Rapid Coastal Assessment of Tagabe River Catchment Report, Port Vila, Vanuatu

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By Milika Sobey, Sam Chanel, Rolenas Baereleo, Mimosa Bethel, Jayven Ham, Rocky Kaku, Janessa Amos, Enelyn Moli and Eriksen Packett
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ABBREVIATIONS

BMU	The German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
Cefas	Centre for Environment Fisheries and Aquaculture
CME	Commonwealth Marine Economies
CPCe	Coral Point Count with Excel extensions
dbh	Diameter at breast height
DEPC	Department of Environmental Protection and Conservation
DSPPAC	Department of Strategic Policy Planning and Aid Coordination
GEF	Global Environment Facility
GOV	Government of Vanuatu
ICCA	Ifira Community Conservation Area
IRD	L'Institut de recherche pour le développement
IW	International Waters
MEP	Marine Economies Programme
MWPZ	Matnakara Water Protection Zone
NACCC	National Advisory Committee on Climate Change
NAPA	National Adaptation Programme for Action
NOC	National Oceanography Centre
PEBACC	Pacific Ecosystem-based Adaptation to Climate Change
R2R	Ridge to Reef
RapCA	Rapid Coastal Assessment
SCUBA	Self-contained underwater breathing apparatus
SPC	Pacific Community
SPREP	Secretariat of the Pacific Regional Environment Programme
TRCMP	Tagabe River Catchment Management Plan
UKHO	United Kingdom Hydrographic Office
UNELCO	Union Electrique Du Vanuatu Limited
USP	The University of the South Pacific
VIP	Ventilated Improved Pit
WPZ	Water Protection Zone

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EXECUTIVE SUMMARY

Ecosystem data gaps are common features in this region. The Global Environment Facility (GEF) Ridge to Reef International Waters (IW R2R) Rapid Coastal Assessment (RapCA) methodology was designed to collect missing or inadequate information. The overall goal and objective of the RapCA is to conduct fieldwork/surveys, collect the data, and report on the "biodiversity assessments" and "water quality assessments" across chosen key ecosystems and habitats for the demonstration site of the Tagabe River catchment.

The scientific and technical results, coupled with baseline data, photos and images, and lessons learned, provide critical biodiversity information, and improve understanding of the characteristics and current state of key habitats. This in turn, is useful to inform policy discussion and development of management actions and interventions towards an Integrated Watershed Management Plan. More importantly, the RapCA outputs would fill in the data gaps in the agreed baseline indicators and enable the long-term monitoring of the R2R project site.

This exercise was the first trial of the methodology devised to conduct a rapid assessment of coastal areas of the pilot sites in each country. Primary data was collected for three specific indicators to characterise the Tagabe catchment, the pilot site for the GEF IW R2R project in Vanuatu. The researchers conducted fieldwork over three days in teams comprising personnel from the Department of Environment Protection and Conservation (DEPC) and the Fisheries Department; a consultant botanist; and students from the University of the South Pacific (USP). The USP students worked simultaneously in the collection of primary data on the indicators E1 Diversity, E3 Habitat Quality and SE4 Exploitation of Living Resources.

For the measurement of indicator E1, researchers conducted a forestry survey in the catchment. Relative dominance of endemic, native, and introduced species was determined.

A checklist of 63 plant species was compiled, of which 30 were endemic (47.6 per cent endemism). Of the six plant species listed for Vanuatu in the IUCN Red List, three are found in Tagabe Catchment: the Bangulu Palm (*Carpoxylon macrospermum*), which is listed as Critically Endangered, the Montgomery Palm (*Veitchia arecina*) and the Pacific Kauri (*Agathis macrophylla*), which are listed as Endangered. Invasive weeds and vines such as *Merremia peltata*, *Panicum maximum, Urena lobata* and *Mikania micrantha* are a dominant issue in the catchment.

The reef survey revealed the benthos was predominantly hard rock with reduced hard coral cover. Piscivores such as surgeonfish in abundance, and large numbers of giant clams and sea urchins were observed. The counts would indicate that the taboo currently in force in the Blacksands coastal area is allowing the replenishment of species targeted by fishers.

Creel surveys were conducted to record measurement of indicator SE4. The researchers interviewed 27 respondents from the Blacksands community. Fishing is a major revenue earner for the community, and with the taboo in place, the fishers are being forced to fish offshore in deeper waters. The fishing methods used, and the corresponding catch composition suggest a shift from inshore to offshore fishing.

The exercise helped in implementing a national document, the Tagabe River Catchment Management Plan 2017–2030, and was conducted by Vanuatu nationals rather than the norm of using internationally recruited consultants. Similarly, the marine surveys assisted in providing the baseline data for the Ifira Community Conservation Area Management Plan.

This is the first time the RapCA method was being tested and as expected, issues were encountered. The lessons learnt were as important as the technical output of the activity. The need for sufficient preparatory work, refinement of methodologies and sampling design and data quality assurance all need addressing.

The Tagabe Catchment is of high conservation value due to the high endemism. Vanuatu has six plant species on the IUCN Red List, three of which are in Tagabe Catchment, which makes its protection even more critical. The taboo has allowed for the replenishment of commercially important finfish and invertebrate species. The Blacksands community has adapted to the taboo by changing their fishing grounds and methods so that they are fishing further offshore. The findings are important to establish baseline targets under the current state of the catchment.

1.0 INTRODUCTION

Component 1 of the GEF Pacific International Waters-funded Ridge to Reef Program seeks to implement national pilot projects in 14 countries. The national projects have been designed to integrate land, forest, water, biodiversity, and coastal resource management to enable poverty reduction, sustainable livelihoods, and climate resilience. Output 1.1.1 states "14 national pilot project area diagnostics based on R2R approach including: baseline environmental state and social data incorporating climate change vulnerabilities; and local governance of water, land, forests and coasts reviewed". Activity 1.1.1.3 supports this output through the characterisation of the pilot site in terms of the physical, biological, and social variables that will lend to the holistic management of the ecosystems, site surveys to ground truth compiled information and data, and conduct the rapid assessments of the coastal areas identified by the countries requiring ridge to reef interventions.

The methodology for the rapid assessment of the pilot site followed an extensive literature survey to determine methods and indicators widely used in characterising terrestrial, freshwater and coastal ecosystems. A workshop was convened by the Project Coordination Unit at SPC where experts in various disciplines compiled a list of indicators and methods that could be used to describe the health of the different habitat types in the Pacific context. Indicators were categorised, with 22 categories of indicators selected for the characterisation of the pilot site (Annex 1). The collection of primary data at any one site would be largely dependent on the data sets available locally, the scope of the exercise, the expertise available in country and costs involved.

The data gaps to be filled by the fieldwork in Vanuatu were determined by an extensive literature review and discussions with project managers of the Pacific Ecosystem-based Adaptation to Climate Change (PEBACC) project, funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and implemented by the Secretariat of the Pacific Regional Environment Programme (SPREP) and the Vanuatu Government; and the Commonwealth Marine Economies Programme for the Pacific funded by the United Kingdom Government and implemented by Cefas – Centre for Environment Fisheries and Aquaculture Science, UK Hydrographic Office and National Oceanography Centre. Both projects are being implemented in Fiji, Vanuatu, and Solomon Islands.

After reviewing the 22 indicators that were selected for measuring in RapCA, the only ones where primary data collection was deemed necessary were for Exploitation of Living Resources (E1), Diversity (E3), and Habitat Quality (SE4). The data for the other indicators can be accessed from different government agencies and project reports. The focus of this report will be on those indicators listed above for which primary data was collected. The aim is to use the data and information to establish baselines for ongoing monitoring of stress reduction targets into the future.

1.1 Description of pilot site

Tagabe River Catchment is the pilot site for Vanuatu's national IW R2R project. This river catchment is of national significance because it is the only source of potable water for Port Vila's residents. It provides water for residential areas, businesses, agriculture, and industry. There are, however, several pressures on the environment in the catchment and they include the following:

- Solid waste disposal on the riverbank and in the water;
- Toilet facilities close to the river;
- Bathing and laundry are done in the river;

- Deforestation for bush gardens and firewood;

- Use of pesticides in adjacent farms; and

- Development pressure for new residential areas (Tawney 2006).

