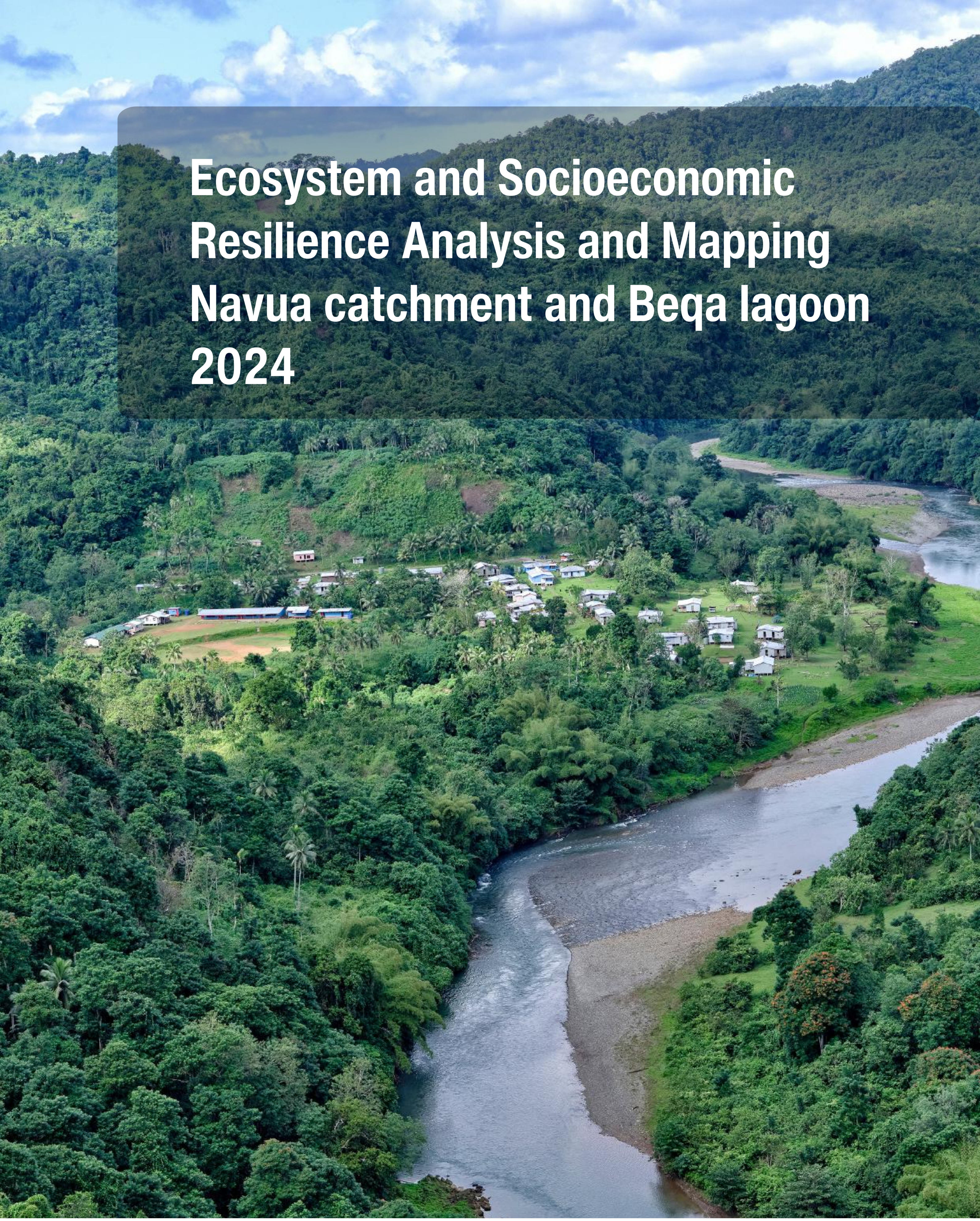
Ecosystem and Socioeconomic Resilience Analysis and Mapping Navua catchment and Beqa lagoon 2024



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This report is part of a series of studies and discussions and consultations with the people of Fiji who live within the Navua catchment and Beqa lagoon. The work culminated in the development of an Integrated Ecosystem Management Plan for the Navua catchment and Beqa lagoon and is testament to the commitment of these communities to prosper sustainably and in harmony with their natural ecosystems. We thank and acknowledge all the communities within the catchment and lagoon who supported the development of the plan. The Government of Fiji supported the development of this plan through input and review from several government agencies including the three provincial governments and various line ministries.

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Acronyms

BioRap	Rapid biological assessment
COTS	Crown of thorns starfish
EbA	Ecosystem-based Adaptation
ESRAM	Ecosystem and Socioeconomic Resilience Analysis and Mapping
ESV	Ecosystem and Socioeconomic Vulnerability
ESVOA	Ecosystem and Socioeconomic Vulnerability and Opportunity Assessment
GEDSI	Gender, Equity, Disability and Social Inclusion
GSI	Gender and Social Inclusion
IEMP	Integrated Ecosystem Management Plan
MPA	Marine Protected Area
PEUMP	Pacific-European Union Marine Partnership
SOGIESC	Sexual orientation, gender identity and gender expression, and sex characteristics
SPREP	Secretariat of the Pacific Regional Environment Programme

1 Introduction

1.1 The project

The Pacific-European Union Marine Partnership (PEUMP) Programme promotes sustainable management and sound ocean governance for food security and economic growth, while addressing climate change resilience and conservation of marine biodiversity. It follows a comprehensive approach, integrating issues related to oceanic fisheries, coastal fisheries, community development, marine conservation and capacity building under one single regional action. The PEUMP is built around six Key Result Areas (KRA).

Designed to meet KRA 5 of the PEUMP, the By-catch and Integrated Ecosystem Management (BIEM) Initiative is led by the Secretariat of the Pacific Regional Environment Programme (SPREP) to support Pacific countries deliver their priorities to halt the decline of protected marine species, strengthen the sustainable management of their coastal and marine ecosystems and support poverty reduction. The objective of the BIEM Initiative is "*to reduce the by-catch of threatened species in Pacific islands' fisheries and to improve the health of coastal ecosystems through an integrated approach to coastal management and ecosystem-based adaptation to climate change*".

The current project underpins KRA 5.2 and 5.3 of the BIEM, which focus on supporting adoption of integrated 'ridge to reef' ecosystem management and climate change adaptation. To support these KRAs, the project seeks to address the economic, social and environmental challenges of the Navua catchment and Beqa lagoon by halting the decline of biodiversity and strengthening the sustainable management of the coastal and marine ecosystems through an integrated ridge to reef management approach.

Specifically, this project aims to:

> *"Address these challenges by developing and implementing a gender, social inclusion (GSI) and human rights sensitive integrated ecosystem management (IEM) plan for Navua catchment and Beqa Lagoon area, Central Division, that identifies realistic activities to increase the natural adaptive capacity of coastal habitats to promote human health and poverty reduction, support sustainable livelihoods and contribute to the delivery of Fiji's conservation priorities."*

Drawing from the project brief, the objectives of the project include:

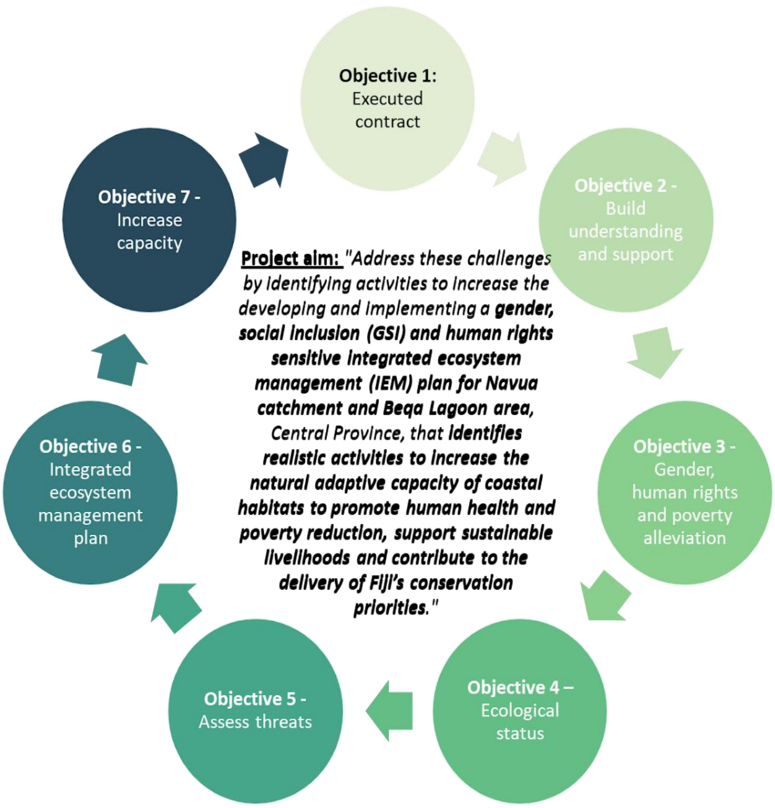
Objective 1 – Fully executed contract that delivers objectives and associated outputs to time and quality.

Objective 2 – Build understanding and support for the Navua catchment and Beqa lagoon area ridge to reef initiative amongst communities and stakeholders.

Objective 3 – Put gender, human rights and poverty alleviation considerations at the heart of the planning and implementation of activities.

Objective 4 – Map and assess the ecological status of the selected coastal area and associated catchments that coastal communities depend upon for their livelihoods.

Objective 5 – Assess the threats to ecosystems, livelihoods and human health as a result of current/planned resource use and the expected impacts of climate change and identify opportunities to address them.



In doing so, identify key users of selected coastal areas and associated catchments by gender, age, disability, ethnicity and socioeconomic status. Apply a GSI lens when identifying threats and risks as well as opportunities for best adaptation.

Objective 6 – Develop and secure endorsement of a widely supported integrated ecosystem management plan for the Navua catchment and Beqa lagoon area that identifies realistic activities to increase the natural adaptive capacity of coastal habitats to promote human health and poverty reduction, support sustainable livelihoods and contribute to the delivery of Fiji's conservation priorities.

Objective 7 – Work with and increase the capacity of women, men and the youth in coastal communities, Government authorities and partners to actively manage natural resources. Identify appropriate capacity building activities carefully with regards to existing power dynamics and gender roles as to meet the 'do no harm' minimum standard. Capacity building opportunities should allow, however, for empowerment and agency enhancement such as building confidence through knowledge and training or support inclusive decision making.

1.2 The study area

The Navua River and Beqa lagoon in Fiji are vital resources for the 15,000 people living in the catchment. The river provides water for agriculture, transportation and tourism activities such as rafting. The Beqa lagoon, a large, enclosed bay protected by a reef, is a rich ecosystem with cultural significance and supports fishing and tourism. However, these resources are threatened by activities such as land degradation from logging and overfishing in the lagoon. Climate change is expected to worsen flooding and erosion, harming the environment and people's livelihoods. Women and people with disabilities are especially vulnerable due to limited access to resources and decision making.

1.3 Purpose of this report

This report presents the Ecosystem and Socioeconomic Resilience Analysis and Mapping (ESRAM) prepared as part of Objective 4. ESRAM is a framework employed globally to evaluate and strengthen the resilience of both, natural ecosystems and the socioeconomic systems closely linked to them. ESRAM provides an integrated approach that considers both ecological and social dimensions, providing decision-makers with a systematic tool to analyse relationships between ecosystems and the communities they support. By mapping vulnerabilities and strengths using GIS software, ESRAM helps identify and enable the design of adaptive strategies for sustainable development.

The identification of ecosystem-based adaptation options is critical in dynamic environmental and socioeconomic landscapes such as those found in Fiji. Resilience through adaptive strategies is required to combat challenges like climate change, natural disasters and increases in human activities. Much of the broader evidence base is documented in other sections of the detailed project documents. This is deliberate to ensure that the reader of this report is able to focus on the key information and points.

Figure 1. Naceva village on Beqa Island

2 Scope and Methodology

This section outlines the methodology and some of the key data inputs for the ESRAM.

2.1 Identification of ecosystem services

Natural assets provide a range of benefits or 'ecosystem services' that contribute to human wellbeing through their extent and condition. 'Ecosystem services' are the benefits people obtain from the natural environment, often in conjunction with built assets (MEA 2005). According to the Millenium Ecosystem Assessment (MEA)[1], ecosystem services are categorised into four service categories:

- *Provisioning services*: all the products directly obtained from the ecosystems (e.g. fish from nursery areas within a mangroves system).
- *Regulating services*: the benefits obtained from the regulation of ecosystem processes such as mitigating the risk of storm surge.
- *Cultural services*: non-material benefits, for instance recreational/tourism, aesthetic, cognitive and spiritual benefits.
- *Habitat services*: also known as supporting services, these are natural processes that are necessary for the production of all other ecosystem services (impacts can be indirect or can occur over a very long time). For example, they could include photosynthesis, nutrient cycling and the water cycle.

