. This review found that at the upper catchment, there is more human activities and concertation of human population at the lower reaches of the river considering China Town. At mid reaches it is quite shallow and still water where some solutes might sink to the substrate. The increase in conductivity in relation to concentration of human population and associated increase in human activities.

Dissolved Oxygen (DO)

Dissolved Oxygen is a naturally occurring parameter important for aquatic life made possible by the photosynthesis process. The maximum level of DO that can support aquatic life would be 110%, and any higher would trigger stress on aquatic organisms. The minimum level of DO within a water body is 5.5mg/l and anything less would stress aquatic organisms as well. For lethal treatment inhibiting DO will result in fish or aquatic organisms getting killed. At 0%, aquatic flora will increase in growth and dominance (MECDM. (2019)).

The average value for DO calculate for the Mataniko River water quality was 95.95% and most of values recorded falls above the average range. The average DO result is within the safe range to support any aquatic organisms. Thus, the low DO values being obtained in sites downstream closes to the river mouth, indicates high organic and inorganic waste pollution and less pollution in the upper stream river.

Turbidity

This parameter reflects the clarity of water or measure light penetrating the water medium measured by infrared light with the unit FNU or NTU. Turbidity is influenced by the high number of suspended solids entering the water column thus changing the water colour. As a result, heat can be absorbed by the suspended solids, which is then detected in the water column.

Turbidity according to studies and monitoring by MECDM decreases from the upper catchment and increases in from the mid to the lower reaches. Following the SIWA sewage treatment, the turbidity is generally poor due to nutrients, wastes and mucky mud from surrounding sites and residents and business houses. The readings are above 10NTU, compared to 1NTU in the upper catchment, which is colourless and has fewer substances suspended in the water column.

Honiara Coastal Water Qualitymonthly monitoring carriedout by the Solomon Islands R2R Team.

4. DISCUSSION

4.1 General Observation and trend

4.1.1 Ecology of Mataniko River Catchment

The upper catchment of Mataniko River is dominated by riparian plants distributed along the riverbanks and flood plains. Canopy layers reach over 20 meters in height with several plant types from medium-size trees, shrubs, herbs, ferns and orchids undergrowth and symbiotic plants that attach to their host trees (epiphytic plants). The two distinctive vegetation for Mataniko River Catchment were riparian vegetation and the ridge-top/grassland vegetation where their compositions, structure, distribution, altitudinal range, and sociability (plant association) differ from each other.

There is a growing concern over the relationships between native plant species and invasive or exotic plant species introduced in the sixties. With the rise of the texture industry, the Barana region, in Mt Austen (part of Mataniko River Catchment), was used as a research field area where the plants were quarantined for purpose of converting into commercializing products.

The plants include the rain tree, kapok tree, African tulip, paper mulberry tree and others. The plants eventually spread into the wild thus, changing the natural composition and structures of the vegetation. These trees are distributed by birds, animals and winds and their roots. To date, these trees are seen in the wild as well as in the communities.

The freshwater ecology at the upper catchment is still intact but threatened with anthropogenic activities which impact aquatic lives due to shifts in water quality. This has also changed the composition, abundance, and structure of aquatic organisms in the Mataniko River. Great awareness and rehabilitation conducted through community empowerment approach are crucial at this stage. Over time Mataniko River Catchment will be haunted by its good ecology stories but no evidence of its intactness.

The growing human activities at the upper catchment has contributed to increased sedimentation and siltation into the water system. Since natural control mechanisms such as plants been cut off and the geology of the area had changed, the flood patterns have changed.

Within the freshwater ecology, three fish species had been introduced for food security and malaria control strategy. The three species are *Gambusia holbrooki*, *G. affinis* and *Oreochromis mossambicus* or Tilapia.

The latter was introduced for aquaculture, but it was no longer suitable due to its slow growth and uncontrolled recruits during spawning. This species is widespread in the Solomon Islands and especially in the Guadalcanal rivers, especially at the lower reaches.

Gambusia affinis is known to control mosquito larvae thus the species was introduced into streams and swamps near the coastal areas especially the North Guadalcanal after Alligator creek where malaria incidents are high. This species is found only in Guadalcanal.

Studies in Africa and Asia had shown that these species can compete with native fish species and can adjust and adapt quickly to changes (chemical and natural competitions) and toleration level (during low oxygen and low flows or stillness (pool-like) is high.