Figure 1 provides a map showing boundaries, total areas stretching from the upper areas or ridge of the catchment upstream and downstream, including reef systems adjacent to the point of discharge
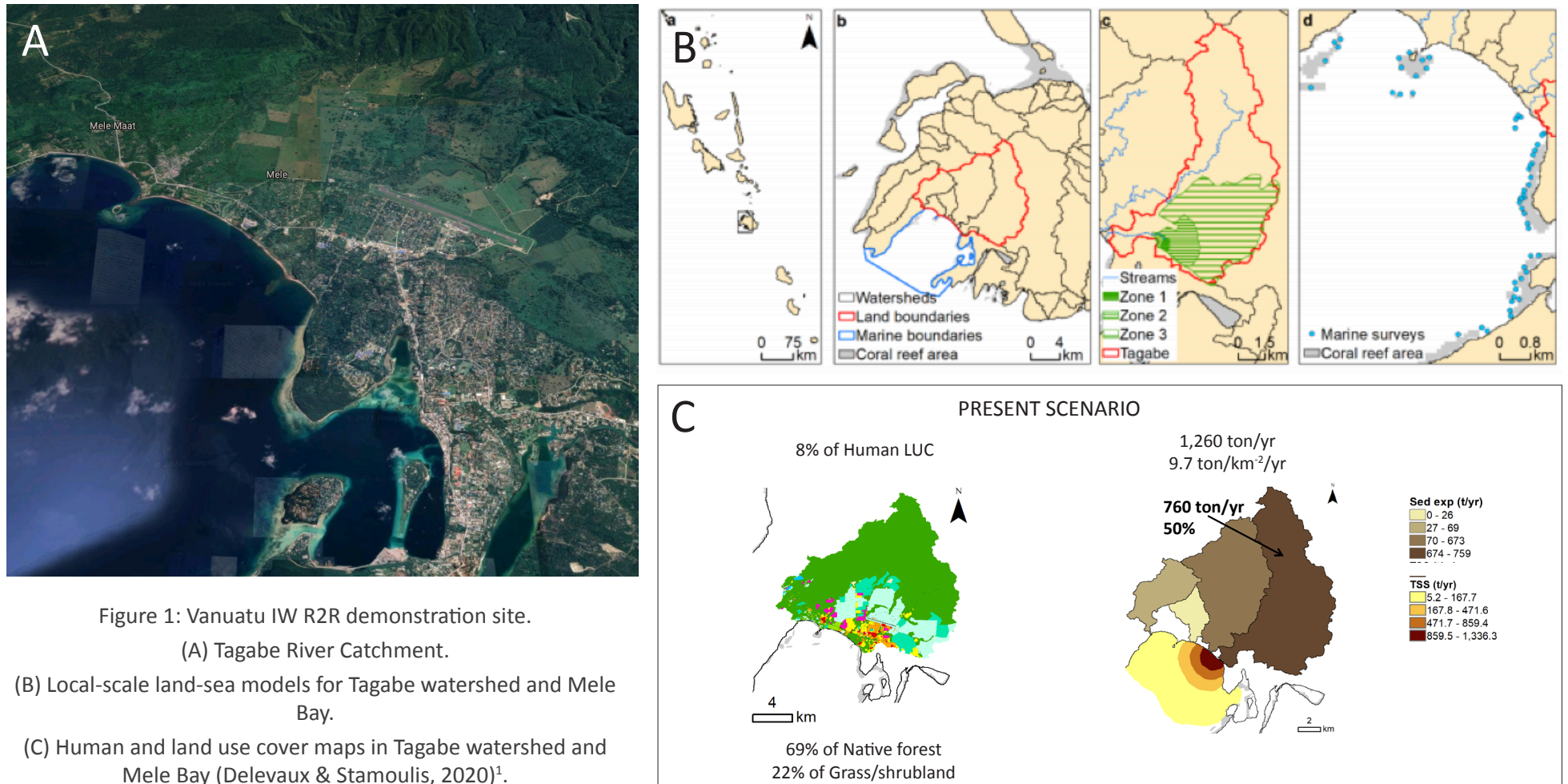
Figure 1: Vanuatu IW R2R demonstration site.

(A) Tagabe River Catchment.

(B) Local-scale land-sea models for Tagabe watershed and Mele Bay.

(C) Human and land use cover maps in Tagabe watershed and Mele Bay (Delevaux & Stamoulis, 2020)[1].

[1] Original data and maps from Delevaux & Stamoulis (2020). Maps slightly rearranged for presentation slides (unpublished) and presented by Dr Delevaux at the First Series Technical Consultation of the Regional Scientific and Technical Committee for the GEF Pacific Ridge to Reef Programme.

The Tagabe River Catchment Management Plan 2017–2030 (TRCMP) was officially launched in March 2018. The plan seeks to improve the management of the catchment to protect Port Vila's water supply (Government of Vanuatu 2018). There are three Water Protection Zones (MWPZ 1, MWPZ 2 and MWPZ 3), which cover an area of 25.7 km^2 within the catchment; in the catchment plan, these areas are called Matnakara water protection zones, MWPZ. These zones are areas that have been designated for the protection of the quantity and quality of groundwater and where land use practices are regulated. MWPZ 1 is fenced and includes state land and the UNELCO (Union Electrique Du Vanuatu Limited) facilities – UNELCO is the utility company that distributes water and electricity. There is also a national botanical garden within MWPZ 1. MWPZ 2 is the recharge area where the international/domestic airports and the Government Agriculture station are located. MWPZ 3 is the water catchment area where there are livestock farms, a quarry, and settlements (Government of Vanuatu 2018). The lower catchment has the Tusker brewery, petrol station and high-density human settlements.

1.2   Policies and Legislation

Environment related policies and legislations currently in place have been successfully implemented with support from relevant government line ministries and private sector, including local communities. However, these are outdated and no longer fully support changing environmental situations due to climate change and frequency of severe natural disasters such as tropical cyclones and habitat degradation. There has been increased land-based development with changing landscape from upstream high ridges to lower coastal areas and adjacent reef systems. This report recommends a review of relevant policies and legislations relating to the environment, including mainstreaming ridge to reef approach and principles in future revised policy and legislative frameworks.

The TRCMP contains a comprehensive summary of policy measures and legislation intended for implementation to effectively protect, manage, and safeguard the utilisation of the catchment area. If all the measures and legislations were to be implemented and complied, then additional efforts such as R2R interventions to restore habitat by revegetation (target, 2,570 ha) and planted endemic species (target, 30 ha) will complement and support continuity thereby ensuring sustainability. That said, the following identifies specific areas in the TRCMP relevant and important to the findings of this study.

The Environment Protection and Conservation Act (2002) has a section dedicated to biodiversity and protected areas, which encompasses registration of Community Conservation Areas such as that being pursued by the customary landowners of Tagabe for the Ifira Community Conservation Area (Ifira Marine Management (IMM) 2017). Any development activity that will impact the coastal environment or water resources are subject to Environmental Impact Assessment provisions of the Act. Any site deemed to provide critical ecosystem services may be declared a Community Conservation Area. The Act also requires the production of a national State of Environment report every ten years. There has been a lapse of 25 years since the last one was produced for Vanuatu. The State of the Coast report that this RapCA report will contribute to will thus provide a valuable addition to the national repository of environmental assessments.

The Forestry Act (2001) provides protection for forest areas that have scientific, cultural, or social significance. Such forests can be declared Conservation Areas where all commercial activities are prohibited. Specific plant species can be protected under this Act.

The Water Resources Management Act (2002) governs the use, protection, and management of water resources in Vanuatu. The Act allows for the declaration of Water Protection Zones (WPZ) to conserve and protect significant water resources intended for supplying water in rural and urban

areas. Authorities are responsible under the Act to provide public awareness on reasons for the declaration of an area as a WPZ. The Minister responsible may, in collusion with other Ministers, devise regulations consistent with the Act to protect public health, freshwater and marine fisheries and deter pollutant discharges into water.

The Vanuatu National Environment Policy and Implementation Plan 2016–2030 includes the protection of vulnerable forests, watersheds, catchments, and freshwater resources.

1.3   National Plans

There are at least four national policies or plans that may be directly linked to the implementation of the Vanuatu IW R2R project, and are outlined below:

i.   The National Sustainable Development Plan (2016–2030) under the Environment pillar seeks to protect vulnerable watersheds, catchments, and freshwater resources, and to protect biodiversity and ecosystems (Department of Policy Planning and Aid Coordination (DSPPAC) 2016).

ii.   The National Adaptation Programme for Action (NAPA) seeks to promote community-based marine resource management to strengthen the adaptive capacities of coastal communities to climate and coastal changes (National Advisory Committee on Climate Change (NACCC) 2007).

iii.   The Vanuatu National Environment Policy and Implementation Plan (2016–2030) aims to have six water protection zones declared by 2020 and six watershed management plans (SPREP 2017). The MWPZ 1–3, the TRCMP and the RapCA have helped in the realisation of the Implementation Plan.

The results from the R2R technical and rapid coastal assessments at Tagabe catchment relative to terrestrial biodiversity, freshwater flora and fauna and marine ecosystems, provide the opportunity to establish the current state of biodiversity and the extent of human impacts from resource exploitation and other resource uses.

iv.   Most of the content of the National Invasive Species Strategy and Action Plan (2014-2020) is centred on invasive faunal species. The strategic measures and actions to control the invasive species are discussed. Specific mention is made of the Big Lif vine (*Merremia peltata*), Wan dei rope (*Mikania micrantha*) and giant Mimosa (*Mimosa diplotricha*). Other species marked for future interventions include *Solanum torvum* and *Urena lobata*.

2.0 AIM

The Rapid Coastal Assessment (RapCA) for Vanuatu IW R2R demonstration project aimed to collect primary data and information currently not available to characterise the Tagabe catchment. A minimum data set is needed to sufficiently describe the location, size, special features, management issues and ecological characteristics of the Tagabe Catchment.

RapCA is specifically focused on filling data gaps important to establish baselines for the indicators listed below, which, in addition to the other eighteen (18) agreed R2R indicator categories, must be relatable to reporting requirements and tracking targets for the sustainable development goals, the Convention on Biological Diversity (Aichi targets), GEF focal areas and other international and regional frameworks:

- E1 Diversity
- E3 Habitat Quality and
- SE4 Exploitation of living resources
- E6 Water Quality

Moreover, the collection of baseline data under this report and ongoing monitoring of selected indicators provides clear tracking of Vanuatu stress reduction targets of 30 ha restored habitat planted with endemic plant species, and 2570 ha restored habitat from revegetation and restoration.

3.0 METHODOLOGY

3.1 Indicator E1 Diversity

A total of nine 1000 square metre plots were assessed in the three Water Protection Zones of the catchment, WPZ 1, WPZ 2 and WPZ 3, as demarcated in the Tagabe River Catchment Management Plan 2017–2030 (Figures 1 and 2). In each plot, a tape 100 m long was extended and all trees within 5 m on either side of the transect were identified, and their diameter at breast height (dbh) and height were measured (Figure 3).