Community consultation on socioeconomic implications of natural resource use and management was conducted at district level for the Navua catchment and Beqa lagoon communities (November – December 2023) with 162 participants from 53 communities [2]. Through the consultation process, a wide range of ecosystem services was identified, with stakeholders being asked to consider four key biomes in the region: native forests; land (excluding native forests); terrestrial waterways; and marine and coastal areas. The ecosystem services have been detailed and categorised into the four service groups as outlined above for each of the biomes considered.

2.2 High-level valuation of existing ecosystem services

Based on the mapping undertaken for the rapid biological assessment (BIORAP) (see Attachment 1 for a series of community maps), a high-level valuation of the existing ecosystem services was undertaken using a benefit-transfer approach. This approach is suitable in instances where data, resources and time are constrained. Benefit-transfer involves applying values from comparable studies and making necessary adjustments to accommodate the specific context, uncertainties, and limitations of the project. By applying insights from comparable research, the benefit-transfer method becomes a valuable tool in situations where the collection of original data may be challenging. This can ensure an efficient and informed analysis that specifies inputs for the broader ESRAM framework.

This benefit-transfer approach will also be supported by qualitative information from the consultation process undertaken across several villages, particularly where appropriate valuations are not available or less suitable for key ecosystem services. This consultation approach also provided a means to sense-check the values used for the benefit-transfer process. Where quantitative values could not be determined, they are captured qualitatively through the narrative.

2.3 Understanding of pressures and threats

This step in the methodology outlines the key threats and pressures to ecosystem services as identified through the consultation process. As with the identification of ecosystem services, stakeholders were asked to consider the four key biomes in the region, the ways in which they use the natural resources, and how those resources were being impacted or changed over time. This section also includes a summary of climate change projections for Fiji.

[1] The Millennium Ecosystem Assessment involved over 1,360 global experts and assessed the impact of ecosystem change on human well-being. Its findings provide a scientific basis for sustainable conservation and use of ecosystems.

[2] Raviravi District (21 participants) 29% women, 52% men and 19% youth (male); Sawau District (31 participants) 23% women, 74% men, 3% youth (male); Serua & Batiniwai (29 participants) 7% women, 93% men, no youth present; Nuku & Deuba District (30 participants) 30% women, 70% men and no youth present. People of diverse SOGIESC and persons with disability representatives had focal points that often reside outside of the communities.

2.4 Case studies

Three case studies are provided which delve deeper into ecosystem service values and their management for some priority services or locations. These are:

- Coastal mangroves for erosion protection of Queen's Road.
- Forestry management.
- Fisheries management.

These case studies were selected to better cover issues that came up frequently through the consultation process.

2.5 Other development opportunities

There were two key themes that came up repeatedly in consultation that may represent significant development opportunities for the study area in the form of water supply and waste management issues. These issues are important to consider for socioeconomic resilience and are discussed in detail.

Figure 2. Consultation with community participants

3 Identification of ecosystem services

The services provided by the ecosystems within the study area are very diverse; however, the following tables (Table 1 to Table 4) provide a summary of the ecosystem services for each of the biomes discussed with stakeholders.

Figure 3. Mangrove forest on Beqa Island

Table 1. Key ecosystem services provided by native forests in the study area

Provisioning services	Regulating services	Cultural services	Habitat services
Logging. Native forests provide materials through logging that have value for building, firewood, etc. **Hunting food.** Hunting for animals, including wild pigs provides food for communities within the Navua catchment. **Seasonal fruits.** Provisioning services within the Navua catchment include seasonal fruits, such as damu. However, it should be noted that a significant proportion of these fruit bearing trees have been cut down over recent decades. **Materials for cultural practices.** The native forests provide materials for practices such as traditional medicine, the traditional weaving of mats commonly used in community halls, wood for crafting the tanoa, and wood for the lali drums.	**Carbon sequestration.** Native forests act as vital regulators of carbon sequestration, efficiently capturing and storing carbon dioxide from the atmosphere, thus contributing significantly to climate stability and ecological balance. **Water quality improvement.** The native forests hold soil in place and therefore play a role in limiting sediment loads in the catchment.	**Recreation.** Environmental assets provide a wide range of experiential services such as bushwalking, birdwatching and fishing. **Ecotourism.** Opportunities for local communities to develop and offer ecotourism opportunities utilising the natural environment. **Local knowledge.** Species associated with native forests serve as valuable indicators for local communities (e.g. tabadamu/soge [barking pigeon]). For example, they can provide information such as early warnings of storms, contributing to traditional knowledge systems and enhancing community resilience. **Existence and bequest.** Local residents generate cultural value simply from knowing healthy ecosystems (and their component biodiversity) exist (referred to as 'existence value') and will be available for their children and grandchildren to enjoy (referred to as 'bequest value'). This includes important bird species in the Navua catchment. **Visual amenity.** Native forests in the Navua catchment are areas of outstanding natural beauty. These are important to local residents as well as to regional and international tourists.	**Native and non-native habitat.** Native forests in the Navua catchment provide vital habitat services, offering nursery environments for diverse species, including native and non-native species (albeit to a lesser extent than dedicated native forests), supporting biodiversity and ecosystem resilience.

Table 2. Key ecosystem services provided by land (excluding native forests) in the study area

Provisioning services	Regulating services	Cultural services	Habitat services
Agriculture. Agriculture in the Navua catchment, featuring crops like yaqona and taro, sustains local livelihoods, fosters food security, and preserves cultural agricultural practices. **Livestock.** Contributes to the local economy by providing sources of income, employment, and diversified food production. **Commercial non-native forestry.** Provides employment, income and subsistence opportunities for local economies through utilising non-native forest resources sustainably. **Habitation.** Local land provides space for habitation, enabling community growth, social cohesion, and cultural preservation within the Navua catchment. **Septic tank/rubbish pit space.** Accommodates infrastructure for septic tanks and rubbish pits, ensuring proper waste disposal and sanitation practices within the region. **Mining exploration.** Mining exploration occurs within the Navua catchment area. This includes the Korokayiu mine, which is prospecting for valuable minerals including copper and zinc from the region. This generates both employment and income for the local communities.	**Carbon sequestration**. Non-native forest areas also sequester carbon; however, where logging of these forests occurs, these benefits may be lost in the long-term. **Water quality improvement.** Similar to the native forests, non-native forests may hold soil in place and therefore play a role in limiting sediment loads in the catchment. Again, where logging of these forests occurs, these benefits may be lost.	**Yaqona farming.** Deeply rooted in Fijian culture, yaqona (or kava) serves as a focal point for traditional ceremonies, social gatherings and cultural practices. It has significant cultural value for fostering community bonds, supporting spiritual connections, and in preserving indigenous knowledge within the Navua catchment.	**Native and non-native habitat.** Provides vital habitat services, offering nursery environments for diverse species, including native and non-native species. Also critical in supporting biodiversity and ecosystem resilience.

Table 3. Key ecosystem services provided by terrestrial waterways in the study area

Provisioning services	Regulating services	Cultural services	Habitat services
Gravel extraction. Gravel extraction from terrestrial waterways is vital to construction projects, creating job opportunities and income streams crucial for local economies. **Fishing.** Fishing in terrestrial waterways sustains communities by providing both income and essential food sources, such as prawns, eels and fish, thereby supporting livelihoods, ensuring food security and preserving cultural practices deeply tied to traditional fishing methods and lifestyles. **Water supply.** Terrestrial waterways play a pivotal role in supplying freshwater for human consumption, agriculture and industrial processes. **Transport.** Terrestrial waterways serve as efficient transportation routes, fostering trade, connectivity and economic growth within the Navua catchment.	**Flood mitigation.** Terrestrial waterways significantly contribute to flood mitigation by absorbing and gradually releasing excess rainwater. This natural regulation reduces the risk of flooding, protecting communities, agricultural lands and infrastructure.	**Local swimming.** Swimming in creeks and waterfalls along terrestrial waterways boosts tourism and local recreation, providing cultural spaces for relaxation, nature appreciation and community bonding. R**ecreation/tourism.** River tubing, boat rides and other water-based tourism activities in the area generate income, attract visitors and promote appreciation for biodiversity and conservation. These activities may also contribute to fostering sustainable tourism practices and environmental awareness. They are also often combined with other tourism activities (e.g. village visits) in local villages which generate greater economic activity. **Visual amenity.** Waterway assets in the Navua catchment are areas of outstanding natural beauty. These are important to local residents as well as to regional and international tourists.	**Native and non-native habitat.** Provides vital habitat services, offering nursery environments for diverse species, including native and non-native species. Also critical in supporting biodiversity and ecosystem resilience.

Table 4. Key ecosystem services provided by marine and coastal assets in the study area

Provisioning services	Regulating services	Cultural services	Habitat services
Fishing. Fishing in marine and coastal areas within the Navua catchment sustains communities and provides essential food sources like prawns, eels and fish, supporting both income generation and subsistence needs while preserving cultural ties to marine resources. **Mangroves.** Mangroves in marine and coastal regions supply firewood and building materials, offering sustainable resources for fuel and construction. **Transport.** Marine and coastal areas serve as vital transportation routes, facilitating the movement of goods and people, while enhancing connectivity and economic development within the Navua catchment.	**Reef coastal protection.** Local reefs in the Navua catchment play a vital role in protecting the coastline from wave energy, while mitigating the impacts of erosion and safeguarding coastal communities and infrastructure from the impacts of storms and sea-level rise. Furthermore, they provide for safe anchorage of boats. **Mangrove coastal protection.** Mangroves along marine and coastal regions serve as natural barriers, effectively reducing wave energy and protecting coastal areas from erosion, storm surges and other extreme weather events. These effectively enhance coastal resilience and ecosystem stability. Furthermore, they provide for safe anchorage of boats. **Carbon sequestration.** Carbon sequestration from marine and coastal assets within the Navua catchment help mitigate climate change by absorbing and storing carbon dioxide, contributing to global efforts to reduce greenhouse gas emissions and maintain environmental balance.	**Recreation/tourism.** Diving, snorkelling, surfing, kayaking and other tourism activities in marine and coastal areas generate income, attract visitors and promote appreciation for marine biodiversity and conservation. These activities also contribute to fostering sustainable tourism practices and environmental awareness. **Visual amenity.** Marine and coastal assets in the Navua catchment are areas of outstanding natural beauty. These are important to local residents as well as to regional and international tourists.	**Mangrove nursery habitat.** Nursery habitats in mangroves in coastal areas provide essential environments for juvenile marine species, supporting their growth, development and biodiversity. These habitats play a crucial role in maintaining healthy marine ecosystems, sustaining fish stocks and enhancing coastal resilience against environmental stressors. **Coral reef habitat.** Coral reef habitats serve as critical assets for the Navua catchment and Beqa lagoon region specifically. The lagoon's coral reefs support an array of marine species, including fish, invertebrates and coral colonies. These reefs serve as essential breeding grounds, nurseries and feeding areas for various marine organisms, contributing to the region's biodiversity.

4 High-level valuation

De Groot et al. (2012) provide a wide range of international ecosystem values that have been collected from over 300 case studies. These provide medium or 'more likely' estimates of the monetary value of ecosystem services from 10 different biomes, including those present in the Navua catchment, as well as minimum and maximum ranges collected from various sources. These more likely estimates represent the median values outlined in De Groot et al. (2012). Estimated values for these biomes were applied across both land types and marine types for the Navua catchment, using appropriate benefit-transfer methods, including indexing to 2023 Fijian dollars. Values were also rounded to the nearest $100 for simplicity. These ecosystem values have been presented in Table 5 and Table 6 for land type and marine type, respectively, in 2023FJD per hectare per year.

Table 5. Unit values applied to land/asset type (FJD/ha/year)

Land/asset type	De Groot (et al.) biome type	More likely value	Range (low to high)
Cleared land*	N/A	N/A	N/A
Forestry lease	Tropical forest	$18,000	$5,400 to $71,200
Native forestry	Tropical forest	$18,000	$5,400 to $71,200
Human habitation*	N/A	N/A	N/A
Lowland mixed	Tropical forest	$18,000	$5,400 to $71,200
Lowland primary	Tropical forest	$18,000	$5,400 to $71,200
Mangrove	Coastal wetlands	$661,700	$1,000 to $3,030,500
Near-coastal forest	Coastal wetlands	$661,700	$1,000 to $3,030,500
Upland forest	Tropical forest	$18,000	$5,400 to $71,200

*Note these land types were excluded from valuation by De Groot et al. (2012), as discussed below.

Table 6. Values applied to marine/asset type (FJD/ha/year)

Marine/asset type	De Groot (et al.) biome type	More likely value	Range (low to high)
Live Coral	Coral reefs	$352,249	$125,600 to $7,267,400
Live Coral/Dead Coral Matrix	Coral reefs	$352,249	$125,600 to $7,267,400
Coral Rubble/Dead Coral	Coastal systems	$28,917	$89,300 to $143,600
Sand	Coastal systems	$28,917	$89,300 to $143,600

It should be noted that the unit values for some ecosystem services have a broad range. This reflects the physical attributes (location, scale, condition, scarcity) of the respective underpinning studies as well as the scope of values/benefits captured in each study.

Some biome types, mainly consisting of cultivated land and urban areas, were excluded from analysis by De Groot et al. (2012), as they were classified as human-dominated systems. Although these biomes do produce ecosystem services, De Groot et al. (2012) note that there was an insufficient quantity of primary valuation studies to provide a meaningful analysis.