The Mataniko River Catchment is one of the most populated rivers in Honiara. Upon observation during community consultation supported by reviewing updated monitoring reports from 2018 and 2019, the team discovered animal husbandry and poultry projects along the river side, a primary school, residential areas, squatter settlements, a sewage treatment plant, and the China Town. These infrastructures had contributed to the polluting of the Mataniko River Catchment.

The river has been used for washing and swimming whilst used as a waste depositary field for facilities. Plastic wastes seem to be the most generated wastes followed by organic wastes. Other forms of wastes include tin cans, butane gas bottles, Styrofoam, bags, iron rods, aluminium, and batteries.

Turbidity increases downstream due tendency of the water (the sloppiness) to diffuse sediments to the lower reaches or settle in pool areas. At mid reaches of the river, there is a decrease of sloppiness thus river flow is slower allowing suspended particles in the water column. Turbidity is relatively high during and after rainfalls due to suspended particles and sediment transported through gullies, valleys, and streams. Most runoffs are from unmanaged runoffs within the settlements and residents along the riversides and infrastructures.

pH level is measured to be between 7-8 which is expected where rivers and lakes have pH ranging from 6 to 9 (Mattson (1999). Mataniko River Catchment is neither acidic nor basic where it is possible due to the disposition of limestone in the upper catchment of the river. Limestone helps the river to buffer the water to be neutral most times.

The temperature was found to be constant owing to environmental conditions as well. The team found that in the upper catchment, vegetation cover is obvious whilst from the areas where human settlements are and going downstream has higher exposure areas. Temperature is still important for establishing a baseline between the surface ambient environment and the surroundings.

DO is decreasing downstream, indicating high biological activities (more organisms demanding oxygen) taking place in the lower reaches of the river. This biological activity includes the breaking down of organic materials, fish and crustaceans respire. Two main processes that have been affected in this area are the respiration of fish and other aquatic organisms, as well as the bacterial decomposition process.

Conductivity is found to be lower in the upper catchment and high in the lower reaches of the river. This indicates that that there are fewer dissolved particles or solutes in the upper catchment than in the lower reaches. Accumulation of solutes and insoluble substances are found at the lower reaches. In addition to this is the settlements, residents and the China Town and the oceanic influence into the river mouth this includes ships, boats, canoes etc. coming into the river.

5. CONCLUSION

The review concludes that the ecology of the Mataniko River catchment is still intact at the upper catchment whilst decreases in flora and fauna composition downstream. Due to the environment being impacted by human and city expansion, more tolerable species of plants and animals are present in the mid-lower reaches. Water quality is poor from the upper catchment to the lower reaches, as previously stated. This is not good for humans due to the presence of pathogenic organisms. There is a possibility that waterborne disease such as cholera, diarrhoea, malaria, and skin diseases like scabies, will become more prevalent in the catchment soon.

Along the riverside, human settlements are expanding and growing with the unmanaged disposition wastes into the river. At the upper catchment, gardening, farming, and milling of timber is obvious and changing of landscape and the same with human settlements have been increasing downstream.

A stakeholder approach is important in involving all communities, sectors, stakeholders, men, women, youths, and children in a campaign to protect the environment and its services.

6. WAY FORWARD FOR MATANIKO RIVER CATCHMENT

Upper catchment protection and conservation

There is intense indiscriminate harvesting of trees which includes sawmilling, excavation, road construction, tipping of soil and quarrying in areas of Barana and the upper catchment of Mataniko. It is recommended that all developments are subject to the EIA process to ensure the environmental state is defined, the consultation processes involve all (inclusive men, women, youths, children, and others) to be effective, impacts are mitigated, and monitoring of the development planned and actioned. A developer who includes communities and other users will have to comply with national and provincial laws to acquire approvals to do such activities/development. By scaling the activities, the MECDM must advise and support the developer to go through the EIA process and obtaining development consent.

The community must be aware of such processes to understand the implications and methods for resolving environmental issues if developments are carried out in the catchment.

To address subsistence farming activities on flanks of hills, valleys, and flood plains, which has been exacerbated by population growth and migration, it is high time for communities to be aware of the impacts of such activities on the environment. It is high time to ensure communities and state authorities initiate dialogue over issues to manage land use system with buffer strategy etc. To plan and address issues associated with rapid increases in subsistence farming, all members of the community should participate in a dialogue.