Due to invasive plants being a major issue in the catchment, the nine plots were also assessed for the invasive weeds/vines present (Figure 4). The relative frequency of the four main invasive weed plants, namely *Merremia peltata*, *Panicum maximum*, *Urena lobata* and *Mikania micrantha*, was determined. The invasive species were assessed within a 10 m x 10 m quadrat, along a 100 m transect. With the use of a hand-held GPS, coordinates were recorded for quadrats sampled and an information sheet was used to assist with the identification of species.
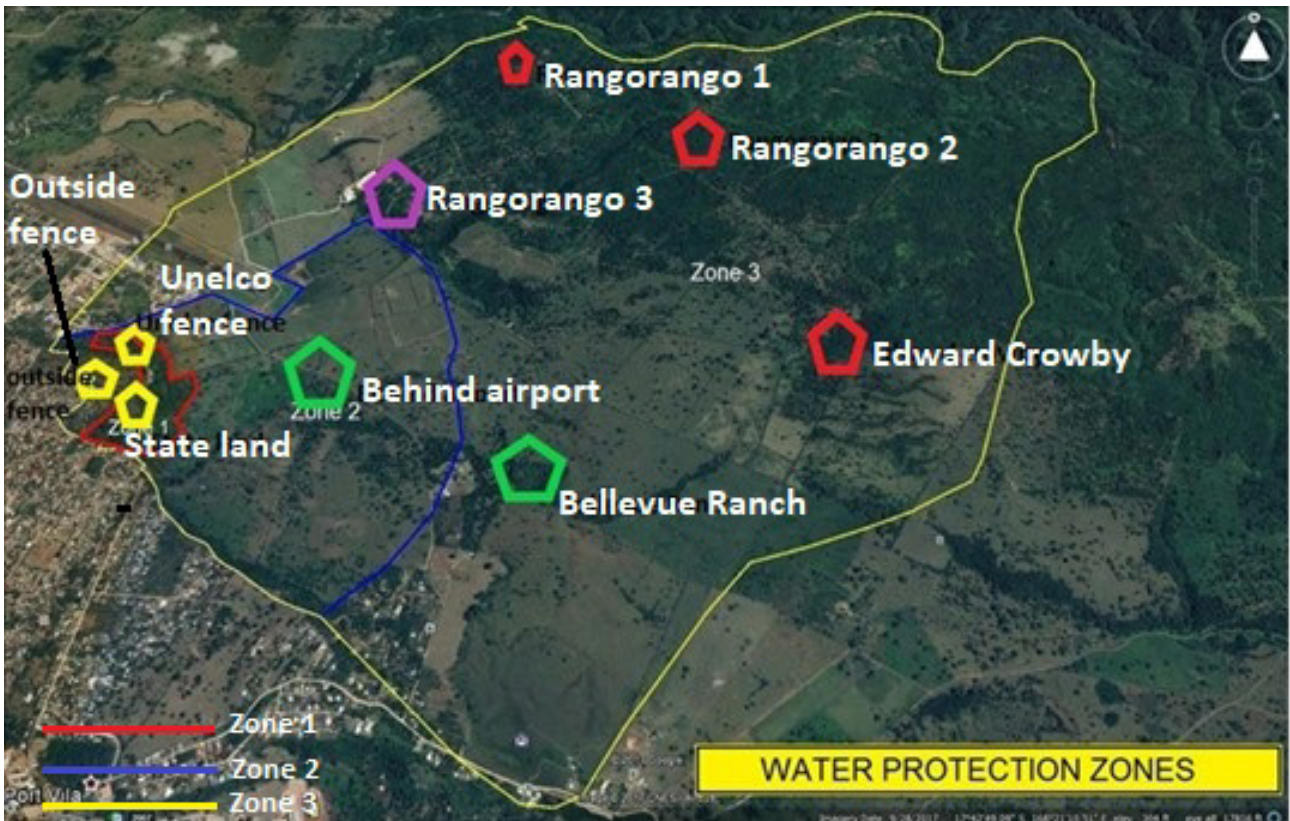
Figure 2: Nine Plots in Water Protection Zones in Tagabe River Catchment Area

Figure 3: Local botanist Sam Chanel (L) conducting forest assessment with field assistant

Figure 4: Assessment team recording invasive weeds/vines.

3.2 Indicator E3 Habitat Quality

3.2.1 Reef Survey (Invertebrate counts, sediment type and substrate cover)

The reef survey involved SCUBA diving and the assessment of six transects in the Blacksands reefal area (Figure 5), which is part of the Ifira Community Conservation Area (ICCA). The transects were 50 m in length with two divers simultaneously covering a 2 m wide corridor on either side of the tape (total sample area of 200 m^2).

For each of the six transects sampled, invertebrates, sediment type and substratum coverage were estimated using a photographic method developed by L'Institut de recherche pour le développement (IRD) to quickly and quantitatively describe contrasting reef habitats (Dumas et al. 2009).

Pictures were taken from the surface along transects using a standard digital 10 Mpixels Canon S110 camera in underwater housing, oriented perpendicular to the substratum; 25 pictures were taken per transect (i.e. one shot every two meters) and subsequently imported into an image analysis software including efficient, user-friendly features for the estimation of sediment/substratum cover (CPCe "Coral Point Count with Excel extensions" software, Kohler, and Gill 2006). Surface estimates expressed in per cent cover were derived from random stratified point count techniques using a nine-points.m^{-2} ratio ensuring reliable habitat profiles with low bias and high precision. A total of 17

local habitat variables were considered, related to sediment type and substratum coverage by large, sessile organisms. Percentage cover was then aggregated at the transect level.

The invertebrates targeted by local fishers were counted along each transect.

3.2.2 Fish counts

The fish counts were done at three of the six transects used for the reef survey: Transect points 1 and 2 and the third fish count was in the same area as transects 5 and 6. Counts were done by two divers who counted all fish 2 m on either side of the tape (Figure 6).

Figure 5: Transects where fish and invertebrate counts were done in Blacksands
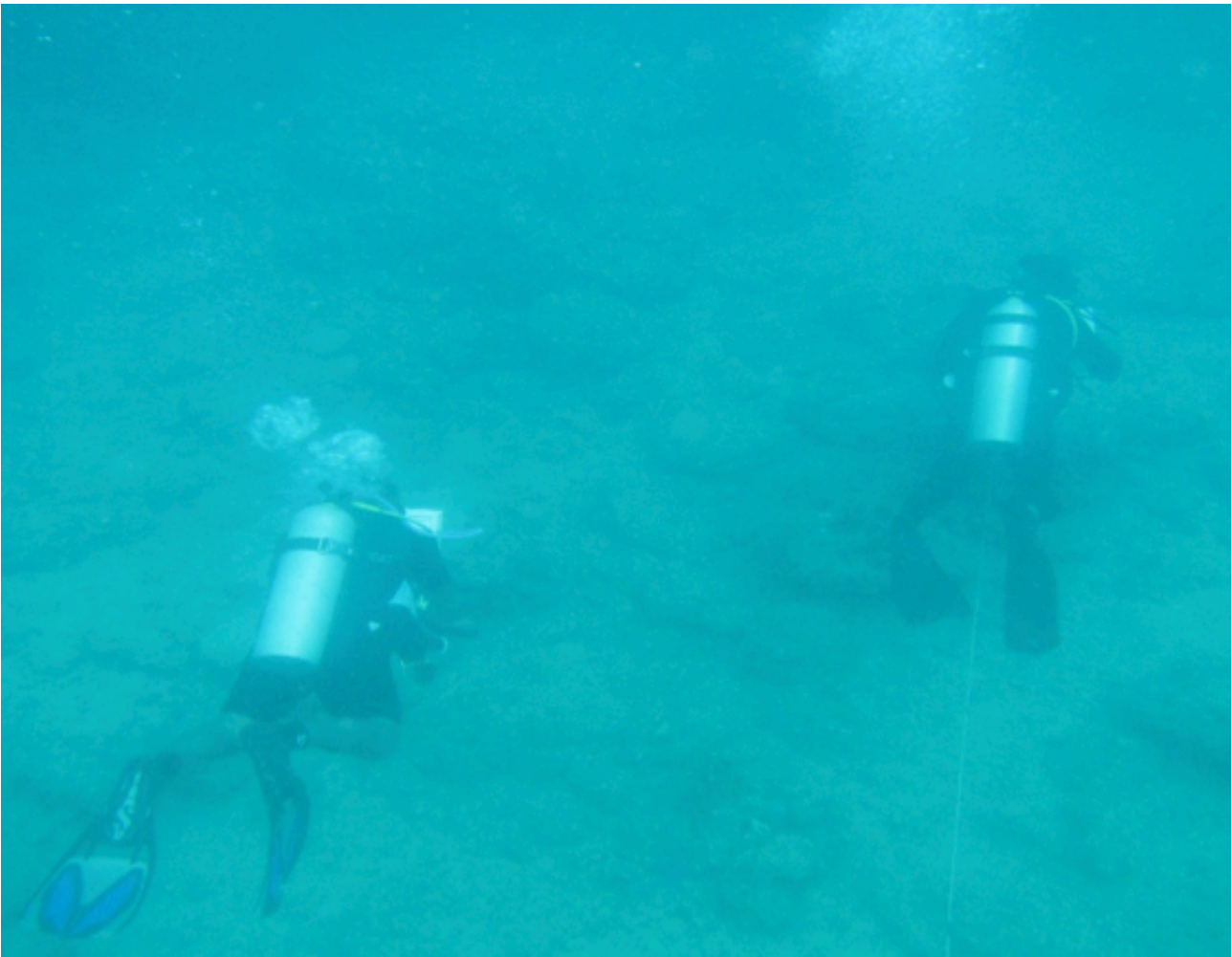
Figure 6: Divers conducting counts along transect at Blacksands

3.3   Indicator SE4 Exploitation of living resources

A questionnaire was designed (Annex 2) with questions related to the following subject areas:

- Habitat and Fishing Ground;

- Methods of Harvesting;

- Consumption patterns; and

- Targeted fish species and economic value

The SHEFA provincial office informed the field team that there were roughly 100 households in the Blacksands Community thus, the interviews were conducted using a sample size of 27 households (Figures 7–9). The questionnaires were administered over three days and it took roughly 20 minutes per household to complete.