Cleared land and human habitation land types were therefore not valued for the Navua catchment.[3] These provided a relatively small proportion of the total land coverage (6.3%) and largely consist of space for agriculture/livestock and community settlements.

Based on the values outlined in Table 5 and Table 6 and the mapped areas of each asset, high level estimates of the total ecosystem value for biomes within the Navua catchment were calculated. The asset types and areas were developed through the BIORAP assessment and further detail can be found in the BIORAP report. Table 7 below presents the estimated ecosystem service values for all land types in the area, with valued land providing a more likely estimate of approximately FJD6.98 billion. Over FJD2.1 billion of this value is attributed to mangrove ecosystems, with an additional FJD2.4 billion attributed from near-coastal forests.

[3] It can be assumed that communities cleared land for agriculture and housing as these uses were deemed more valuable than the previous use of the land. Therefore, the value attributed to this land may be relatively high, however for the reasons outlined by De Groot et al. (2012), values have not been included within this study.

Table 7. Estimated ecosystem values for land areas (FJD millions)

Land/asset type	Land area (ha)	More likely value	Range (low to high)
Cleared land*	(11,441)	N/A	N/A
Forestry lease	8,930	$160.5	$48.2 to $635.6
Native forestry	8,214	$147.6	$44.3 to $584.6
Human habitation*	(932)	N/A	N/A
Lowland mixed	62,787	$1,128.1	$338.8 to $4,468.6
Lowland primary	47,514	$853.7	$256.4 to $3,381.6
Mangrove	3,187	$2,108.7	$3.3 to $9,658.0
Near-coastal forest	3,600	$2,382.0	$3.7 to $10,909.6
Upland forest	11,208	$201.4	$60.5 to $797.7
Total	**145,440 (157,813)****	**$6,982.0**	**$755.2 to $30,435.8**

*Note these land types were excluded from valuation by De Groot et al. (2012), as discussed above.
** Includes land types not valued.

Table 8 provides estimated values for marine ecosystem services within the catchment area, with over 20,200 ha of marine area providing a more likely estimate of over FJD18.2 billion. Almost FJD14 billion of this value is attributed from over 11,500 hectares of live coral.

Table 8. Estimated ecosystem values for marine areas (FJD millions)

Marine/asset type	Marine area (ha)	More likely value	Range (low to high)
Live Coral	11,574	$13,916	$1,454 to $84,116
Live Coral/Dead Coral Matrix	3,229	$3,882	$405 to $23,464
Coral Rubble/Dead Coral	866	$85	$77 to $124
Sand	3,475	$343	$310 to $499
Total	**19,144**	**$18,227**	**$2,247 to $108,203**

These values provide means to understand the economic trade-offs associated with development that could compromise the realisation of the ecosystem services. For example, the losses associated with mangrove clearing.

Annual economic values provided within the National Marine Ecosystem Service Valuation for Fiji (Gonzalez et al. 2015) are presented in Table 9. These values have been provided as an example of local estimates that are available, however we have not incorporated them into further analysis as some values are not specific to the contribution of ecosystem assets.

Table 9. Annual economic value of marine and coastal ecosystem services in Fiji

Service	Ecosystem	Unit Value (2023$FJD/yr)
Subsistence fisheries	Inshore	$107/ha
Commercial fisheries	Small-scale inshore artisanal fishing	$27-$98/ha
	Offshore tuna	$0.20/ha
Mineral and aggregate mining	Aggregate mining	$6.09/m^2
Tourism	Coral reefs and lagoon	$1,667/ha
	Mangroves	$7,256/ha
	Coast	$247,213/km
	Coastal land	$2,472/ha
	Fiji land	$764/ha
Carbon sequestration	Ocean	$8.25/ha
	Seagrass	$1,847/ha
	Tidal marshes	$3,364/ha
	Mangroves	$4,676/ha

5 Understanding threats

Pressures and threats identified by stakeholders

Pressure on and threats to ecological assets are likely to result in impacts on ecosystem services. This section presents the insights from consultation related to potential impacts on ecosystem services.

Table 10 presents a summary of key pressures and threats identified by stakeholders for each of the biomes discussed in consultation.

Table 10. Summary of key pressures and threats by biome

Biome	Pressures/threats
Native forest	• **Commercial Forestry operations:** Commercial forestry operations result in significant areas of loss, significantly greater than losses for clearing by villagers in the interior. Furthermore, the mahogany has naturally spread beyond plantation areas and is invading native forests. • **Invasive species:** Invasive species such as the African tulip trees threaten biodiversity and hinder native forest recovery from other impacts. • **Agriculture clearing for yaqona and other crops:** Threatens native forest areas, largely driven by population growth (i.e. need more space for housing and agricultural production to meet demand), productivity decline of existing cultivated land. • **Lack of alternative income sources:** Even where communities acknowledge a need to protect native forest areas, a lack of alternative income sources can put pressure on landowners to agree to leases with forestry companies. • **Mining exploration:** Should the prospecting activities result in larger scale extraction, there may be impacts on native forest areas (e.g. through clearing).
Land (excluding native forest)	• **Pest animals:** Pests such as mongoose and wild pigs threaten not only ecosystems through predation but also have impacts on crops and livestock. • **Saltwater inundation:** Temporary flooding and regular tidal inundation (increasing due to sea level rise) can sterilise land for cropping, impact on local community housing and other infrastructure and have health impacts (e.g. inundation of septic pit areas). • **Erosion**: Results in loss of land available for other uses, impacts on buildings, other infrastructure, and access (e.g. road impacts). Can also be exacerbated by human activities (e.g. fast boats). • **Declining productivity of agricultural land:** The allelopathic effects of mahogany have sterilised land in some locations, while intensive farming has impacted soil quality.[4] • **Kava dieback disease**: reduces crop yields of yaqona impacting on income and availability for cultural practices. May also trigger switch to more expensive substitute products, subsequently reducing cashflow required to maintain livelihoods. • **Small black ant**: A number of villages mentioned a specific ant that has been noticed in recent years. These ants tend to farm and protect sap-sucking insects like aphids and scale insects, which secrete honeydew that the ants consume. This relationship leads to higher populations of these pests, which damage crops by extracting essential nutrients.[5] This has reduced crop productivity, resulting in impacts to livelihoods. • **Population growth**: Increases demand for land for buildings and agriculture. • **Land tenure restricting expansion of village boundaries**: Limits available space for new buildings or farmland.
Terrestrial waterways	• **Overfishing/poaching:** Threatens aquatic biodiversity and ecosystem balance in waterways. Communities noted fewer and smaller aquatic species in many areas resulting in impacts to livelihoods.

[4] Allelopathy is a biological phenomenon in which plants release chemicals into the environment that can affect the growth, survival, or reproduction of other plants. These chemicals, known as allelochemicals, can inhibit or promote growth depending on their nature and concentration.

[5] For further discussion of the ants and associated bugs and insects see Thaman R. 2018.

Biome	Pressures/threats
	Water-borne disease: Poor water quality and flooding are factors in the spread of water-borne disease (e.g. typhoid, leptospirosis) in local communities. **Inappropriate harvesting practices:** Communities noted the use of chemical "fish bombs" used in some areas to achieve greater harvests. These "fish bombs" typically use chemicals such as chlorine, fertilisers, or duva root. These have had two major impacts, including a decrease in reproduction rates by affecting larvae and eggs as well as affecting village water supplies (there are cases of villages having to empty out reservoirs due to contaminated water). Lack of awareness was suggested as a key factor driving this. **Heavy rainfall:** Results in poor water quality, particularly increased incidence of water-borne disease, and sediment in water supplies. **Allelopathic effects from mahogany plantations:** Chemicals released by mahogany trees contaminate waterways, harming aquatic life and ecosystem health. This also reduces the size and quantity of aquatic species available for communities to harvest for subsistence and income. **Livestock along riverbanks:** Contribute to water pollution and water-borne disease through destabilising riverbank sediment and greater levels of manure near the water supply. **Population growth:** Increases pressure on water supply and aquatic species used for subsistence and income. **Wastewater and other polluted discharge:** Wastewater and runoff from villages and seepage from septic can return directly and indirectly to waterways, impacting on both ecological functions and human health. **Infrastructure maintenance requirements:** Impose challenges for managing and preserving waterway ecosystems. **Droughts:** Exacerbate water scarcity and stress on aquatic habitats. **Sedimentation:** Caused by forestry and farming practices upstream, leading to flooding and restricted waterway access. **Impact of gravel extraction from rivers**: Gravel extraction from rivers, while sometimes providing a source of income, can lead to habitat destruction, increased sedimentation, and altered water flow, adversely affecting aquatic ecosystems and species.
Marine and coastal areas	**Overfishing/poaching:** Threatens marine biodiversity and disrupts ecosystem balance. Communities noted fewer and smaller aquatic species in many areas resulting in impacts to livelihoods. **Loss of reef habitat:** Endangers marine species and disrupts coastal ecosystem dynamics, reducing the nursery habitat ecosystem services provided. **Clearing of mangroves for development:** Leads to habitat destruction and coastal ecosystem fragmentation, reducing the nursery habitat ecosystem services provided. **Crown of thorns starfish (COTS):** Destroys coral reefs, affecting marine biodiversity and ecosystem health. **Sedimentation:** Exacerbates flooding and hampers waterway access, driven by upstream forestry and farming practices. Sediment loads are also effectively burying coral reefs in some locations. **Nutrient pollution:** Impacts marine ecosystems and contributes to COT growth and oxygen depletion. **Increased waste generation and poor waste management:** Increased access to cold storage and access to commercial products results in more litter and waste generation, polluting marine and coastal environments and impacting visual amenity and marine life.

The degree to which these pressures and threats reduce the extent or condition of key ecosystems will determine the reduction (or in some cases, possible increase) in ecosystem service values derived from the study area. Quantifying this is beyond the scope of the current study, however it is worth highlighting that threats to high-value biomes with significant importance to local communities should be prioritised for urgent attention. For example, addressing mangrove clearing and water quality issues (sediment and nutrient loads), will be critical for retaining the significant level of value associated with marine and coastal areas.

Climate change projections

Climate change is projected to have significant impacts on Fiji over future decades, with projections pointing to increased temperatures, altered rainfall patterns, rising sea levels, and intensified tropical cyclones (PICCM 2021). The region's delicate ecosystems, including natural assets surrounding the Navua catchment and Beqa lagoon, face heightened vulnerability in the future. Some of the likely impacts associated with these changes include bleaching events for coral reefs as well as the gradual erosion of coastal mangroves (Ellison 2010). These events are expected to substantially reduce the ecosystem service values provided by natural assets within the catchment, if left unmanaged.

Shifts in precipitation may also result in more frequent droughts or floods, affecting agricultural productivity and freshwater availability, increasing erosion risk, impacting on the reliability of harvests for traditional food sources, increasing natural disaster risks to homes and economic infrastructure, while rising sea levels threaten coastal communities and infrastructure, exacerbating coastal erosion and inundation risks (Pacific Climate Change Science (PCCS) 2013). These changes pose substantial challenges to Fiji's economy, food security, community wellbeing and overall resilience, emphasising the urgent need for informed adaptation measures to be implemented.

Utilising projections provided by the Pacific Climate Change Science (PCCS 2013), Figure 4 and Table 11 provide respective mid-point and ranges for projected changes in annual average surface air temperatures across Fiji. Under a medium emissions scenario, by 2090 Fiji is likely to experience temperatures 1.2 to 2.5 degrees Celsius hotter than the base period (1986 to 2005).

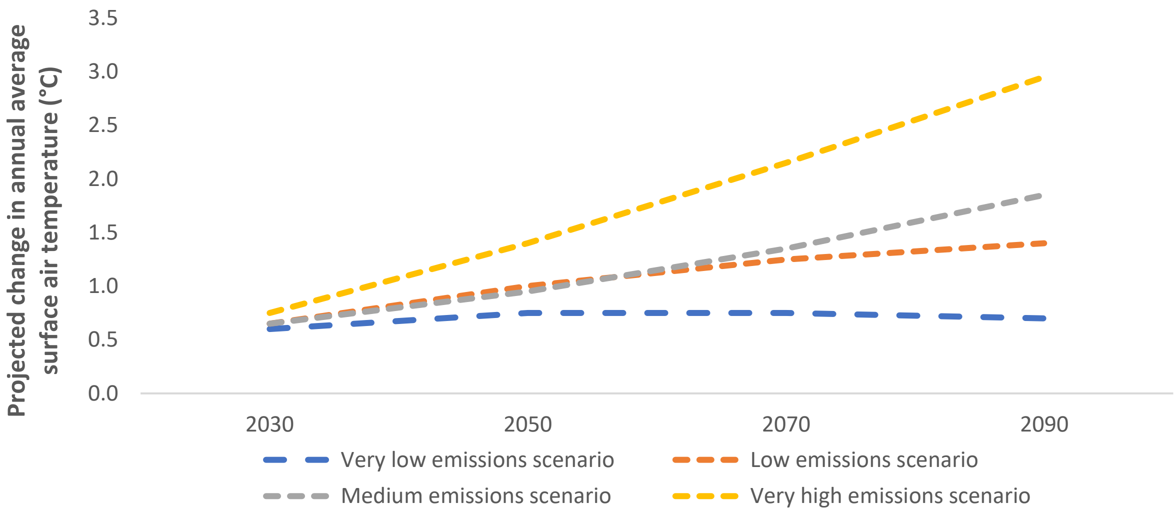


Figure 4. Projected changes in annual average surface air temperature for Fiji (mid-point) adapted from PCCS 2013)

Table 11. Projected changes in annual average surface air temperature for Fiji (°C) (adapted from PCCS, 2013)

Emissions scenario	2030	2050	2070	2090
Very low emissions scenario	0.4 – 0.8	0.5 – 1.0	0.4 – 1.1	0.3 – 1.1
Low emissions scenario	0.3 – 1.0	0.6 – 1.4	0.7 – 1.8	0.8 – 2.0
Medium emissions scenario	0.4 – 0.9	0.6 – 1.3	0.9 – 1.8	1.2 – 2.5
Very high emissions scenario	0.5 – 1.0	0.8 – 2.0	1.4 – 2.9	1.9 – 4.0

Source: PCCS (2013)
Note: These projections are relative to the period 1986-2005.