It is very crucial to value the ecosystem services of Mataniko River Catchment to lure support to protection and conservation of areas crucial to community livelihoods. The community has to be attentive to this idea which will needs time and effort to do.

6.1 Reforestation and River Ecosystem Rehabilitation

Due to the level of exploitation and felling, there has been bare areas that will influence surface water flowing, sedimentation and siltation transported into the river through the gullies, valleys, and streams.

These immediate exposed areas need reforestation of indigenous plant species or approved plant species. This requires surface stabilization by planting vines and shrubs with the advice from Botany experts, this is to allow native species to germinate and establish slowly. It is by experienced that such reforestation and rehabilitation is possible by studying areas been lit by fires and how such areas regenerate overtime.

6.2 Invasive Species Management

On land, the African Giant snail and the Coconut Rhinoceros have been observed to be rapidly increasing in Barana village, Mt Austen and into the Mataniko River Catchment. These organisms had been an obstacle to human livelihood in the area attacking food gardens crops, fruits such as coconuts, pawpaw etc. and the vegetation. It is recommended that communities coordinate with MAL and MECDM through a workable plan that would propagate management measures for these species.

6.3 Waste Management and River Clean-Ups

Solid wastes and liquid wastes are eminent and causing pollution to the river and public nuisance. Most wastes in Honiara are mainly commercial wastes, industrial wastes, construction wastes and household wastes in two mediums that is liquid and solid.

Sewage systems and liquid wastes from residential and villages along the river side are not treated and are openly disposed of on the riverbank, shoreline or at water ways. It is time that state Authorities work with supporting agencies to look at facilities to harness cleanup and management of waste in the Mataniko River Catchment. Awareness and discussions on sewage wastes to include all sectors, stakeholders, individuals, and members of the community (including leaders, men, women, youths, and other vulnerable members of communities) to ensure collaborative work on addressing waste management and river clean ups.

To address the increase and accumulation of waste in Honiara and especially in Mataniko River Catchment needs the following actions.

6.3.1 Sewage treatment and Septic standardizing

Work with Solomon Water to address sewage system within the Mataniko River Catchment to ensure conduits of sewage for treating are maintained and rehabilitated. Another thing is to enforce laws that govern planning process which has no proper sewage management infrastructures.

Ensure sewage systems are treated to acceptable levels before discharging into water columns. In the absence of sewage treatment, all residential buildings must have septic tanks and soak-ways and designed and approved by the town and country planning board.

Direct disposition of such wastes will not be permitted, and the infringement authorities will ensure to penalize offenders.

6.3.2 Public Awareness and Training

Awareness is important to the local community and the Honiara at large. The laws and penalties concerning litter for example the litter ordinance needs to be enforced. Educating and empowering the local community is one approach to sustainably maintain waste management movements.

Community awareness of the state of pollution of the Mataniko River catchment is important for the community, and there should be different forms of awareness targeting the different sectors of communities. Use of television, digitized app, social media, and on-air talk back show platforms is important to inform the public at large of the negative effects of waste management.

This is so that all sectors, stakeholders, men, women, youths, and other members of the communities to be able to identify and understand and think of ways to address their different contributions to waste and pollution reduction within the catchment and river system.

6.3.3 Disposal drums and bins

The Communities, HCC, MECDM and the business investors needs to support waste management in Mataniko River Catchment rehabilitation in providing drums, bins, timely collection services and resources to promote waste management. Men, women, and youths can effectively be engaged in different components of these work.

6.3.4 Improved waste collection system

Encourage investment on the reuse of collection system and timely removal of waste from collection points. It is high time that the government and HCC procure and harness waste management collection system for the local community. Success will be through Improving and strengthening present waste collection systems with the support from the local communities, including “champions”- men, women, youths, children and other sectors and stakeholders from the planning to implementation. This can be done to ensure resources are channeled to HCC and implemented appropriately.

6.3.5 Collaboration and coordination

Collaboration and understanding of the vision for Mataniko River Catchment rehabilitation is important. Coordination has to made by HCC, MECDM and other development stakeholders. This is important in enforcement, monitoring/inspection, and compliance. Collaboration at all levels is important, highlighting the need for human rights, gender, and social inclusion approaches at the community discussions according to the catchment context and existing systems.