Figure 7: Fisherman being interviewed by enumerator

Figure 8: One of 27 respondents interviewed at Blacksands community

Figure 9: Diana, the lone fisherwoman interviewed

4.0 RESULTS

4.1 Indicator E1 Diversity

A checklist of 63 plant species was compiled, of which 30 were endemic. Their relative dominance is shown in Table 1. The total of 59 invasive vine/weed taxa was recorded in the nine plots.

All nine plots, bar one, had endemic plants, which included *Veitchia arecina*, *Palaquim neoebudicum*, *Ficus adenosperma* and *Chisocheton rex*. Dominant species included the native *Antiarius toxicaria*, *Pangium edules* and *Endospermum medullosum*. The dominant native species found in five of the nine plots was *Syzygium* sp which is one of the main genera of trees in the montane cloud forests of Vanuatu (Mackey et al. 2017).

Invasive vine/weed species such as *Merremia peltata*, *Panicum maximum*, *Mikania micrantha* and *Mimosa pudica* were prevalent in the catchment. The dominant invasive species in three of the nine plots was the rain tree *Samanea saman*.

There were three rare species found; *Cryptocarya lurbinata*, *Garcinia pseudocadifera* and *Gulubia cylindrocarpa*. Of the six plant species listed for Vanuatu in the IUCN Red List, three of them are found in Tagabe Catchment: the Bangulu Palm (*Carpoxylon macrospermum*), which is listed as Critically Endangered; the Montgomery Palm (*Veitchia arecina*) and the Pacific Kauri (*Agathis macrophylla*) both of which are listed as Endangered.

Table 1: Total number of invasive vine/weed taxa recorded in the nine plots.

Plot	Species	Relative Dominance (%)
Rangorango 1	*Antiarius toxicaria*	86
	Dendrocnide harveyi	8
	Hibiscus tiliacus	3
	Dysoxylum gaudichaudianum	1
	Magaranga dioica	1
	Coffea arabica	0.4
	Ficus wassa	0.1
	Myristica fatua	0
Rangorango 2	*Pangium edules*	27
	Endospermum medullosum	17
	Myristica fatua	16
	Pisonia umbellifera	15
	Palaquim neoebudicum	3
	Veitchia arecina	3
	Pometia pinnata	2
	Alangium vitienses	2
	Hibiscus tiliaceus	2
	Dendrocnide harveyi	2

Plot	Species	Relative Dominance (%)
Rangorango 2	*Dysoxylum aneityensis*	4
	Anthocarapa nitidula	2
	Dysoxylum amoroides	1
	Ficus wasa	0
	Cleidion spiciflorum	1
	Dentrocnide latifolia	2
	Dysoxylum gaudichaudianum	1
	Cordiaeum variegatum	0
	Cryptocarya lurbinata	0
	Pipturus argenteus	0
Rangorango 3	*Samanea saman*	55
	Pangium edule	35
	Antiarius toxicaria	5
	Pipturus argenteus	1
	Carica papaya	1
	Syzygium spp.	1
Rangorango 3	*Ficus virgata*	1
	Macaranga tannarius	0
	Macaranga dioca	0
	Myristica fatua	0
	Leucaena leucocephala	0
Bellevue Ranch	*Samanea saman*	83
	Ficus smithii	9
	Ficus wasa	6
	Ficus adenosperma	0
	Dendrocnide harveyi	1
	Carica papaya	1
	Ficus virgata	0
Zone 3 Edward Cruby Farm	*Chisocheton rex*	35
	Antiaris toxicaria	28
	Dysoxulum amoroides	18
	Syzydium kajewskii	10
	Anthocarapa nitidula	6
	Muristica futua	3
	Ilex aneityensis	0

Plot	Species	Relative Dominance (%)
Zone 2 Behind Airport	*Syzygium kajewski*	13
	Anthocarapa nitidula	25
	Semecarpus neoebudica	16
	Erythrina variegata	32
	Garcinia pseudocadifera	14
Zone 1 State Land	*Endospermum medullosum*	35
	Citrus sp.	1
	Mangifera indica	9
	Terminalia catappa	14
	Pometia pinnata	4
	Barringtonia procera	3
	Dracontomelon vitiense	22
	Agathis macrophylla	2
	Casuarina equisetifolia	5
	Samanea saman	1
	Metroxylon warburgii	2
	Cerbera manghas	1
Zone 1 UNELCO Fence	*Samanea saman*	80
	Glochidion ramiflora	9
	Gardenia tannaensis	2
	Carpoxylon macrospermum	2
	Fluggia flexuosa	2
	Gulubia cylindrocarpa	1
	Pandanus Halleorum	0
	Dillinia neoubudica	1
	Glochidion namilo	1
	Syzygium buettnerianum	1
	Endiandra aneityensis	1
	Gliricidia sepium	0
	Cordia alliadora	0
Zone 1	*Syzygium malacencis*	24.7
	Syzygium buettnerianum	0.7
	Erythrina variegata	74.6

WPZ 1 of the Tagabe Catchment, which is fenced to prevent trespassing, is where the critically endangered Bangala Palm and the endangered Pacific Kauri are found, but the area also has the highest predominance of invasive species and lowest incidence of endemic species (Figure 10). Lowland forest found in WPZ 2 had the highest predominance of endemic species of the three zones. WPZ 3 consists of primary forest, thus the highest predominance of native species; but the forest is gradually being disturbed by gardening and logging activities and by invasive species.
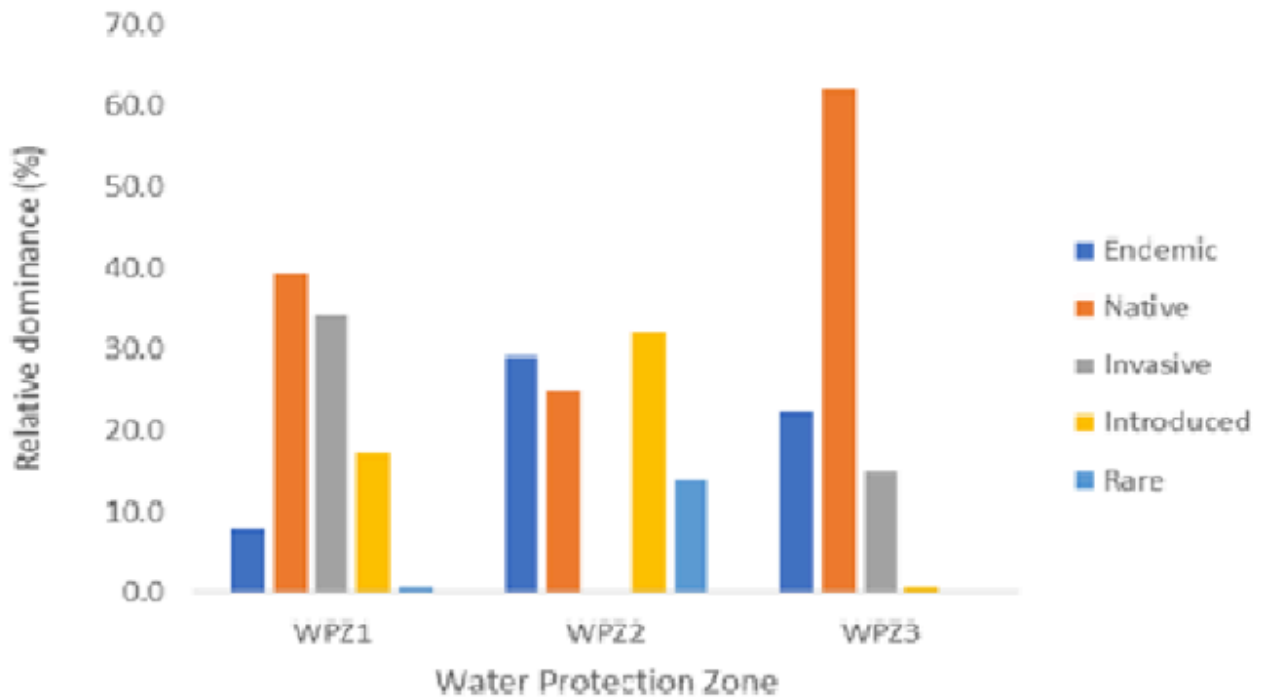
Figure 10: Relative dominance of endemic, native, invasive, introduced, and rare plants in the Water Protection Zones.

Merremia peltata was the most pervasive in WPZ 1 and 3, whereas Urena lobata was the dominant invasive plant in WPZ 2 (Figure 11).
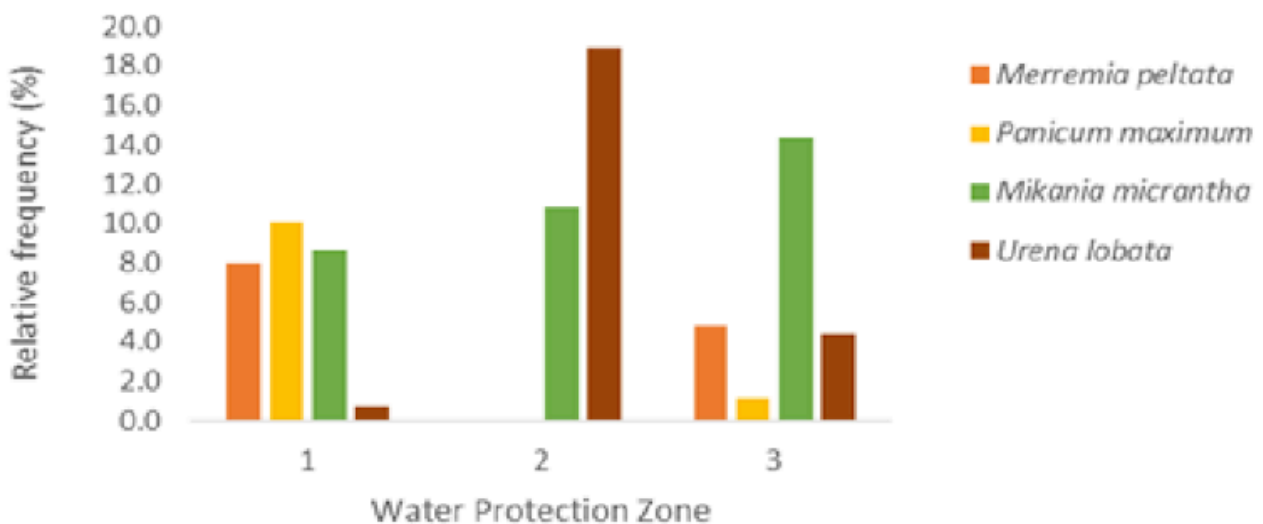
Figure 11: Relative frequency of four main invasive species in Water Protection Zones

4.2 Indicator E3 Habitat Quality

The substrate was predominantly hard rock with coral cover comprising roughly a third of the substratum (Figure 12). There were 29 taxa of finfish recorded at three sites and a total of nine taxa of invertebrates recorded at all six sites. High numbers of clams were found at three of the six transects. Transect 4 had particularly high abundance of clams and urchins (Figures 13 and 14).