Figure 5 and Table 12 provide the respective mid-point and ranges for the projected mean sea level rise for Fiji. Sea levels across the country are expected to rise by between 28 cm and 66 cm by 2090, assuming a medium emissions scenario.

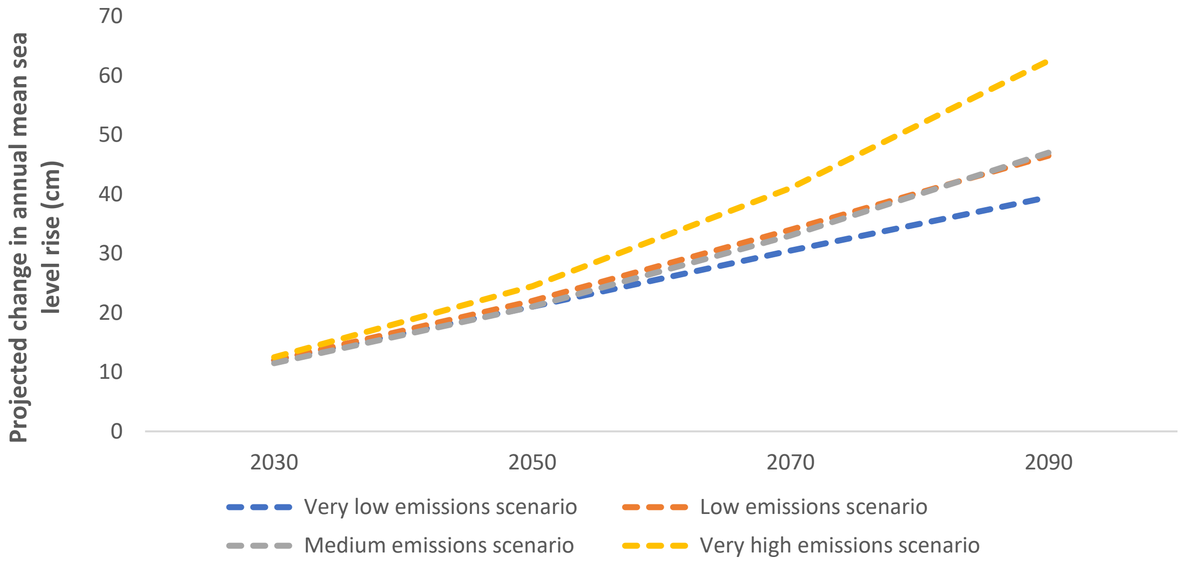


Figure 5. Projected changes in annual mean sea level rise (mid-point) (adapted from PCCS 2013)

Table 12. Projected changes in annual mean sea level rise for Fiji (cm) (adapted from PCCS 2013)

Emissions scenario	2030	2050	2070	2090
Very low emissions scenario	7 - 17	13 - 29	18 - 43	22 - 57
Low emissions scenario	7 - 17	14 - 30	21 - 47	28 - 65
Medium emissions scenario	7 - 16	13 - 29	20 - 46	28 - 66
Very high emissions scenario	8 - 17	16 - 33	26 - 56	39 - 86

Source: PCCS (2013)
Note: These projections are relative to the period 1986-2005.

Again, the degree to which these climate change projections reduce the extent and/or condition of key ecosystems will determine the reduction (or in some cases, possible increase) in ecosystem service values derived from the study area. Quantifying this is beyond the scope of the current study.

Linking the environmental and economic systems to management

The threats outlined above are likely to change the stock or condition of the environmental assets in the study area and therefore, the ecosystem services provided by these assets. These potential changes to ecosystem services have economic and social value (as outlined above) and therefore, may provide logic for investment in management. Should this management result in an improvement (or avoided decline) in the stock or condition of the environmental assets, this improvement will flow through the environmental, economic and social systems. Figure 6 presents a visual representation of the linkages between these systems.

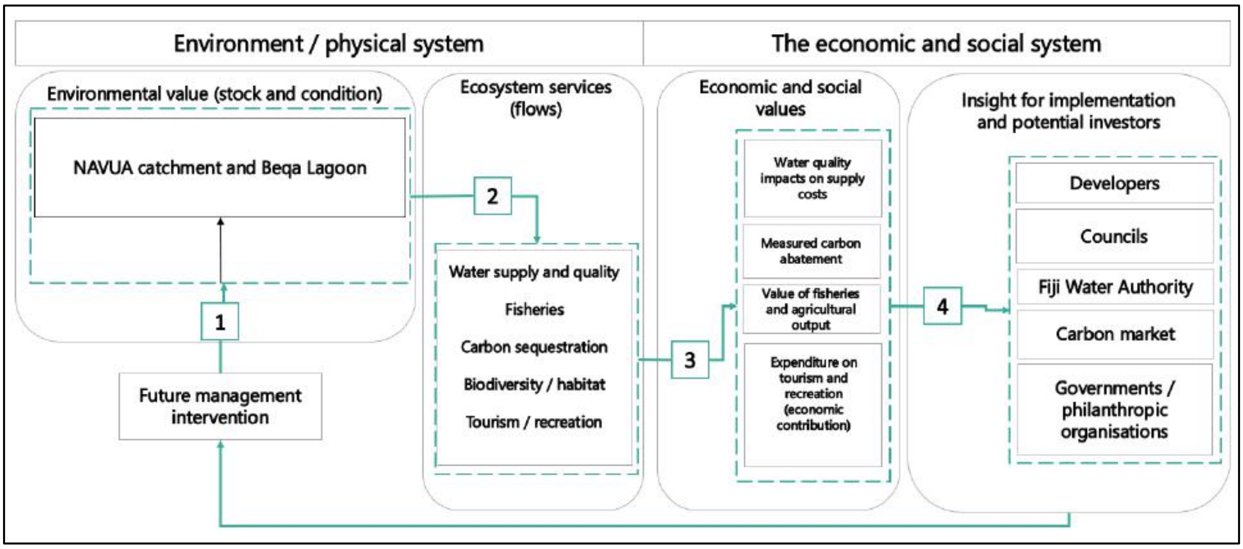


Figure 6. Flowchart of ecosystem services systems

Figure 7. The Navua River near Nabukelevu

6 Case studies

The following case studies provide greater detail on three key issues of interest in the study area. These issues were discussed by many stakeholders in consultation and represent the recommended priorities for future management.

6.1 Case study 1: Coastal mangroves for erosion protection

Erosion risk to transport corridor

Queens Road, a vital transportation artery for Fiji and the Navua catchment, faces the significant threat of erosion, particularly along the stretch to the east of Galoa, among other locations. The erosion along Queens Road presents significant risks such as road damage, infrastructure loss, disruption to transportation networks, and impact to local communities. Lack of access can have significant economic impacts on tourism and the local economy and can be long-lasting if effective mitigation efforts are not put in place. High level estimates from 2017 have cited that approximately 15,000 vehicles travel the Queens Road each day (Prentice 2017).[6] The road is critical for freight transport between communities (e.g. Lautoka to Suva), as well as for everyday usage by locals and tourists.

Figure 8 presents an example of the erosion occurring near Galoa while Figure 9 presents a scenario of a road closure occurring due to erosion along a key segment of the road near Galoa. For this example, the localities of Sigatoka and Suva have been used as start and end destinations. No local adjacent roads can provide alternative routes, and due to the mountainous topography of the area, no temporary local inland roads could be constructed to circumnavigate the closure.

Figure 8. Erosion near Galoa

[6] Population growth has likely placed additional demand on this arterial road since 2017, therefore this estimate can be considered a lower bound estimate for current day usage.

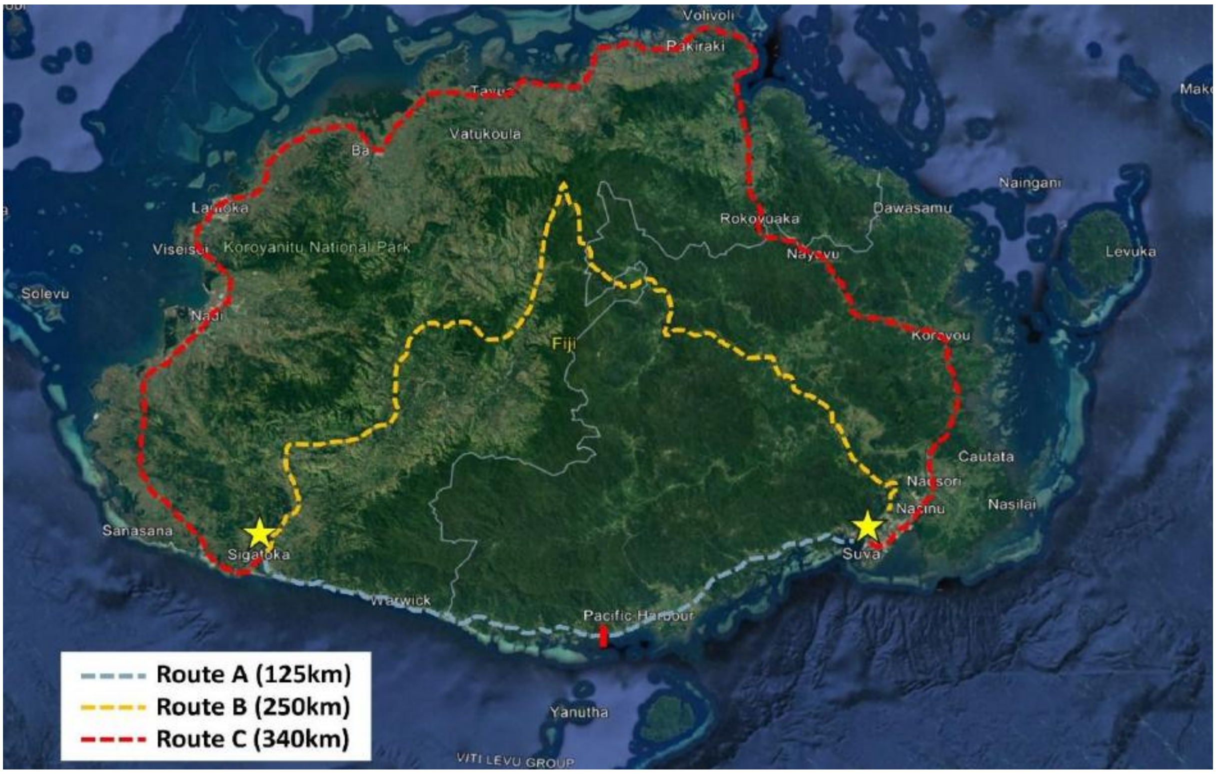


Figure 9. Map of drive routes from Sigatoka to Suva

Route A shows the normal direct route via the southern Queens Road, which requires a drive time of approximately 2 hours 15 minutes (125 km) between the localities. Due to the closure, drivers would be forced to significantly change their route and be directed north, as shown by Routes B and Route C. Route C uses major arterial roads (suitable for freight and heavier vehicles) and is expected to take a drive time of 6 hours and 10 minutes (340 km), while Route B, which uses several dirt roads is expected to take 7 hours (250 km) due to the significantly slower expected speeds on unsealed roads.

This high-level example highlights the significant disruption that road closures can cause along key sections of the Queens Road. For freight traffic between these two localities, this would mean both time and fuel costs doubling or tripling, and for local tourists this would effectively stop any movement between these two regions.

The region’s natural assets provide considerable economic value to local communities and employment through tourism, and lack of access due to erosion of these main roads could result in significant financial losses.

Ecosystem-based adaptation opportunities

Considering the unique coastal landscape present within the Navua catchment and surrounding area, tailored erosion protection measures are being assessed for Queens Road.

While hard infrastructure such as seawalls may be necessary in certain vulnerable areas, there is a growing base of international literature that supports the use of nature-based or hybrid solutions to offer sustainable alternatives. In locations where erosion threats are significant (i.e. to the east of Galoa), strategically planted mangrove communities, potentially in combination with cost-effective rubble-based breakwaters, could support sediment accretion, mitigating coastal erosion and bolstering resilience against natural wave forces occurring along the coastline.