6.3.6 Land use planning and enforcement

Land use planning is an important process to set decision terms according to community and development partners understanding and interests. Land use planning would be an inclusive process where women, youths and other sectors of the communities are included in the planning, development and implementation and monitoring. This planning processes can affect watershed health therefore the community and state authorities had to sit down to set a plan for the Mataniko River Catchment. This plan will ensure to amalgamate town expansion, population growth, economic development, and natural resources management.

In addition to the land use planning process management issues for storm water management, sewage management, flood plain management, stream buffer, illicit discharges, infrastructure, public utilities, detail hydrology geo-tech assessment and mapping needs to be included.

By looking at all the aspects for land use planning, enforcement will become clear with the process of developing or strengthening policies and ordinances to manage expectations for Mataniko River Catchment.

In addition, unexploded ordinance is putting a threat to the catchment therefore a dialogue from responsible authorities and the community on this matter is important. It is really affecting all communities in the catchment having to sort to areas directly affecting the catchment and the river system if moving from such areas would their option. Mataniko Catchment is renowned for in the battel of Guadalcanal during the WWII.

6.3.7 Monitoring and Evaluation

Through the support of the community, relevant agencies like ECD and HCC need to develop monitoring, evaluation and learning framework for Mataniko River Catchment that includes water quality monitoring, ecology monitoring, sediment quality assessment, waste management, hydrology, biodiversity and overall management plan with indicators and outcomes.

6.3.8 Coordination Committee

For better implementation of a framework for Mataniko River Catchment and ensure ownership of the area concerned, establish a committee which will consist of relevant stakeholders and the ECD as the executing agency. The committee composition will be in respect of human rights, gender and social inclusion, stakeholders, and sectors within the community.

The committee will ensure all necessary activities and objectives are met and reported for evaluation and monitoring.

REFERENCES

Adler, G., H., Austin, C., C and Dudley, R.1995. Evolutionary Ecology: Dispersal and speciation of skinks among archipelagos in tropical Pacific Ocean. Chapman and Hall.vol9:529-541

Agency, E., 2009. Water for life and Livelihoods. Part 1: North West river basin district River basin management plan. Department of Environment Food and Rural Affairs. *Environment Agency,* 6-12.

Agency, E. U. S. E. P., 2012. *EPA's Web Archive.* [Online] Available at: https://archive.epa.gov/water/archive/web/html/vms59.html Retrieved on 22 February 2019.

Bartram, J., & Ballance, R. (Eds.). (1996). *Water quality monitoring: a practical guide to the design and implementation of freshwater quality studies and monitoring programmes*. CRC Press.

BirdLife International. 2015. Endemic Bird Area factsheet: Solomon group. Retrieved on 7 January 2015 at URL: http://www.birdlife.org

BOM. 2013. Cyclone tracks - Southern Hemisphere [beta], Retrieved on the 10th of February 2015 at URL: http://reg.bom.gov.au/cyclone/history/tracks/index.shtml

BOSETO, D. 2011. Aquatic fauna Survey of the Kovi Water Catchment, Guadalcanal Island, Solomon Islands. Honiara: IUCN

Brett, J., 2014. Water temperature. *Fundamentals of Environmental Measurements*, 7 February.

Canadian Water Quality Guideline. 2004. Phosphorus: Canadian Water Quality Guidelines for the Protection of Aquatic Life, Canada

Chandan, 2013. *INTERNATIONAL JOURNAL OF SCIENCTIST & TECHNOLOGY RESEARCH.* [Online] Available at: http://www.researchgate.net/publication/273611489

Chakraborty, C., Mazarahul Huq, M., Ahmed, S., Tabassum, T., Miah, R. 2013. Analysis of the Causes and Impacts of Water Pollution of Burigana River: A Critical Study.

Dutson, G. 2011. Birds of Melanesia: Bismarks, Solomons, Vanuatu and New Caledonia. Bloomsbury Publishing. London.

Environmental, F., 2014. *FONDRIEST.* [Online] Available at: https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/ Accessed 24 February 2019.

Gray, W., N. 1974. The fishes of the Solomon Islands. Part 1: The fresh and brackish water fishes on Guadalcanal, Solomon Islands Museum Association, Honiara.

Hancock, I., R and Henderson, C., P. 1988. Flora of Solomon Islands. Research Bulletin No.7. Dodo Creek Research Station, MAL, SIG, Honiara: 203

Hansell, J., F and Wall J., R, D 1976, Land Resources of the Solomon Islands, Land Resource Division Ministry of Overseas Development, England.