The fish counts were conducted along the same transects as the invertebrate counts. There were 29 taxa of fish recorded along the three transects, 8 of which were piscivores. The counts of target species revealed highest abundance of surgeonfish followed by goatfish. The greatest fish species diversity was seen in the third transect, furthest from the river mouth (Figures 15 and 16) where transects 5 and 6 for the invertebrates were laid.
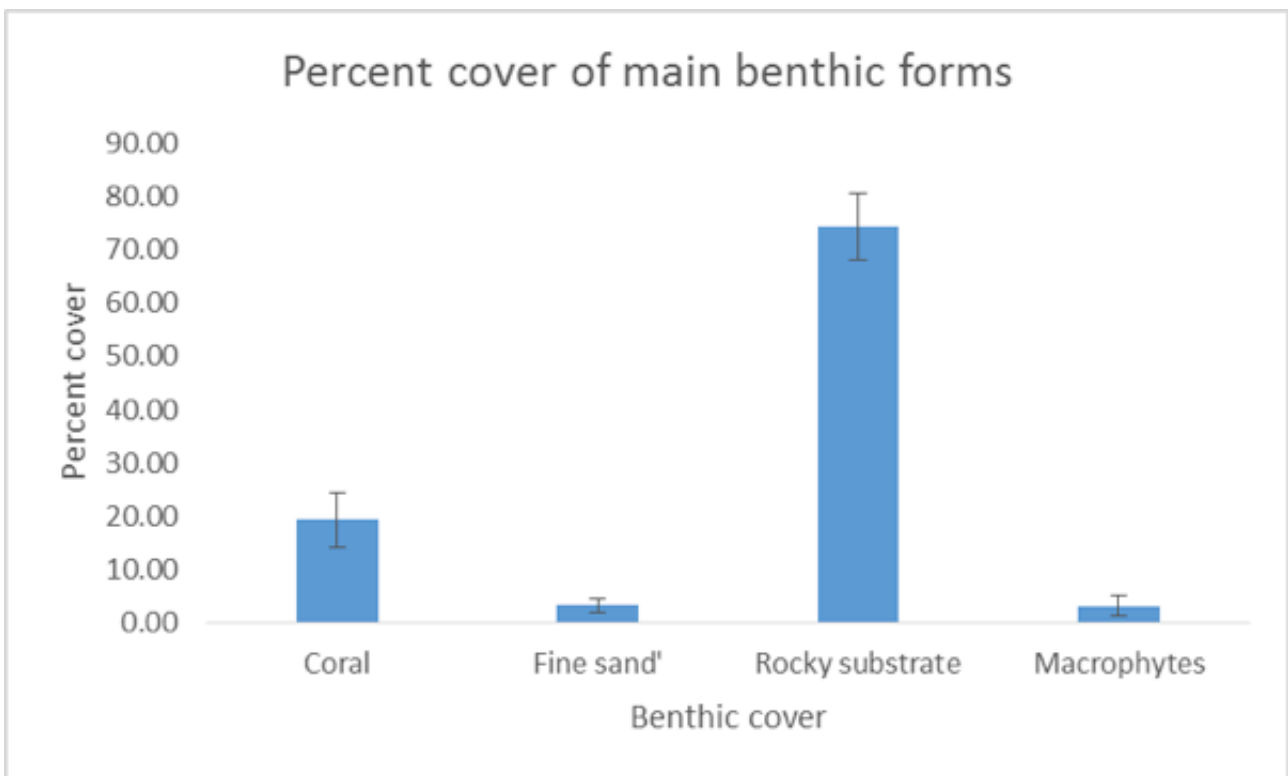
Figure 12: Benthic cover at Blacksands reef
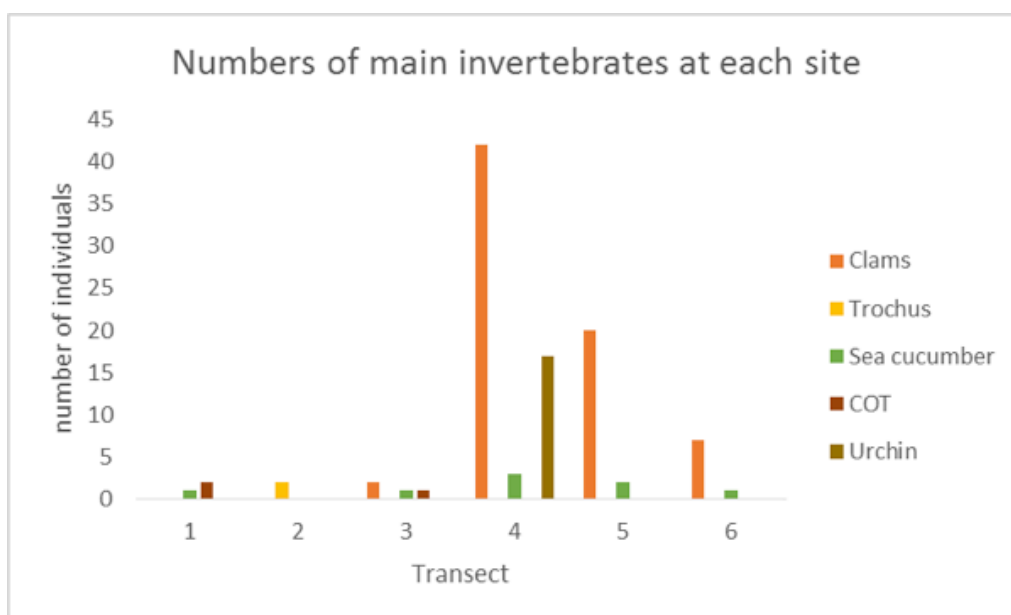
Figure 13: Counts of large sessile invertebrates at Blacksands reef
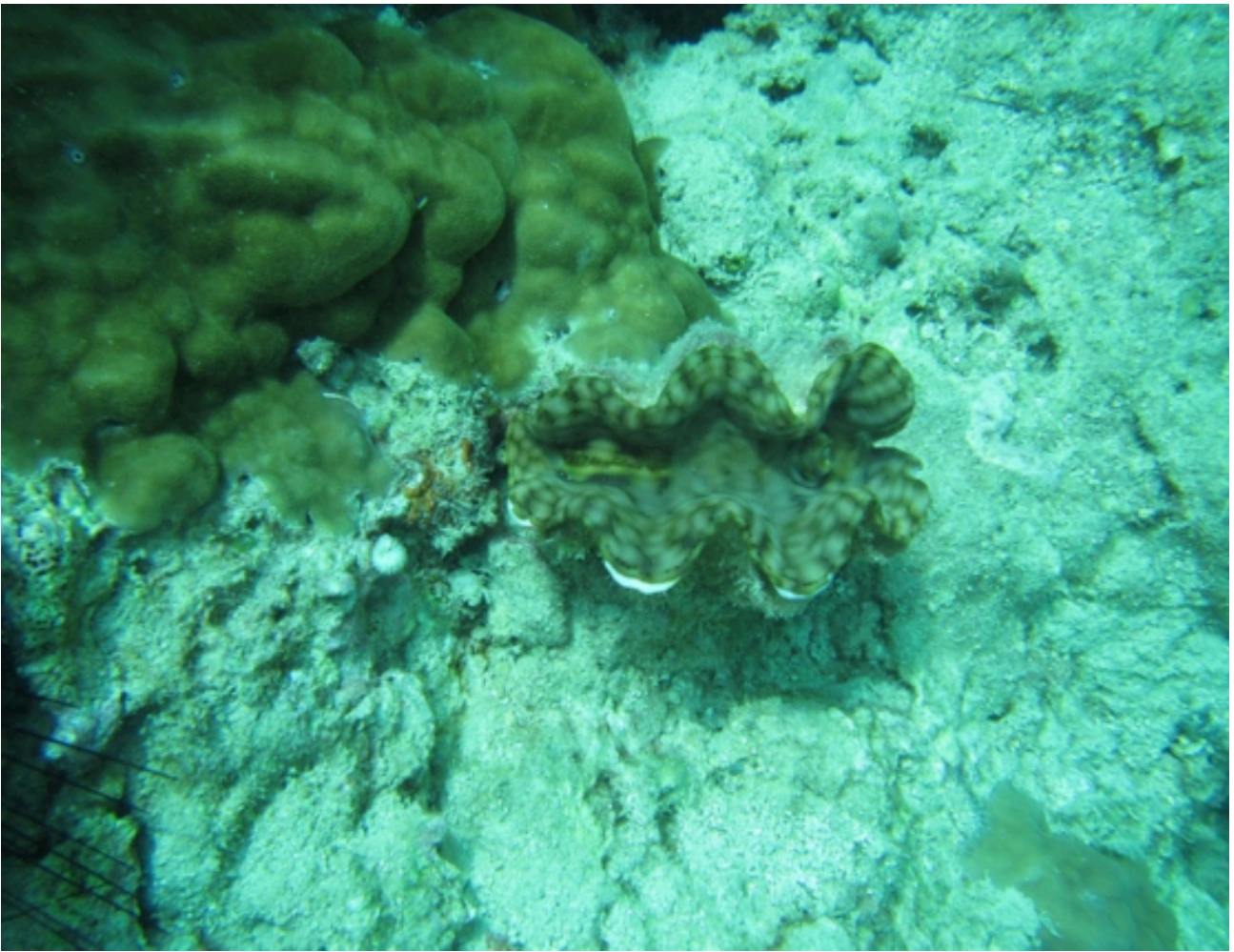
Figure 14: *Tridacna squamosa* seen in numbers at Blacksands
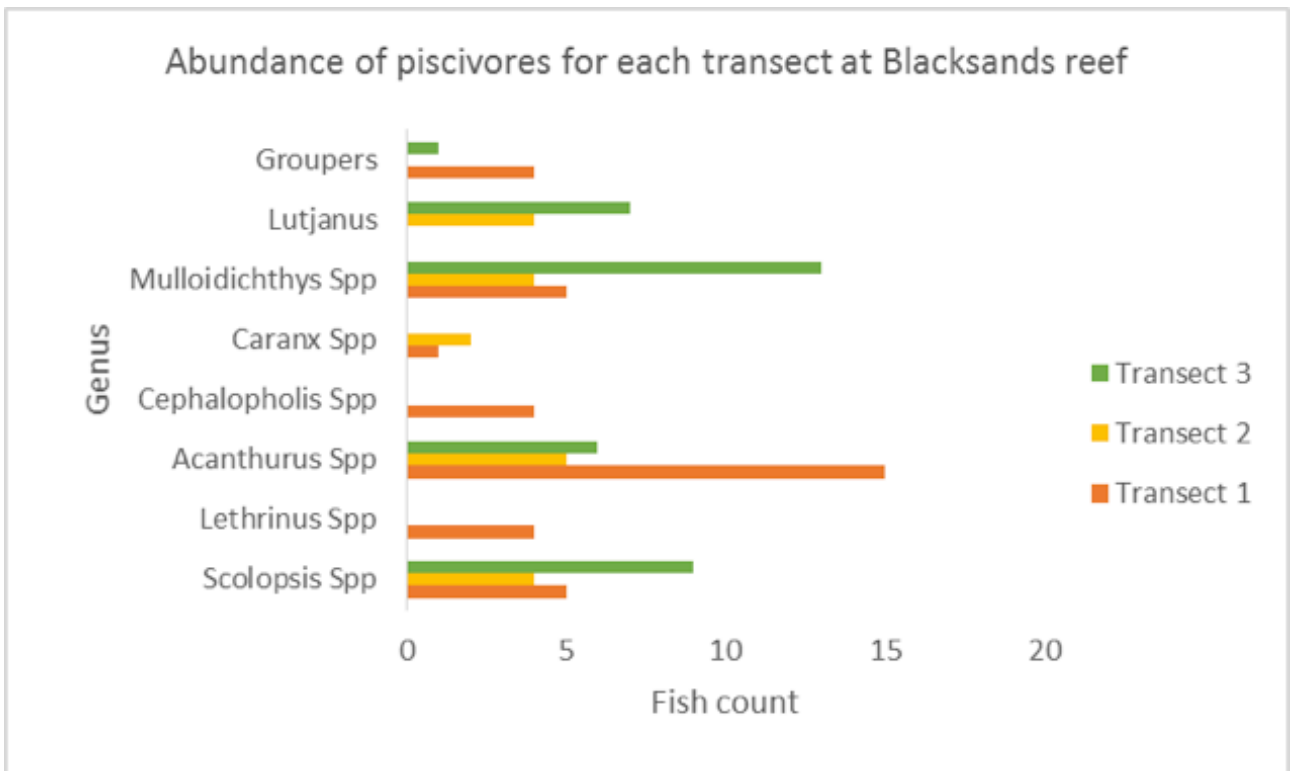
Figure 15: Counts of piscivores at Blacksands reef