In addition to carbon sequestration and erosion mitigation benefits, mangrove communities can offer further advantages when multi-species benefits are considered. Integrating local ivi trees with mangroves is expected to enhance stabilisation efforts and biodiversity. These initiatives also support fisheries by providing habitats for marine life, while also improving coastal water quality by filtering pollutants and sediment. The combined efforts of mangroves and ivi trees contribute to a resilient coastal ecosystem that benefits both the environment and local communities.

However, it is important to note that the implementation of erosion protection measures is not without risks and challenges. Planting mangroves in high wave energy environments, where they historically do not flourish, may carry a higher risk of failure. Additionally, the establishment and propagation period of mangrove seedlings is vulnerable to storm events, necessitating careful planning and management to mitigate potential setbacks. Time to establishment is another critical factor that requires consideration to ensure the long-term effectiveness of erosion protection efforts.

6.2 Case study 2: Forestry management

Current situation

Forestry management within the study area presents a complex interplay between the economic benefits derived from commercial forestry, predominantly non-native mahogany, and the environmental impacts on ecosystem services. The cultivation of mahogany, while contributing to the economic wellbeing of local communities, has raised concerns due to its negative effects on the natural environment and other economic and social values. One significant impact is the dominance of mahogany over native species, facilitated by the easy spread of its seeds. This displacement of native flora has ecological consequences, affecting the intricate balance within the ecosystem.

Furthermore, the presence of mahogany has been associated with environmental degradation. The leakage of sap or other substances into the soil and waterways can lead to the sterilisation of otherwise productive land and harm aquatic species. This contamination poses a threat to the productivity of the affected areas and contributes to the decline of biodiversity (impacting on livelihoods associated with farming and fishing). In order to mitigate these adverse effects, sustainable forestry management practices need to be considered to ensure the trade-offs are well understood and managed.

In addition, once harvested, some areas of former forest area have not been properly managed (including no reforestation) resulting in erosion, weed infestation and losses of ecosystem services.

Figure 10. Cleared mahogany forest

Multi-species reforestation

One potential solution involves a multi-species reforestation approach in areas being logged, aligning with initiatives such as the Fiji Government's 30 million trees programme. This project could be instrumental in restoring the ecological balance by reintroducing native species and reducing the dominance of mahogany, while allowing the economic benefits of forestry to continue.[7] Establishing native species nurseries or enhancing existing operations can be a vital component of this effort. Community capacity building is crucial for the success of such projects, and developing comprehensive guidelines, from nursery operations to planting, can empower local communities to actively participate in sustainable forestry practices.

The locations selected for reforestation efforts should be strategic to maximise positive impacts (based on enhancing ecosystem services). Transitioning from monoculture to multiple species plantations not only enhances biodiversity but also provides employment opportunities in the region.

Native forests, as opposed to exotic species like mahogany, offers more benefits in terms of habitat preservation for native species. The invasive nature of mahogany into native forests underscores the importance of replacing harvested areas with a diverse mix of native species. While this approach is valuable, it should be complemented by other strategies to ensure a holistic and sustainable forestry management plan. Additionally, native forestry species can contribute to agroforestry practices by providing native fruits and bush foods, further highlighting the potential for harmonising economic and ecological objectives in the study area.

Information asymmetry barrier

The issue of information asymmetries in agreements with logging companies provides another dimension to forestry management challenges. Communities raised an issue that when landowners engage in long-term agreements, such as a 90-year lease, with logging companies to secure alternative income sources, there is often a lack of comprehensive information about the potential impacts of these activities. This information gap can result in landowners making decisions without a full understanding of the long-term consequences for both their communities and the broader ecosystem. Fiji does have some existing mechanisms to avoid these issues, particularly through the role of the iTaukei Land Trust Board (TLTB); however, it appears that these processes may need strengthening to better support landowner decision-making.

Addressing these information asymmetries is paramount for achieving future sustainable management of the forest areas. Efforts should be made to ensure that landowners are well-informed about the costs and benefits associated with logging activities. This requires transparent communication and the provision of clear, accessible information regarding the environmental, social and economic implications of such agreements. Community engagement and education programmes can play a crucial role in empowering landowners with the knowledge needed to make informed decisions about the use of their land and resources.

Sustainable forestry management hinges on the collaboration and shared understanding between local communities and logging companies. By fostering transparency, promoting awareness and enhancing the information available to landowners, it becomes possible to strike a balance between economic interests and environmental conservation, ultimately contributing to the long-term wellbeing of both the communities and the delicate ecosystems within the study area.

6.3 Case study 3: Fisheries management

Fishery resource trends

The region's fisheries are facing significant challenges as productivity declines and ecological resilience and livelihoods are impacted. This has become evident in recent years for both terrestrial waterways and larger marine areas. During project consultations, communities raised issues with having sufficient fish available for subsistence and income generation. Many communities within the catchment described substantial shifts in the size and abundance of several fish species, indicating an alarming trend in ecosystem health.[8] This has had impacts on both income and subsistence needs for the greater catchment, with calls for better management being highlighted by several stakeholders.

The significance of the study area's water bodies extends beyond significant biodiversity; they provide essential ecosystem services, support local economies through fishing and tourism, and hold immense cultural value, notably encompassing the internationally renowned Beqa lagoon and Coral Coast. High-level estimates of the wider ecosystem values, as reported in Section 4, suggest that marine areas within the study area are valued at over FJD18 billion per annum, with higher ranges exceeding FJD118 billion. It should be noted that it is unlikely

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[7] It should be noted that despite its negative environmental impacts, mahogany cultivation does offer some value to local communities due to its fast-growing nature and suitability for building materials.

[8] Note that the 2023 survey undertaken for the BIORAP assessment supported these statements by communities.

that locals capture a significant portion of this value given that much of this value is captured by external stakeholders (e.g. carbon sequestration).

The decline in fishing productivity within the catchment has been largely driven by interconnected factors, identified during stakeholder engagement. Water quality has declined due to activities such as mahogany logging, which introduces pollutants into waterways and disrupts the balance of downstream ecosystems. Overfishing has compounded the issue, leading to the depletion of fish stocks and the disruption of marine food chains. Furthermore, the degradation of key habitats like mangroves and coral reefs due to human activities pose a significant threat to marine biodiversity, impacting the reproductive and feeding grounds of numerous fish species.

Poor practices such as chemical approaches to fishing in terrestrial waterways (i.e. "fish bombs" as the locals refer to them; further description in Table 10) are employed by a small contingent of locals and result in by-catch of larvae, eggs and juveniles, reducing the reproductive capacity of fisheries. Furthermore, these practices can sometimes impact on water supplies for communities. A lack of awareness was cited as a key factor in these continued practices. Combatting these drivers requires the implementation of well-managed strategies that focus on sustainable resource management, habitat restoration and the adoption of responsible fishing practices to ensure the long-term health and resilience of the freshwater and marine ecosystems.

Current approaches to management and limitations

Existing initiatives aimed at addressing the decline in fisheries within the study area include the appointment and training of fish wardens tasked with preventing illegal fishing in iQoliqoli and Marine Protected Areas (MPAs).[9] However, stakeholders have highlighted these efforts are impacted by a lack of resources such as boats and enforcement capabilities of wardens. Additionally, some villages have implemented their own community level protected areas, called Tabu Areas where they have agreed within the community to not fish certain stretches of river or ocean.

These initiatives represent key tools for fisheries conservation but are hampered by under-resourced fisheries management. While they have shown success in some areas, challenges also largely persist due to ignorance or a lack of awareness or enforcement of fishing regulations (particularly from outsiders), resulting in continued impacts.

Figure 11. A marine protected area along the Fiji coastline
Source: GVI 2023

It should be highlighted that the presence of MPAs has yielded some promising outcomes, including increased sizes and quantities of species in some locations, as well as a reduced presence of crown of thorns starfish (COTS). The locations of some MPAs in areas away from catchment-based nutrient flows reduces the likelihood of COTS and enhances the resilience of the MPAs. This also aligns with existing international literature (DES 2020). However, the temporary nature of some MPAs (some only lasting for five years) highlights the need for regular re-establishment to maintain their effectiveness, likely causing an increase in regulatory and enforcement costs. It

[9] iQoliqoli are customary Fijian fishing rights areas, i.e. areas reserved for local indigenous users. The Native Land Fishery Commission is responsible for their administration (FAO 1999).

was noted by communities that some of the designated MPAs in the region had lapsed and required renewal. Alternatively, decision-makers could consider longer periods before re-establishment is required.

Addressing these limitations requires strategic investments that support governance and management frameworks surrounding iQoliqoli and MPAs. Through this, stakeholders and community members can better preserve marine ecosystems and promote the sustainable use of fisheries resources. The provision of funding for equipment (such as boats) for fish wardens in MPAs will enhance enforcement efforts, contributing to greater protection of marine resources. Additionally, allocating more resources to fisheries monitoring is likely to improve compliance amongst the community, reducing rates of overfishing.

Ecosystem-based adaptation opportunities

Other initiatives such as coral farming and reef resilience programmes can provide key opportunities for improving marine quality and the productivity of local fisheries. One successful example of coral farming is that of the coral nursery established by Reef Explorer at the Big Foot dive site on the Coral Coast, a favourite amongst diving tourists. Currently, Reef Explorer maintains four coral nursery sites along the Coral Coast where approximately 10,000 corals are propagated and transplanted back onto the reef each year (Reef Resilience 2019). Figure 12 shows a rope nursery implemented at one of the coral nursery sites. This simple rope system has been cited as the easiest and most cost-effective method for propagating new corals of any species that have a branching morphology (Reef Resilience 2019). Once coral fragments have grown large (usually after 6–10 months), excess rope is cut free before the coral is moved back safely to the restoration site.

Figure 12. Rope nurseries propagating new coral in the Coral Coast
Source: Reef Resilience (2019)

In addition to these coral nursery programmes, Reef Resilience also invest in various programmes to control COTS, employing methods such as injecting sodium bisulphate solution into the starfish, killing them without harming the surrounding reef ecosystem. Other methods include taking COTS ashore and burying them, injecting them with toxic chemicals (e.g. formalin, ammonia, copper sulphate), and building underwater fences to control the movement of the starfish. Although effective, mechanical COTS control methods are costly and labour-intensive, suitable mainly for small reefs with significant socioeconomic or biological importance (Reef Resilience 2020).

Communities also discussed the potential of biocontrol initiatives for COTS. They noted that some of the natural predators of COTS have declined in number over time, due to harvesting and other broad drivers of fisheries decline. Natural predators include the davui (Triton's trumpet shell), harvested for souvenirs and the humphead wrasse. Initiatives that support the populations of these species may contribute to COTS control, noting that there could also be risks associated with this approach (e.g. potential impacts of overabundance of these species) and any biocontrol initiatives should be based on a sound understanding of these risks.

Furthermore, on Beqa Island there were initiatives to collect COTS and dry or burn them to use as a natural fertiliser. There was also a scheme running with a local resort who would pay FJD2 per starfish to incentivise their removal from the reefs around the island; however, this scheme has since ceased. The island communities would like to see these initiatives reinstated through investment in equipment to process the COTS into fertiliser and new agreements with tourism operators to manage the COTS populations. There is potential for an initiative like this to support local livelihoods.

Initiatives such as the Reef Resilience programme along the Coral Coast and previous efforts on Beqa Island showcase innovative approaches to tackling marine ecosystem degradation. By developing methods to expand coral reef populations while controlling COTS without causing collateral damage to reefs, these initiatives are prime examples of the potential for science-based interventions to address ecological challenges faced in the region. Sustained commitment and collaboration among stakeholders is imperative to scale up these efforts and achieve meaningful, long-term conservation outcomes and improve water quality and the resulting productivity of local fisheries.

Figure 13. Rock wall and mangroves combining to provide safe harbour at Lalati Village on Beqa Island

Figure 14. Navua River change in colour with sediment plume

7 Other development opportunities

While not focused on ecosystem resilience or ecosystem-based adaptation, two themes were repeatedly discussed in stakeholder consultation, which represent significant opportunities for investment in social resilience and economic development. These themes were water supply resilience and waste management, where every village consulted expressed desired improvements in these areas. While individually these would be quite small projects and face difficultly in attracting funding, catchment-wide strategies may provide the economies of scale required to garner interest from international donors.

7.1 Water supply resilience

The Navua catchment in Fiji faces a range of pressures and threats to its water supply, with implications for both local communities and aquatic ecosystems.

Water quality issues

One significant challenge is the prevalence of water-borne diseases, such as typhoid and leptospirosis, driven by poor water quality and flooding, particularly after heavy rainfall events. Inappropriate harvesting practices, including the use of "fish bombs" (i.e. chlorine/fertilisers or duva root), have had impacts on community water supplies, with contamination of village water sources leading to instances where reservoirs need to be emptied. Livestock along riverbanks contribute to water pollution and disease transmission by destabilising riverbank sediment and increasing the presence of manure near water sources.