Henderson, C., P and Hancock, I., R. 1988. A Guide to the Useful Plants of Solomon Islands. Research Department, Ministry of Agriculture and Lands. Honiara. Solomon Islands

Judith, B., 2009. *Wealth of the Solomons.* Haweii: University of Hawei press.

Teleost Consultancy. 2018. Mataniko River Baseline Report. Honiara. MECDM

Mataki, M. 2011. A critical assessment of the paradigms for solid waste management in pacific island countries. Retrieved on 5th January 2015 at URL: http://researchrepository.murdoch.edu.au/10893/2/02Whole.pdf

Mary, E and Diamond, J. 2010. The Birds of Northern Melanesia: Speciation, Ecology, and Biogeography. Oxford University Press. New York.

McClatchy, W., C., Sirikolo, M., Q., Boe, H., Biliki, E and Votboc, F. 2005. A Proposed PABITRA Study Area on Lauru Island, Western Solomon Island, Pacific Science, 59(2), pp213:239

McCoy, M. 2006. Reptiles of the Solomon Islands. Pensoft Publisher. Bulgaria

MECM. 2008. Solomon Islands National Adaptation Program of Action. Honiara: MECM

MECDM. 2019. Mataniko River Catchment Water Quality Baseline Study. International Water Ridge to Reef Program, Solomon Islands, Honiara, MECDM.Ministry of Environment, Climate Change, Disaster Management and Meteorology.2011. Fourth National Report to the Convention on Biological Diversity. Honiara. Solomon Islands

Mill, D., 2004. *Aquarium Fish.* illustrated ed. s.l.: DK.

Monitors, E., n.d. *Fondriest.* [Online] Available at: https://www.fondriest.com/news/water-quality-and-flow-rate-monitoring-during-water-withdrawal.htm Accessed 9 March 2019

Pacific Horizons/SIG. 2008. Solomon Islands State of Environment Report. Honiara. Solomon Islands

PHCG. 2010. Tina River Hydro Development Project (TRHDP): BASELINE SURVEYREPORT. Honiara, Solomon Islands: Islands Knowledge Institute.

Polhemus. D., A., E. R. A., Allen. R., G., Boseto. D., Polhemus. J., T. 2008. Freshwater Biotas of Solomon Islands: Analysis of Richness, Endemism and Threats. Bishop Museum Technical Report, 1-123.

Schwartz, M., 2006. Beaches and Coastal Environments. *Encyclopedia of coastal science,* p. 1213.

SIG. 2011. Solomon Islands National Statistics Bulletin 06/2011, Report on 2009 Population and Housing Census, Basic Tables and Census Description, Honiara: Solomon Islands.

Steblin, P. 2007. Springbank Dam and Thames River Water Quality, London

Tanner, V., M. 1951. Pacific Islands Herpetology No.5., Guadalcanal, Solomon Island, A checklist of species. Great Basin Nat.11(3-4): 53-86.

Temperature, G. S., 2019. *Temperature, Global Sea.* [Online] Available at: https://www.seatemperature.org/australia-pacific/solomon-islands/honiara.htm Accessed 29 March 2019.

UN Habitats. 2012. Honiara Urban Profile, Retrieved 5 August 2013 Accessed http://www.google.com.sb/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&ved=0CCwQFjAB&url=http%3A%2F%2Fwww.unhabitat.org%2Fpmss%2FgetElectronicVersion. asp%3Fnr%3D3324%26alt%3D1&ei=ei4EUqSJEseeiQKeuYGYBg&usg=AFQjCNHeIf11t_1NdrxxnoivuFA-L2bzCg

Wetzel, R. G. (2001). *Limnology: lake and river ecosystems. gulf professional publishing.*

WHO. (2003, September 7). *World Health Organization*. Retrieved from www.who.in: https://www.who.int/water_sanitation_health/bathing/srwg1.pdf

World Health Organization (WHO). 2011a. Guidelines for Drinking Water Quality (4th Edition), WHO, Geneva. (Page,315,327,334,341,340,383,397,398,412,416,419)

World Health Organization (WHO). 2011b. Hardness in Drinking-Water, WHO Geneva.

Witmore, T., C.1966. Guide to the forest of the British Solomon Island. Oxford university Press, London P:282