Figure 16: Reef at Transect 3 furthest from the river mouth.

4.3   Indicator SE4 Exploitation of Living Resources

4.3.1   Habitat and Fishing Ground

Most of those interviewed had fished in coastal waters before the taboo was imposed on Blacksands reef by the traditional owners of Ifira. With the taboo, the fishers have had to fish offshore in deeper water.

4.3.2   Methods of harvesting and frequency

The main methods used were canoe and hand line, motorised boat, and handline (trolling), net, speargun and reef gleaning. Some fishers fished daily while others fished once a week. Most of those interviewed said that they fished two or three times a week.

4.3.3   Consumption patterns

Much of the catch is sold to fellow community members and some at the market, so fishing is an income generator in Blacksands community. Of the 27 fishers interviewed, only six fished solely for subsistence while the rest engaged in both commercial and subsistence fishing.

4.3.4 Targeted fish species and economic value

The finfish species caught most frequently by the fishers are listed in Table 2. Of the species listed, the 'karong' and 'poulet' fetch the highest average price of VT800/kg – VT1000/kg while at the other end of the spectrum the 'mangru' fetches an average of VT250/kg.

Table 2: Common fish species caught by fishermen from Blacksands community.

Local name	Common English name	Scientific name	Preferred habitat
Red maut	Emperor	*Lethrinus* sp.	Seaward reef
Karong	Trevally	*Caranx* sp.	Seaward reef
Red fish	Squirrelfish	*Neoniphon* sp	Seaward reef
Rice fish	Grunter	*Tarapon jarbua*	Shallow lagoon
Black fish	Surgeonfish	*Acanthurus* sp.	Seaward reef
Poulet	Deepsea snapper	*Etelis* sp.	Seaward reef
Pico	Rabbitfish	*Siganus* sp	Lagoon and coastal reef
Mangru	Scad	*Decapterus macarellus*	Seasonal in lagoon
Rainbow fish	Striped surgeonfish	*Acanthurus lineatus*	Seaward reef
Mustas fish	Goatfish	*Mulloidicthys* sp	Lagoon and coastal reef
Blue fish	Parrotfish	*Scarus* sp	Seaward reef

5.0   DISCUSSION

5.1   Indicator E1 Diversity

Direct observations by the assessment team revealed that Zone 3 of the catchment is primary forest but is being disturbed by activities such as gardening and logging (Figure 17). Whenever there is a gap created in forests, invasive plants are quick to invade, thus the prevalence of *Merremia peltata* in WPZ 3 (Figure 18).

Figure 17: Area cleared for gardening adjacent to forested area in Water Protection Zone 3

Merremia peltata and *Mikania micrantha* (mile-a-minute) are among the top 30 invasive plants in the Pacific, are known to smother growing trees and are so pervasive that fruits of trees are not able to take seed. They can eventually cause the extirpation of native species (Meyer 2000). For instance, in another Pacific island country, Samoa, it has been suggested that up to 50 per cent of the remaining lowland native forest is dominated by *M. peltata* (MNRE 2013).

The high endemicity of the flora of Tagabe catchment, particularly in WPZ 2 and WPZ 3, and the presence of the critically endangered Bangulu Palm (Figure 19), the endangered Montgomery Palm and Pacific Kauri (Figure 20), renders the catchment of high conservation value. Port Vila is recognised for having one of the world's rarest tropical forest areas with high endemism (Blaschke et al. 2017).

Figure 18: *Merremia peltata* has taken over large swathes of WPZ 3

There was a marked decrease in timber trees from the upper to the lower catchment due to the prevalence of farmland. The presence of rare species particularly in WPZ 2 makes it critical to engage with leaseholders to ensure protection for these species. The two farms, Bellevue Ranch and Edward Cruby Farm, each had at least two endemic and three native species each.

The number of introduced species in an area is an indicator of disturbance. Introduced species were observed in WPZ 1 and WPZ 2 where land has been cleared for farms. One sign of a healthy forest

is the absence of alien weedy species and the converse is true. WPZ 1 had the highest incidence of invasive species followed by WPZ 3. Meyer (2000) compiled a list of 18 invasive plants for Vanuatu, but the number has increased in the intervening period as proven in the number of invasive taxa recorded for this study alone. Of the 18 species recorded, 11 were considered dominant invaders of which 6 were recorded as present in Tagabe catchment in the current study. One of these dominant invaders, the Ecuador laurel tree (*Cordio alliodora*) is found only in Vanuatu and was seen in WPZ 1.

The Forestry Department has recommended the establishment of corridors for rehabilitation. The botanical garden that the GEF IW Ridge to Reef project is re-establishing will be in Zone 1, but the zone needs maintenance such as fence clearing and litter collection, which the local community could be engaged in doing.

The PEBACC project is planning to establish a community nursery at Blacksands to grow vetiver grass, bamboo and pandanus. The community nursery will provide plants for regeneration but will also serve as a source of income for community members. The PEBACC project will also work with the Forestry Department in building up the existing nursery with mangrove species and other species such as vetiver grass, bamboo and Natangora for restoration of the riparian zone at the mouth of the Tagabe River.

Figure 19: The critically endangered *Carpoxylon macrospermum* or Bangulu Palm is in WPZ 1

Figure 20: The endangered *Agathis macrophylla* or Pacific Kauri is also found in WPZ 1.

