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1. Introduction and executive summary

This Feasibility Study (FS) supports the Green Climate Fund (GCF) Proposal “Fiji: Coral Reef Resilience Project and will increase the resilience and productivity of the Great Sea Reef. This comes in a time of escalating local (e.g., declining water quality, strengthening storms, toxic levels of pollutants) as well as global threats (e.g., ocean warming, acidification, sea level rise, stronger storms, dryness and drought). The project will support the Government of Fiji in adopting an integrated approach to land-sea management in the face of rapid climate change, particularly within management networks that incorporate ecosystem-based solutions (EbS) to enhance community and ecosystem resilience and support climate adaptation.

Fiji is a ‘small island, big ocean’ nation in the Western Pacific Ocean with an estimated population of over 943,072 people living within 18,270 km² of habitable land¹. Much of its geomorphology is characterised by its prominent Ridge-to-Reef (R2R) geography, traversing from the rugged mountain ranges to coral reefs and coastal mangroves. The mountainous regions of Fiji are primarily composed of volcanic rocks, while the coastal areas are dominated by calcium carbonate from coral reef deposits. Fiji's unique geography and location have resulted in a rich biodiversity with many endemic species. Its island geography has already undergone an extensive assessment of its vulnerability to climate change² across the full spectrum of economic sectors, from coastal infrastructure to health. These features highlight the exceptional value of its terrestrial and marine ecosystems as a centrally important resource base for maintaining climate resiliency in the fisheries, agriculture, forestry, and tourism sectors.

Fiji is highly vulnerable to climate change impacts, including sea-level rise, increased cyclone intensity, and changing rainfall patterns.³ These impacts pose significant risks to the country's economy, infrastructure, and livelihoods. More than 75% of Fiji's population lives in coastal areas, with total dependence on the coastline.⁴ Fiji is one of the world's most vulnerable nations to climate change and climate-related disasters, with key vulnerabilities in its subsistence agriculture sector, coastal and marine resources (including coral reefs), freshwater resources, and land management.

The National Climate Vulnerability Assessment (NCVA⁵) pointed out that the average annual loss of assets due to tropical cyclones and floods alone is estimated to be more than US\$500 million annually, equivalent to more than 5% of Fiji's GDP. Additionally, the Internal Displacement Monitoring Centre estimates that 3,614 Fiji inhabitants are being displaced annually due to storm surges^{6,7}. Additionally, by 2050, Fiji's annual losses due to extreme weather events could reach 6.5% of GDP because of the impacts of climate change, with more than 32,000 people pushed into poverty every year.

The ecosystems of Fiji, particularly coastal forests, coral reefs, seagrass and mangroves, constitute a significant resource base for livelihoods, agriculture, fisheries, forestry and tourism, which are also relied upon for coastal protection. The ocean and coastal assets of the Melanesian region have an estimated annual economic value of at least US\$5.4 billion and a total ocean asset base estimated conservatively at US\$548 billion⁸. These critically important ecosystems support a diverse and extensive range of marine species and ecosystem services that provide numerous benefits to humans, including food, livelihoods, and protection against storm surges and sea level rise. Ecosystems such as coral reefs are also highly vulnerable to climate change and other human activities, causing rapid and unprecedented decreases in their extent, health, and abundance.

The Great Sea Reef (GSR), a vital ecosystem and economic resource for Fiji, is also exposed to these threats. The GSR of Fiji is the third-longest barrier reef system in the world⁹ and a critical resource for Fiji's people and economy. The

¹ Worldometers (n.d.) Fiji population. Available at: <https://www.worldometers.info/world-population/fiji-population/>

² Worldometers (n.d.) Fiji population. Available at: <https://www.worldometers.info/world-population/fiji-population/>

³ Profiles of Adaptation: Fiji | World Resources Institute, <https://www.wri.org/update/profiles-adaptation-fiji>

⁴ How Fiji is turning to nature to cope with climate change | Commonwealth, <https://thecommonwealth.org/news/blog-how-fiji-turning-nature-cope-climate-change>

⁵ YouTube (n.d.) [Video title]. Available at: <https://youtu.be/toOLqRJDV8k>.

⁶ Audrius, S., et al. 2020. Impact Assessment of Climate Change on Storm Surge and Sea Level Rise Around Viti Levu, Fiji. *Frontiers in Climate*, 2. <https://www.frontiersin.org/journals/climate/articles/10.3389/fclim.2020.579715>

⁷ Audrius, S., et al. 2020. Impact Assessment of Climate Change on Storm Surge and Sea Level Rise Around Viti Levu, Fiji. *Frontiers in Climate*, 2. <https://www.frontiersin.org/journals/climate/articles/10.3389/fclim.2020.579715>

⁸ Jupiter, S. (2017) ‘Melanesia's oceans are worth US\$5.4 billion but are at environmental crossroads’, *The Conversation*. Available at: <https://theconversation.com/melanesias-oceans-are-worth-us-5-4-billion-but-are-at-environmental-crossroads-67545>.