The Ministry of Health and Medical Services has been collecting data on the incidence of water-borne diseases in the region. This data includes information on the date and location of each incidence of leptospirosis, dengue fever and typhoid in 2023 (up to 30/11/2023), enabling comparisons across diseases and locations, as well as comparison with climatic variables such as rainfall and maximum sea levels in the region. Figure 15 presents the incidence of water-borne diseases by disease and broad location. It indicates that leptospirosis and dengue fever are particularly prevalent in coastal areas of the mainland while typhoid is mostly occurring in the highland villages. It is also worth noting that many cases are likely to go unreported and this could introduce bias in the data, with the highlands and island communities being more remote. Additionally, a higher proportion of leptospirosis (62%) and typhoid (70%) cases were among men than women; however, dengue was evenly distributed across the two genders (53% male). The proportion of typhoid cases made up of under 18-year-olds (39% of cases) was greater than that of leptospirosis (32%) and dengue (13%), while the over 60-year-old population was least represented in typhoid cases (4% of cases) and more represented in leptospirosis (9%) and dengue cases (13%).

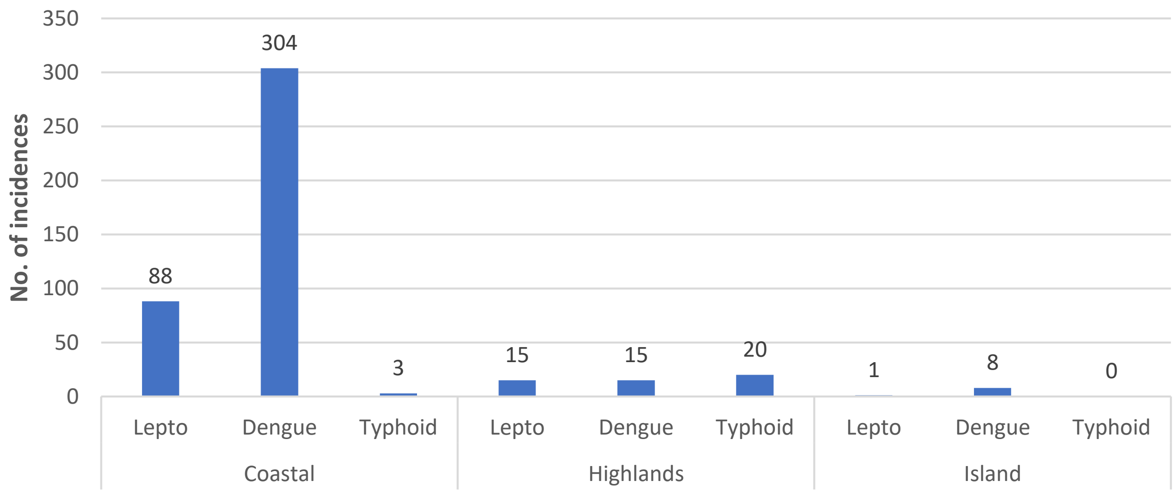

Figure 15. Water-borne disease incidence by disease and broad location
Source: MoHMS

While precise relationships between water-borne disease rates and climatic variables were not obvious from the data, particularly as the data on rainfall is not spatially explicit, there is an abundance of research into the drivers of water-borne disease including inundation and rainfall events. Despite this, it is worth pointing out that there were positive correlations between the maximum sea levels and dengue and leptospirosis cases in coastal and island communities when the data was aggregated to monthly statistics (correlation coefficients between 0.65 and 0.75). This highlights the potential for sea level rise to exacerbate water-borne disease incidence.[10]

Rainfall was not highly correlated with any particular disease or location, with the highest correlation coefficient being with dengue cases in coastal areas (0.27). This could in part be due to the temporal aspect of the relationship between rainfall and water-borne disease, or the lack of rainfall data at a village scale. Figure 16 and Figure 17 present the data for coastal leptospirosis and coastal dengue cases respectively, overlayed with the rainfall and sea level data. These show the spikes in water-borne disease shortly after periods of relatively high maximum sea levels.

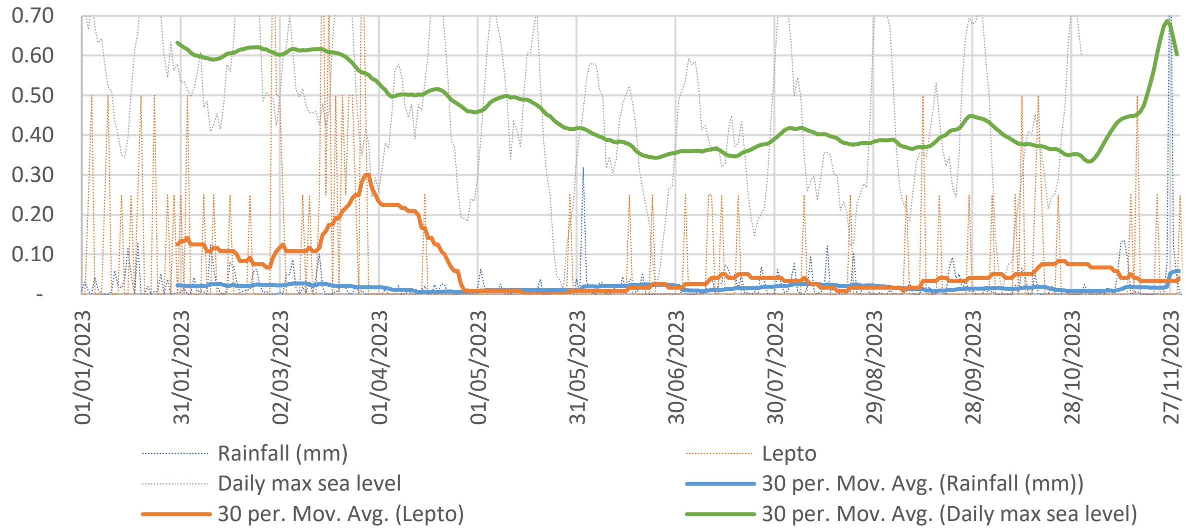

Figure 16. Normalised indices for coastal leptospirosis cases, rainfall and maximum sea levels (incl. 30-day moving average)

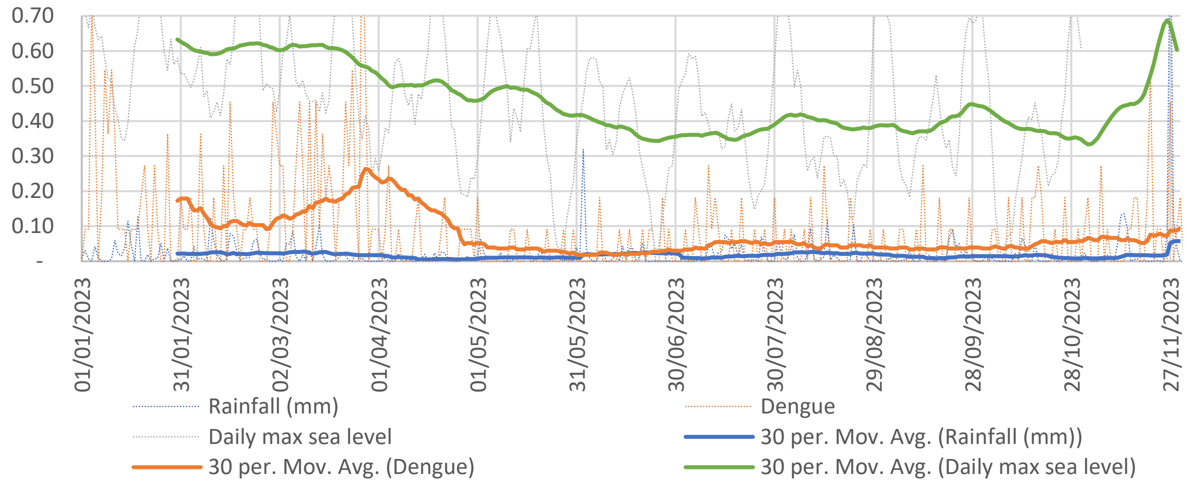

Figure 17. Normalised indices for coastal dengue cases, rainfall and maximum sea levels (incl. 30-day moving average)

[10] Note that these findings are consistent with the vectors of disease spread. Leptospirosis is spread through contaminated water and skin contact, and dengue through mosquitoes, which may explain their higher prevalence in coastal villages. In contrast, typhoid, which is spread by contaminated drinking water or flies, is more common in highland areas.

Water quantity issues

Population growth in the region exacerbates pressure on water supply volumes, while infrastructure maintenance requirements and the potential for droughts further challenge the management of water resources in the study area. Many villages discussed old and failing infrastructure (pipes, pumps, etc.) or lack of pressure due to elevation differences and low reservoirs.

Proposed management approaches

To enhance water supply resilience, a recommended starting point involves strategic interventions. Rainwater tanks emerge as a valuable solution, providing an alternative supply that is likely to remain full during sediment-related impacts on other sources. However, their current usage is limited, often confined to specific households or community buildings. Addressing this limitation involves a feasibility assessment and identification of a selection of public buildings for installing rainwater tanks as a contingent water supply during compromised conditions. This initiative could aim to develop a business case for funding agencies, such as the Asian Development Bank (ADB), focusing on communities not adequately serviced by the Fiji Water Corporation. This holistic approach not only improves water supply reliability and quality but also contributes to enhanced health outcomes (provided mosquitos are controlled) and potential employment opportunities for villages during construction and operations. Ultimately, it forms a crucial component of a sustainable and resilient water management strategy for the Navua catchment.

7.2 Waste management

Challenges

In the realm of waste management, there are notable challenges, including overflowing rubbish pits and lack of appropriate collection systems. These result in litter being spread around impacting on visual amenity, aquatic species, and human health (particularly where open containers provide ideal breeding conditions for dengue mosquitoes). Furthermore, unsafe burning practices and seepage of septic tanks during inundation events pose potential health risks.

Proposed management approaches

In some villages it may be feasible to implement more frequent rubbish collection, including recycling. A number of villages said that rubbish sorting was already occurring effectively; however, it was just being buried anyway. Often the behaviour change aspect of these initiatives represents a significant barrier but in the case of these villages it has already been overcome.

The practice of burning waste without proper equipment raises concerns about potential health impacts, highlighting the need for incinerators or improved rubbish collection systems. Additionally, septic tanks are susceptible to flooding and erosion, posing potential health risks. While it may not be possible to connect all villages to sewer mains, there is likely value in some more strategic planning around the location of this kind of infrastructure within village footprints, and ensuring designs are fit-for-purpose.

Overall, it is clear that a region wide strategy would enable communities to access funding that takes advantage of economies of scale. These measures would not only contribute to a cleaner and healthier environment but also promote community wellbeing and sustainable development in the Navua catchment.

8 Next steps – develop EbA options

A full list of options and analysis of each will be presented in the Ecosystem-based Adaptation (EbA) options report; however, in developing the ESRAM some initial potential options were identified for further investigation (some of which have been touched on in the case studies above). These include:

- **Multi-species reforestation of cleared land** – project could link to 30 million trees programme and also initiate native species nurseries or enhance existing nursery operations, providing opportunities for community development and capacity building.[11]
- **Analysis and refinement of buffer zones around highly eroding waterways** – this would restrict clearing, agriculture, housing to protect water quality and local climate-dependent water supplies, particularly in the highlands.
- **Maintenance and enhancement of mangroves on fringe of coastal communities** – this would mitigate the need to expand hard infrastructure (e.g. seawalls). Implementation would need to consider species composition (e.g. mangroves plus ivi trees) to maximise effectiveness and co-benefits. Furthermore, consideration should be given to the feasibility of a mangrove nursery as feedstock for community-led potential projects.
- **Mangrove planting to protect key road infrastructure** – work would need to be undertaken to determine where this EbA option is feasible given wave energy, current erosion levels and critical assets at risk. Again, if feasible, this could link to a mangrove nursery as feedstock for community-led potential projects.
- **Research and pilots into biocontrol of COTS** – local species such as davui predate on COTS and avenues of strengthening these populations could be assessed for feasibility and risks. This could be supported by the reinstatement of previous programme where payments were made to villagers for physical removal and reuse (e.g. fertiliser).

Figure 18. Navua River at Navua Town

[11] The most recent budget estimates suggest that the 30 million trees programme continues to be a priority for the Ministry of Forestry (Republic of Fiji 2024).

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Appendix 1: Community maps

Figure 19 through to Figure 27 below provide maps of the Navua catchment and Beqa lagoon areas. More detailed maps have also been included for each of the districts in the study area.