5.2   Indicator E3 Habitat Quality

The Ifira Marine Management (IMM) team developed a management plan for the ICCA which stipulates different activities to reduce anthropogenic effects on the coastal environment. The plan also stipulates fines that will be imposed on those who breach the regulations regarding, for example, the harvesting of crabs, undersized catch, and solid waste disposal (IMM 2017). The IMM Committee uses municipal wardens to patrol the area however, it does not have any legal powers as the ICCA is not officially gazetted. This is problematic as there are several parties that hold jurisdiction in the area: the municipal council, the SHEFA provincial office and the customary landowners.

The RapCA marine assessments will provide the IMM team valuable baseline data for the ICCA. The data collected showed that the taboo imposed by the IMM Committee in 2017 is already beginning to show positive results. The invertebrate surveys revealed an abundance of giant clams *Tridacna maxima, T. crocea* and *T. squamosa*, followed by sea urchins, *Tripneutes gratilla. Tridacna squamosa* stocks are depleted on the reefs of the other islands in Vanuatu so their presence on a reef so close to a large community shows the effectiveness of the taboo. The presence of piscivores like emperors, snappers and surgeonfish is also a positive outcome of the taboo imposed. The low counts of butterflyfish recorded could be due to the low coral cover. Chaetodonts are an indicator species for reef health so their numbers are proportionate to hard coral cover. The low coral cover is to be expected for a reef that is in close proximity to a river mouth. The further the reef transect from the river mouth, the greater the faunal diversity. This is because catchments are the conduit for sediments from deforestation and other land use practices, nutrients from runoff and sewage, pesticides from farming and large volumes of freshwater to the coast, all of which have a detrimental impact on the health of adjacent reefs (Wilkinson and Brodie 2011).

The underwater survey done by the PEBACC project in Blacksands had similar results for the benthic type and determined percentage cover for hard coral to be 18 per cent (Blaschke et al. 2017). The PEBACC survey registered higher algal cover and lesser rocky substrate than the current study. Rather than doing fish counts, four divers who had extensive experience of diving in Vanuatu, were interviewed by the PEBACC project on their perspectives on the reef at Blacksands. All four divers stated that there had been a loss of top predators, piscivores, herbivores and invertebrates from the reef which had caused the cessation of commercial diving in the area for the last 15 years. All groups appear to have made a return, most likely due to the taboo placed on the area.

5.3   Indicator SE4 Exploitation of Living Resources

The taboo requires fishers to fish 500 m away from the coastal reefal area. The favourite target species of the fishermen would indicate that they have moved offshore to fish on outer reef slopes as a result of the taboo. Of the species listed in Table 2, all but three species are found in deeper water. Some fishers pool resources and fish in motorised boats further offshore; others troll and use nets. Some use nets that have 1" mesh, while others are using mosquito nets, both of which will catch undersized fish.

Most respondents (78 per cent) fish commercially, so it is an important source of revenue for the community. Their primary market is fellow community members of Blacksands. Trevally and deep-sea snapper are the most lucrative species, with the smaller shallow water species fetching a much lower price. The lone female respondent gleans on the reef and uses an iron rod for spearing fish in shallow waters. The lack of female respondents is likely due to the taboo restricting their fishing activities as women traditionally only fish inshore. With their fishing curtailed, many were found on the days of the creel survey to be playing bingo instead, which may, in fact, constitute an alternative source of income for the women.

The respondents were generally fine with the taboo but felt it had gone on for too long. The taboo will be lifted on special occasions e.g. 24 July – Children's Day and 30 July – Independence Day. At the time of writing, the taboo had been lifted since Christmas 2018. A re-survey of the transects would be interesting to see what, if any, impacts the lifting of the taboo has had on the invertebrate and finfish stocks.

Of the three indicators measured as part of the RapCA, the primary data collected from the creel survey was the least robust. There were several reasons for this. Firstly, the enumerators were not trained sufficiently by the author on the use of the questionnaire and the information being sought in each section. The information provided on the size of the catch was subjective. There were no measurements made on site of the lengths and weights of the catch. The information on size and weight was provided anecdotally so there were inconsistencies in figures given. The fishermen were also reluctant to give honest answers regarding their catch out of fear of reprisals.

5.4   Indicator E6 Water Quality

The indicator was not measured in situ due to a lack of equipment, but the UNELCO power plant does regular monitoring of the groundwater and surface water in Tagabe catchment. The Marine Economies Programme (MEP) also conducted water quality tests and toxicity tests at 19 sites in and around Port Vila. Results produced by both agencies in 2018 for the site in Tagabe River under the road bridge showed faecal coliform levels well above the 200 cfu/100 ml deemed safe by international agencies such as US EPA and the EU Bathing Waters Directive (Devlin et al. 2018). In fact, the Tagabe Bridge site showed the highest water toxicity of all 19 sites sampled by the MEP team. The high faecal coliform levels are due to sewage pollution emanating from the pit latrines and water seal septic tanks located on the riverbank (Tawney 2006). The high toxicity is due to some industrial activity (Devlin et al. 2018). Solid waste disposal has been a major issue in the catchment, but the findings of these recent studies would indicate that sewage pollution also needs to be addressed with some urgency.

The Live and Learn Office in Port Vila has conducted extensive public awareness raising in the Blacksands community on water and sanitation issues (I. Bakaniceva, pers.comm.). Many of those in the Blacksands community are from the outer islands who have migrated to Port Vila for employment and education. They do not have a formal lease to the land upon which they have built their homes and the insecurity is a deterrent to building a permanent toilet structure for many households. Another major problem within the community is the sharing of unimproved toilets, which is basically a pit toilet with a slab and commonly referred to as the *bush toilet*. A bush toilet can be shared by 25–50 persons, leading to water quality and health issues. Some of it has to do with cultural perceptions, where a phone, fridge or TV is considered of higher priority than a permanent toilet. Live and Learn has been promoting the Ventilated Improved Pit (VIP) latrine, which includes a septic tank and a vent however, the community buy-in has been slow. The poor sanitary conditions are likely contributing to the high faecal coliform counts seen downstream.

6.0   Conclusion

The RapCA for the Tagabe Catchment successfully provides a new set of primary data important to establish baseline governance, socio-economic and environmental indicators for the State of the Coast and Rapid Coastal Assessment. The baseline indicators provide the basis for periodic future indicators for monitoring progress and tracking the achievement of targets and contributions of the Vanuatu IW R2R demonstration project. While the assessment is focused only on four indicator categories, the results provide a wealth of important ecosystem related data that can used in future upscaling and future R2R investments and integrated coastal management planning. The findings of the assessment also add value to the characterisation of project sites and the identification and prioritisation of spatial ecosystem 'hot-spots' for protection and management using R2R investments.

The results of this assessment have revealed high endemism in the forests of Tagabe catchment. A critically endangered plant species, the Bangulu Palm, is found in the catchment. Two endangered plant species, the Pacific Kauri, and the Montgomery Palm, are also found in the catchment. The Forestry Act 2001 [Cap 276] allows for forest areas of scientific importance to be declared Conservation Areas and for the protection of specific plant species. The forests at Tagabe catchment are of high conservation value due to the high endemism and the presence of critically endangered plant species and it is recommended that it be declared a Conservation Area so that all commercial activities are prohibited. The Forestry Department has earmarked forest conservation and reforestation of the TCRMA as a high priority (Govt of Vanuatu 2018) and the results of this assessment serve to confirm the need for conservation.

The invasive plants need to be managed. If their growth can continue unabated, the native plant species, ecosystem services and ultimately the livelihoods of people dependent on forest biodiversity will be impacted. Vanuatu has 98 per cent of land under custom ownership, which makes the implementation of national plans such as the National Invasive Species Strategy and Action Plan (2014–2020) more challenging. The management of invasive species requires a multi-sectoral approach involving all stakeholders who benefit from the goods and services provided by the catchment (Lenz et al. 2019).

It is recommended that fish and invertebrate counts be repeated on the same transects to determine the impacts of the lifting of the taboo in the ICCA in December 2018. The presence of species such as the giant clam, *Tridacna squamosa*, in Blacksands reef when numbers have dwindled on reefs of the other islands in the archipelago is significant (R. Kaku pers. comm). All recreational diving in Blacksands ceased in 2003 due to low coral cover and loss of piscivores, both of which were primarily attributed to land-based pollution. Coral cover is still low at 20 per cent, but the presence of piscivores in the current study after the taboo had been imposed for a year, would indicate that the disappearance may have been due to fishing pressure instead.

There were many lessons learnt in this first trial of the RapCA . Sufficient preparatory work before the field survey proper will ensure the cooperation of stakeholders, the efficient use of resources, the collection of scientifically robust data and reduce misinformation. The methodologies need to be sorted out well before the commencement of fieldwork to ensure necessary consumables and equipment are purchased well in advance. Necessary approvals to access the study need to be secured well in advance. This is particularly relevant where private properties are concerned. Communication with project partners is critical to avoid unnecessary duplication of effort. Enumerators in the creel survey must be given ample training in the administration of the questionnaire to ensure they understand the information being sought before they commence interviews. The community and provincial liaison officers must be fully briefed on the purpose of the creel survey well before the exercise. That will eliminate any suspicions and misinformation and ensure that answers provided

by interviewees are reliable. Those collecting data in the field must pay attention to detail when recording data to reduce anomalies. Sampling design for the forestry assessment showed some bias and the plots were too large. Future plots for assessment should be smaller i.e. 500 m^2 so that a greater number can be sampled. The primary author needs to remain in country after the fieldwork is completed so that when doing data analysis, any discrepancies can be resolved immediately.

Additional recommendations include:

- The need to develop a R2R National Monitoring Protocol to further assess the effectiveness of these interventions.

- The development of permanent vegetation sampling plots for both flora and fauna assessments would require proper GPS coordinate recording, mapping, and physical marking on-site to ensure that sites are easily accessed and identified, and methodologies easily replicated.

- Vegetation data gathered on biomass can be useful in modelling indicators for climate change mitigation in the future.