⁹ Status and trends of coral reefs and associated coastal habitats in Fiji's Great Sea Reef, <https://www.worldwildlife.org/publications/status-and-trends-of-coral-reefs-and-associated-coastal-habitats-in-fiji-s-great-sea-reef>

GSR stretches over 200 km in length from the island of Vanua Levu to the Yasawa Islands¹⁰. It encompasses over 1,200 km² of reef systems, including the third-largest barrier reef system in the world¹¹. The GSR is a diverse and complex ecosystem, featuring a high-value coral reef, two major deltas, mangrove systems, seagrass beds, and fish nursery grounds¹². Four of Fiji's six major rivers drain into the reef, influencing the GSR's ecological processes and connectivity with the surrounding land and seascape.

The biodiversity and health of the GSR make it more resilient to the effects of current climate changes¹³, and it provides a wealth of benefits to coastal communities, the local environment, and coastal livelihoods. However, projected climate changes are likely to slowly degrade this resilience, and critical thresholds will be breached over time. This may lead to severe impacts on the environment, livelihoods, coastal communities, and economies when the GSR's resilience capabilities are exceeded. This report highlights the benefits of the GSR, the likely impacts of climate change on its resilience, and the urgent need for interventions to ensure its long-term health and sustainability.

1.1. Benefits of the Great Sea Reef

The GSR provides a wealth of benefits to Fiji. These benefits are summarized in Table 1 below, and further details are provided in the following sections.

Table 1. Benefit of the GSR to Fiji.

Benefit Category	Specific Benefit	Description
Economic Benefits	Tourism	A major tourism hub, generating over a quarter of Fiji's GDP and supporting a diverse range of businesses. ¹⁴
	Fisheries	Contributes FJ\$12-16 million annually to Fiji's economy through the inshore fisheries sector. ¹⁵
	Coastal Protection	Protects coastlines from storms and erosion, reducing the costs of coastal defence and infrastructure repair. ¹⁶
	Mangrove Forests	Mangrove-related fisheries contribute an estimated FJ\$19.2 million annually. ¹⁷
Livelihoods	Income and Employment	Supports the livelihoods of approximately one-tenth of Fiji's population, particularly those in coastal communities who rely on the reef for fishing and tourism-related income. ¹⁸
	Food Security	Provides a primary source of protein for many Fijians, with an estimated 75% of their dietary protein coming from the ocean. ¹⁹
Environmental Benefits	Biodiversity	Supports 74% of Fiji's coral species, 55% of reef fish species, and 40% of all known marine flora in Fiji. ²⁰
	Threatened Species	Serves as a refuge for 12 threatened species on the IUCN Red List, including the hump head wrasse, bump head parrotfish, camouflage grouper, green turtle, and spinner dolphin. ²¹

¹⁰ Great Sea Reef - Landscape Finance Lab, <https://landscapefinancelab.org/featured-landscapes/great-sea-reef>

¹¹ Status and trends of coral reefs and associated coastal habitats in Fiji's Great Sea Reef, <https://www.worldwildlife.org/publications/status-and-trends-of-coral-reefs-and-associated-coastal-habitats-in-fiji-s-great-sea-reef>

¹² Great Sea Reef - Landscape Finance Lab, <https://landscapefinancelab.org/featured-landscapes/great-sea-reef>

¹³ Vulnerability of Fiji's mangroves and associated coral reefs to climate change | WWF, <https://www.panda.org/es/?199611/Vulnerability-of-Fijis-mangroves-and-associated-coral-reefs-to-climate-change>

¹⁴ Status and trends of coral reefs and associated coastal habitats in Fiji's Great Sea Reef, <https://www.worldwildlife.org/publications/status-and-trends-of-coral-reefs-and-associated-coastal-habitats-in-fiji-s-great-sea-reef>

¹⁵ Great Sea Reef generates \$16m - The Fiji Times, <https://www.fijitimes.com.fj/great-sea-reef-generates-16m/>

¹⁶ Corals Tutorial: Why are coral reefs important? - NOAA's National Ocean Service, https://oceanservice.noaa.gov/education/tutorial_corals/coral07_importance.html

¹⁷ The Great Sea reef Weaving Together Communities for conservation - Panda.org, https://wwfint.awsassets.panda.org/downloads/great_sea_reef_case_study.pdf

¹⁸ The Great Sea reef Weaving Together Communities for conservation - Panda.org, https://wwfint.awsassets.panda.org/downloads/great_sea_reef_case_study.pdf

¹⁹ Investing in Coral Reefs and the Blue Economy | Joint SDG Fund, <https://jointsdgfund.org/programme/investing-coral-reefs-and-blue-economy>