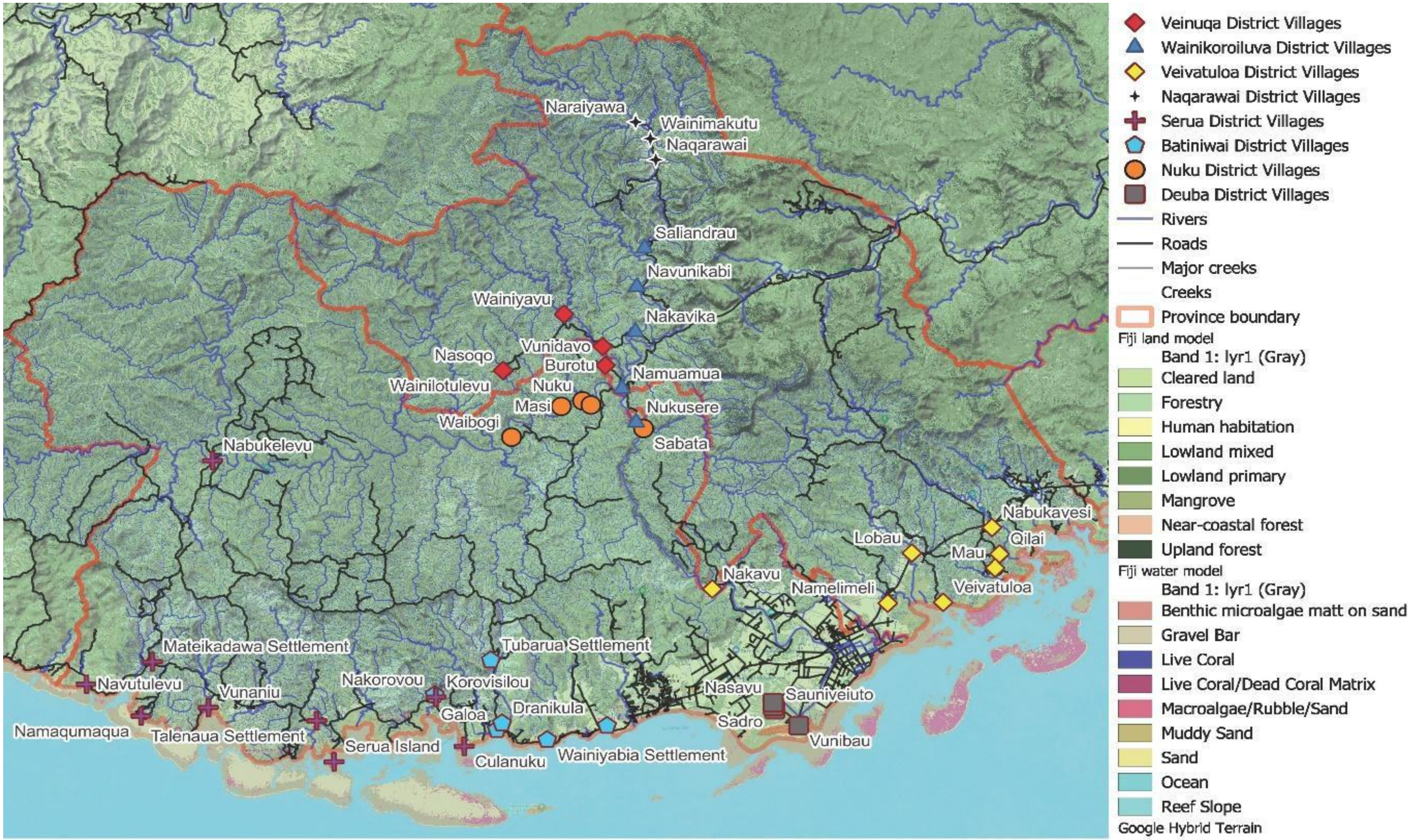

Figure 19. Navua Catchment

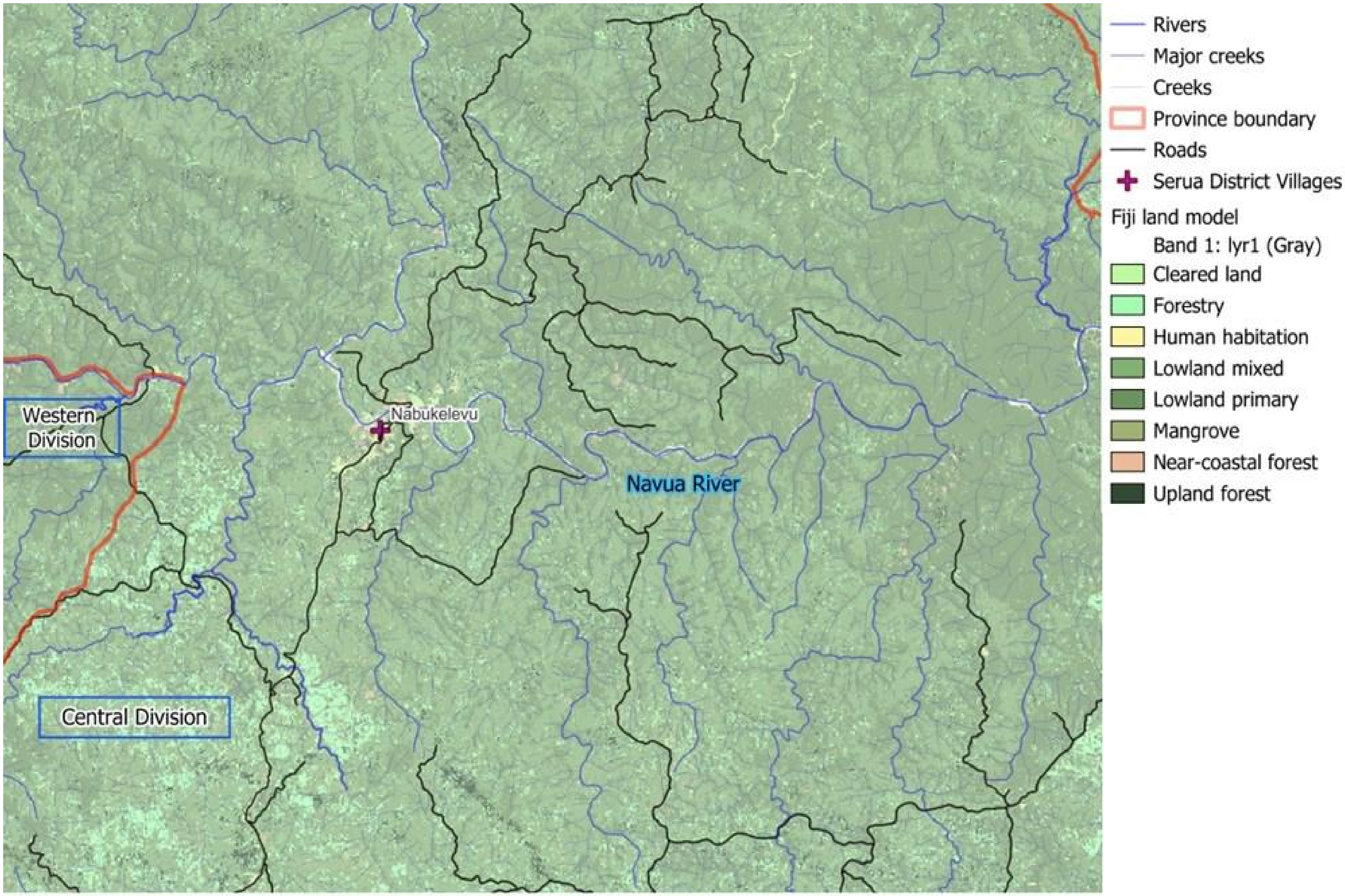

Figure 20. Serua district highlands, Serua Province

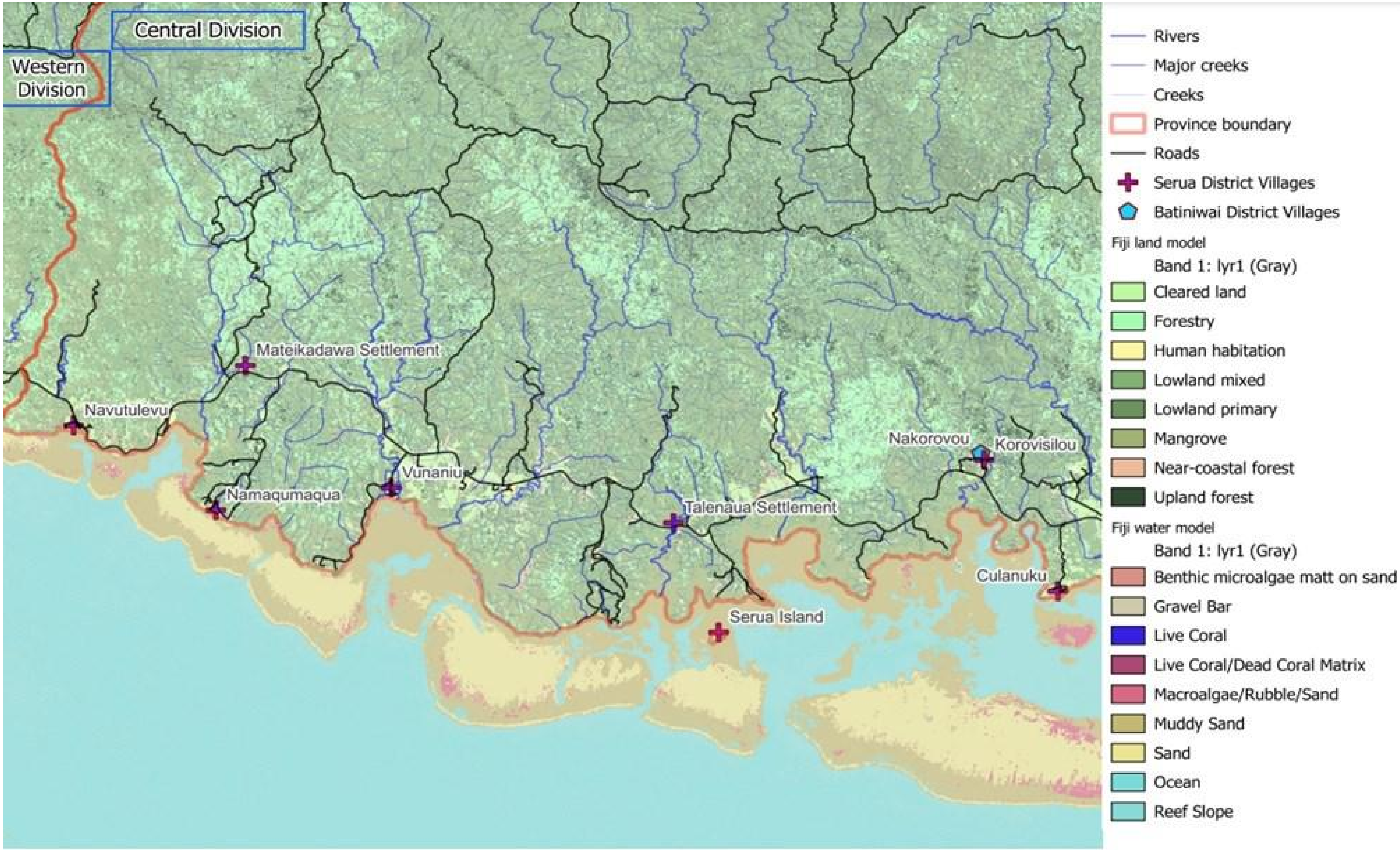

Figure 21. Serua district coast, Serua Province

Figure 22. Batiniwai district, Serua Province

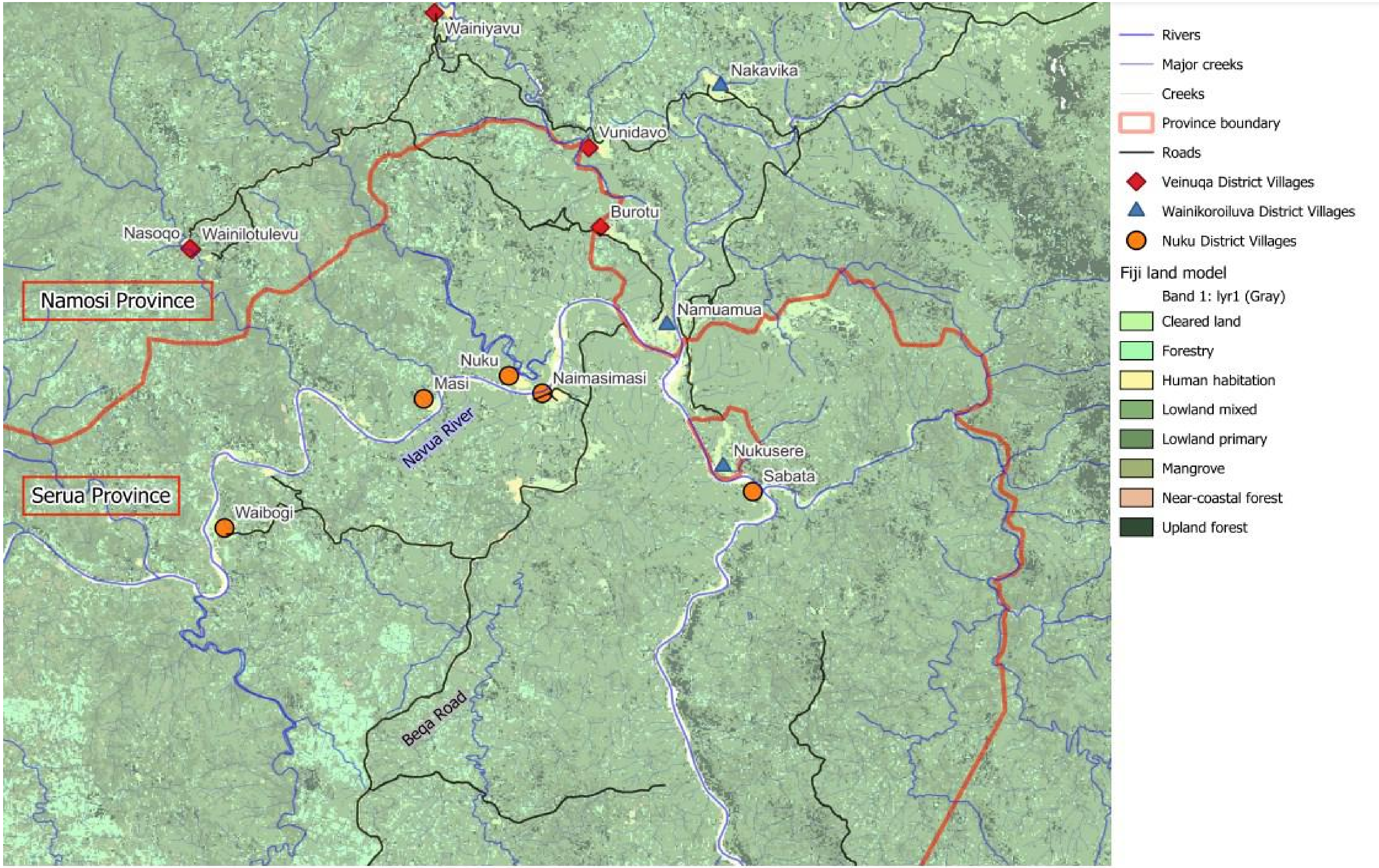

Figure 23. Nuku district, Serua Province & Veinuqa and Wainikoroiluva districts, Namosi Province