- The incursion of invasive species into forested areas has been highlighted in this report. Sampling efforts to measure the incursion of these invasive species into forested areas are essential and this will further lead to the development of management plans towards forest conservation efforts.

- Further geo-spatial assessments of invasive species incursions can analyse both current and model future distribution patterns. This can better inform decision making in conservation and protected areas.

- Data gathered in such rapid assessments need proper data gathering records such as: GPS records for sampling plots or areas surveyed analysis on the degree of endemism, distribution, and threats to the flora and fauna as a measure of the conservation value of the assessed areas.

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ANNEXES

Annex 1: Suggested List of Governance, Socio-economic and Environmental Indicators for State of the Coasts Report and Rapid Coastal Assessment

Code	Indicator	Measurement	Type/Focus					Collection Techniques	Existing Data
			D	P	S	I	R		
G1	Legislation	o Existence of legislation for R2R o Adequacy (matrix) of legislation (including gender assessment) o Ratification of MEA's and regional policies and frameworks o Protected areas						- Document review - Interviews with NRM managers and other experts - Surveys	-
G2	Traditional Governance	o land tenure type o presence of traditional governance mechanisms						Document and record review	-
G3	Coordinating Mechanism	o Existence of coordinating mechanisms for various sectors (or cross-sectoral) and legal basis o Participation o Stakeholder representation						- Document review (meeting records etc) - Interviews with NRM managers and members	-
G4	Management plans	o Existence, characteristics, and status of NRM plans o Extent (percentage) area covered by NRM plans						- Document review - Interviews	-
G5	Active management	o Level of implementation of plans o Procedures, legal tools, and monitoring and sanctioning applied for enforcement of NRM plans/actions o Level of enforcement of, or compliance with, NRM plans						- Document review - Interviews - Surveys	-
G6	Monitoring and evaluation	o Monitoring programs at sites o Existence of an operational monitoring and evaluation system with related indicators within NRM Plans						- Document and record review	-

		o Consideration of results and adjustments in NRM initiatives					▓		
G7	Stakeholder Participation	o Community practice in landcare, coastal care and marine care groups (e.g. LMMA)			▓			− Interviews − Surveys − Document review	−
G8	NGO and CBO activity	o Existence and characteristics of NGOs and community organisations active in land, coastal, marine and biodiversity conservation o Level of activity of NGOs and community organizations			▓			− Document reviews − Interviews	−
G9	Knowledge and Training	o Education and training programmes that incorporating ICM/IWRM/NRM o Number of community receiving relevant information o Number and % of community practices informed by information and evidence					▓	− Document and record review − Surveys − Interviews	−
G10	Risk Management	o Availability of hazard maps o Availability and coverage of emergency response plans o Institutional mechanism for emergency response o Availability and coverage of risk based urban planning					▓	− Document and record review − Interviews	−
SE1	Demographics	o Population size, distribution o Levels of education (sex disaggregated) o Levels of employment (sex disaggregated) o Site specific total income			▓			− Database − Document review	−
SE2	Human pressures on habitats	o Population density o Land use/land cover patterns o High impact fishing gear practices o Number and location of ports o Extractive resource use (sand mining, dredging, mangrove harvesting)	▓					− Monitoring programs − Databases − Interviews − Surveys	− DEM and land use − Ministry of Ag. and Forestry

		o Number and location of waterways extraction (dredging, mining) o Tourism (?)							
SE3	Pollutants and introduction	o Population % access to improved functioning sanitation o Number, location and estimate volume of point source discharges (coastal and surface water) o Non-point source nutrient loading (fertiliser imports) o Number and location of informal settlements						− Monitoring programs − Databases − Document review − Surveys − Interviews	−
SE4	Exploitation of living resources	o Consumption patterns (marine and terrestrial resources) o Economic value o Targeted species (fauna and flora) o Harvest and fishing areas o Frequency of harvest/fishing o Methods of harvest/fishing						− Document review − Database − Interviews − Surveys	−
SE5	Coastal protection	o % of shoreline with natural protection o % of shoreline with human-made protection (proportion adhoc or engineered)						− Surveys − Document review	−
E1	Diversity	o Occurrence of special species (marine and terrestrial) o Occurrence of invasive species (marine and terrestrial) o Richness of fish communities o Richness of coral communities						− Species inventory − Sampling − Monitoring programs	− Birdlife International for Atolls − Pacific Invasive Learning Network − PROCFISH − SPC
E2	Abundance	o Juvenile coral o Marine flora o Biomass (key fisheries) o Number of individuals (marine mammals)						− Monitoring programs and surveys	− Turtle Database − SPREP − PROCFISH

E3	Habitat quality	o Coral health o Habitat type (coast and catchment) o Habitat cover (coast and catchment) o Mangrove and seagrass health						− Monitoring programs and surveys − Remote sensing − Databases	− Vegetation of Tropical Island Pacific (book) − Art Whistler (book) − Seagrass Watch − FAME developing a methodology for seagrass
E4	Species health	o Richness of threatened and vulnerable fisheries species						− Monitoring programs and surveys	− PROCFISH
E5	Biodiversity hotspots (coast and catchment)	o Key biodiversity areas o Important bird areas o Protected areas o Recently identified priority areas (BIORAPs) o Nationally threatened and endemic species						− Document review − Interviews − Databases − Surveys	− National and Regional KBA − Birdlife International − BIOPAMA – SPREP − BIORAP – SPREP − Review of surveys, list of species (not in IUCN), NBSAP
E6	Water quality (coast and catchment)	o Physico-chemical parameters o Nutrient concentration (phosphate and nitrates/nitrites) o Faecal coliform o Chlorophyll a concentration o Incidence and duration of harmful algal bloom (coast) o Defined and enforced riparian zones (catchment)						− Monitoring programs − Sampling	− IAS − FAME
E7	Shoreline stabilisation	o Shoreline erosion o Shoreline accretion						− Monitoring programs	− GSD

Annex 2: Fish and Marketing Survey (Creel Survey Form)

Creel survey carried out by (enter organization/ department):

HQ N0. Village:………………………………… …	Name of Interviewer:……………………………………….. Date of Interview:……………………............
First Name:…………………………………… ………. Last Name:………………………………… Male/ Female/other (circle your answer) Age(refer to age range)……………………….. Home island:……………………………	N0.of members of household:………………. Man/Woman (25-60 yrs.):……………. 61 yrs> (Man/Woman):…………. Who fishes in the household, M/W? ………………………………………………………………………… ……………….

Section A: Habitat and Fishing Ground

1. Which areas do you fish?
    a. Coastal Reef
    b. Outer reef
    c. Mangrove
    d. Reef Flat

Site	Location (on map, lat/long, or distance to each fishing ground
1.	
2.	
3.	
4.	
5.	

2. Do you go to only one habitat per trip?

3. If, no how many and which habitats do you visit during an average trip?
    a. Coastal Reef
    b. Outer Reef
    c. Mangrove
    d. Reef Flat

4. How often do you fish in each of the habitats visited?
    a. Days
    b. Weeks
    c. Month

Section B: Methods of Harvesting

1. Fishing method/ gear used for each species group *(separate pelagic fish, reef fish, crabs, lobsters, etc.) how many people involved and how much time spent doing each activity?*

Methods	Species group	Number of people in your household involved in each fishing trip	Men/Woman	No. hours in each fishing trip/month	No. of fishing trips per week/month	Period (Night or Day)
Use canoe						
Nets (circle appropriate) Cast net / seine net						
Vertical Line (deep down)						
Boat with engine						
Spear gun						
Reef gleaning						
Hand line/ Pole line						
Other fishing gears						

2. Do you use more than one technique per trip for this habitat? If yes, which ones usually? *(Specified from the above)*

Section C: Consumption Patterns

3. **What type of Fish you usually catch for your family and for marketing?**

Market (Commercial)

Common Name	Language Name

Family (Subsistence)

Common Name	Language Name

4. **How many hours spent on the fishing trip each today for commercial purposes? _____Hrs**

5. **How many hours spent on the fishing trip each day for subsistence purposes? _____ Hrs**

6. **Are there annual seasons/periods that you engage intensely in fishing?**
   a. **Months**

7. **How many kilos of fish do you usually catch in one trip? (*Tick*)** *For this table if they don't give you the weighed amount just write down the number of fish caught.*

Methods	1-5 kg	6-15kg	15-30kg	Over 30 kg
Use canoe				
Nets (circle Appropriate) Cast net/ Seine net				
Vertical Line (deep bottom)				
Spear gun				
Reef gleaning				
Boat with engine				
Hand line/ Pole line				
Other fishing gears				

Section D: Targeted Fish Species and Economic Value

8. **What type of fish you normally catch/target during a fishing trip and how many?** (*Ask for number of fish in 0ne plastic*)

Type of fish you catch	Kg/ number of the catch	Kg/ number of fish caught	Kg/ number of fish sold	Expected income from overall catch sold?

9. **If you market the fish, who are the buyers of your fish?**

    a.   **Your community members**
    b.   **Other community members**
    c.   **Road Market?**
    d.   **General Public?**
    e.   **Other**

10. **What types of fish is highly demanded by purchasers?** (*Rank them from high to low demand))*

Type of Fish	Ranks of Demand

Fishing Activities

6. User (age, gender, status)	

1. Fishing gears	2. Method (use of canoe or boat or wade)	3. Number of this gear you have		4. Targeted fishes	5. Period of use (month. Season, etc)
		Today	Before		
Fishing line					
Nets (circle appropriate) Cast net/ Seine net					
Spear gun					
Boat with engine					
vertical line (deep bottom)					
Reef gleaning					
Other					

7. Purposes of fishing (rank) Food (F); Kastom (K); Sold (S) – Nature of Sales?	
8. Catch (rank- per year)	
9. Effectiveness (rank- per hour)	