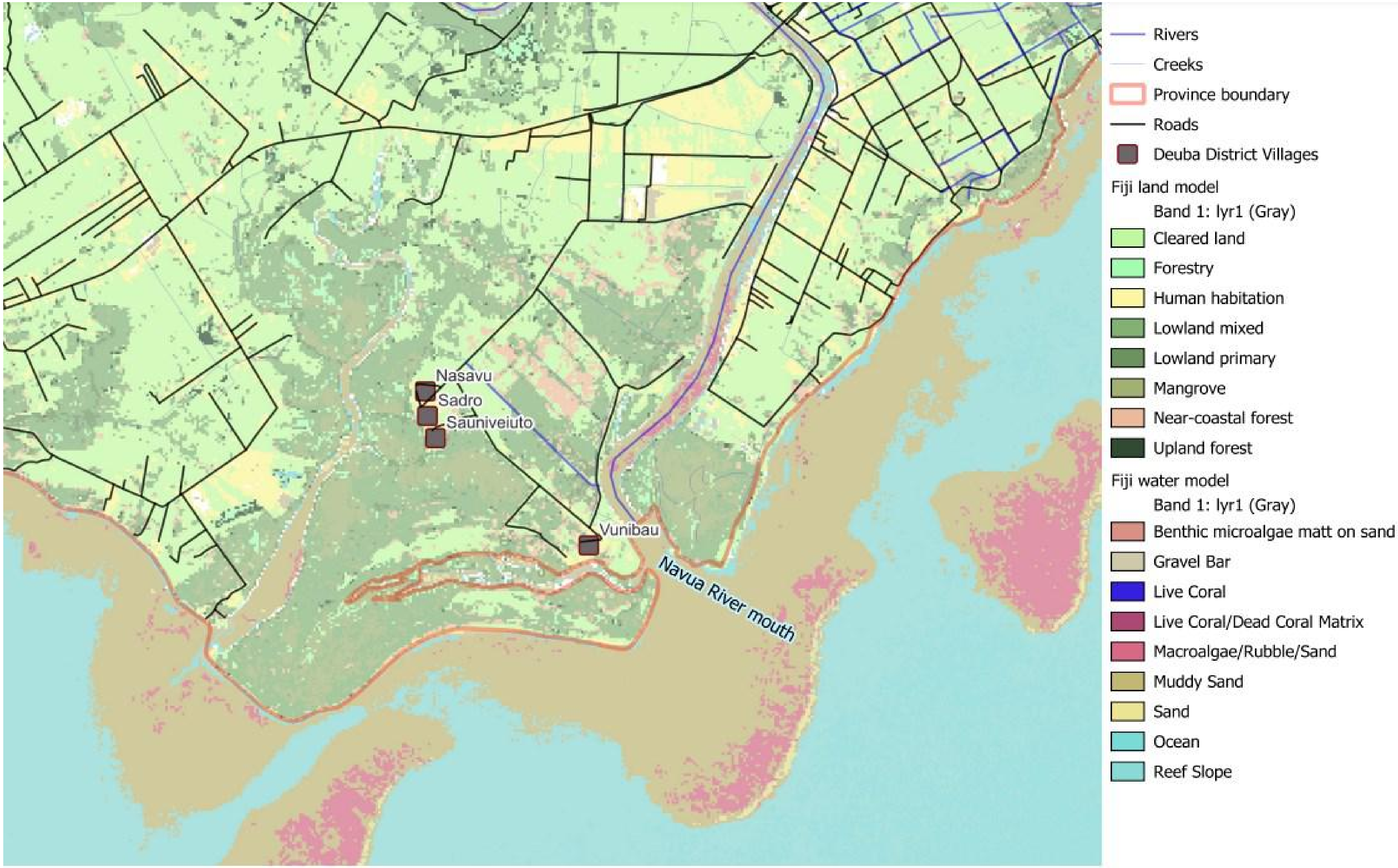

Figure 24. Deuba district, Serua Province

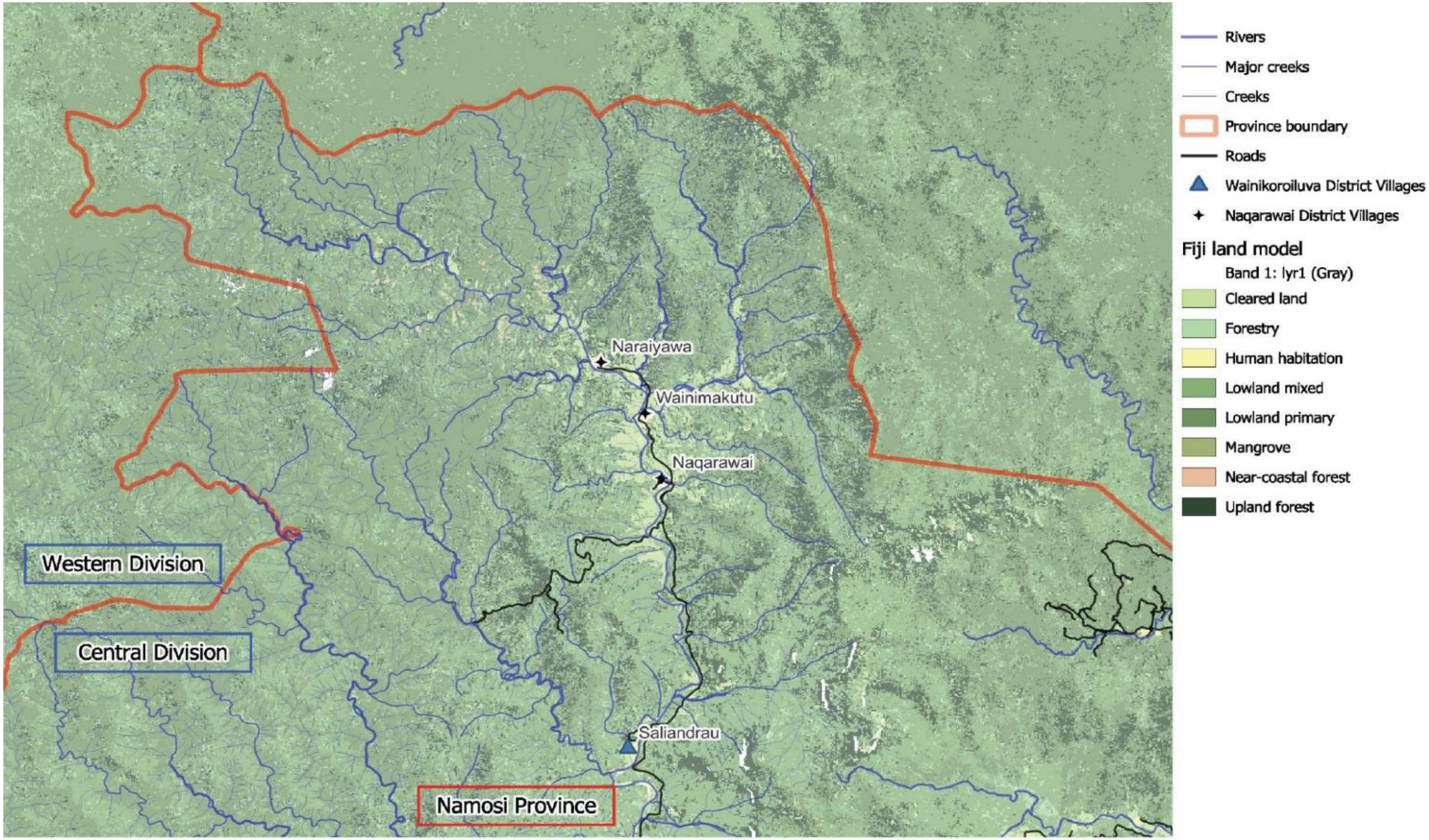

Figure 25. Naqarawai and Wainikoroiluva districts, Namosi Province

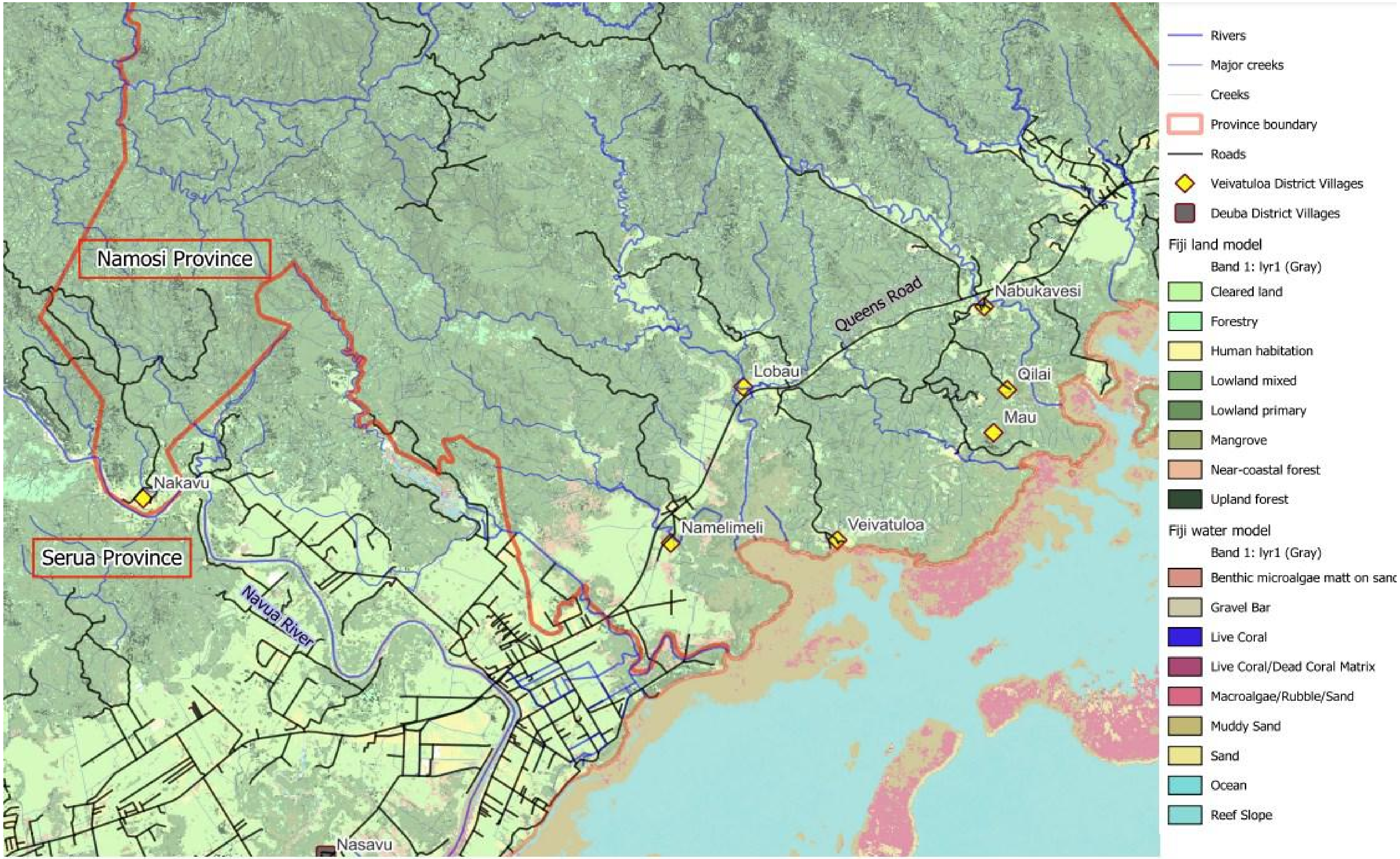

Figure 26. Veivatuloa district, Namosi Province

Figure 27. Raviravi and Sawau districts, Rewa Province

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