²⁰ Discover the Importance of Fiji's Great Sea Reef - PADI Blog, <https://blog.padi.com/discover-the-importance-of-fijis-great-sea-reef/>

²¹ The Great Sea reef Weaving Together Communities for conservation - Panda.org, https://wwfint.awsassets.panda.org/downloads/great_sea_reef_case_study.pdf

	Mangrove Forests	Mangrove forests, covering 340 km ² , play a vital role in protecting coastal communities from surging sea levels and cyclones. ²²
Cultural Significance	Cultural Identity	Holds deep cultural significance for Fijians, serving as a source of identity and traditional practices for coastal communities. ²³
	Community Well-being	The reef's health is intertwined with the well-being of these communities, who have relied on it for generations for sustenance, income, and cultural practices. ²⁴

1.2. Impacts of Climate Change on the Great Sea Reef

Climate change poses serious challenges for Fiji, with many hazards being slow-onset events (as defined by the Cancun Agreement, COP16). While increasing sea temperatures are a slow onset event, taking decades and centuries to reach a threshold, sudden changes as thresholds are crossed can have catastrophic effects on ecosystems and human communities. Like the rest of Melanesia, Fiji faces some of the most significant impacts from climate change despite being a relatively minor contributor to global greenhouse gas emissions (National Climate Change Policy 2018²⁵). Rapid-onset events, such as volcanoes (natural) and tipping points (i.e., sudden and precipitous environmental changes, positive or negative), are rare in the Fijian context although events such as tipping points have serious consequences²⁶.

Over the past 40 years, numerous coastal regions, including many in Fijian waters, have witnessed the loss of ecosystems such as corals, mangroves, seagrass and coral reefs (e.g., Souter et al. 2020), many of which are being overwhelmed by shorter and shorter return periods between extreme events such as intense marine heat waves, storm surge, and mortality events^{27 28}. These mortality events directly result from human-driven climate change (i.e., ocean warming and acidification). They are exacerbated by other factors such as ocean acidification, overfishing, rapid sea level rise, and declining water quality²⁹. The Global Climate Risk Index has ranked Fiji as 15th among countries facing high disaster risk due to its exposure to extreme events, such as storms, flooding and sea-level rise. In alignment with the Sustainable Development Goal (SDG 13: 'Take urgent action to combat climate change and its impacts'), numerous international organizations collaborate through the UNSG platform to formulate conventions, resolutions, frameworks, proclamations, and acknowledgements. These efforts aim to observe and project changes in future baselines, impacts, and extreme events, threaten its infrastructure, people, ecosystems, and livelihoods^{30 31}.

The GSR has however shown remarkable resilience to past climate variations, including cyclones and bleaching events³². This resilience may be attributed to a combination of factors, including the reef's location, oceanographic conditions, and the genetic diversity of its coral populations. Critically, the GSR's current resilience is also built upon traditional knowledge and past adaptation efforts, providing a strong foundation for further investment.³³ Traditional knowledge, passed down through generations, has enabled communities to adapt to environmental changes and develop sustainable practices.³⁴ This existing knowledge, combined with past adaptation efforts, has contributed to the GSR's current resilience.

²² WWF-Pacific launches Great Sea Reef report, https://www.wwfpacific.org/priority_places/fiji/great_sea_reef_seascape/#:~:text=A%20major%20tourism%20hub%2C%20it,surging%20sea%20levels%20and%20cyclones.

²³ Discover the Importance of Fiji's Great Sea Reef - PADI Blog, <https://blog.padi.com/discover-the-importance-of-fijis-great-sea-reef/>

²⁴ Fiji's Great Sea Reef: The first marine biodiversity survey | WWF - Panda.org, <https://www.wwf.panda.org/es/?102860/Fijis-Great-Sea-Reef-The-first-marine-biodiversity-survey>

²⁵ Republic of Fiji (2018) National climate change policy 2018-2030. Available at: <https://fijiclimatchangeportal.gov.fj/ppss/republic-of-fiji-national-climate-change-policy-2018-2030/>.

²⁶ Lenton TM, et al. Operationalising positive tipping points towards global sustainability. *Global Sustainability*. 2022;5:e1. <https://doi.org/10.1017/sus.2021.30>

²⁷ Hughes, T. et al. Global warming and recurrent mass bleaching of corals. *Nature* 543, 373–377 (2017). <https://doi.org/10.1038/nature21707>

²⁸ Hughes, T.P. et al. (2017). Coral reefs in the Anthropocene. *Nature* 546, 82–90. <https://doi.org/10.1038/nature22901>.

²⁹ Hughes, T.P. et al. (2017). Coral reefs in the Anthropocene. *Nature* 546, 82–90. <https://doi.org/10.1038/nature22901>

³⁰ World Bank (n.d.) Fiji country profile. Available at: https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/15854-WB_Fiji%20Country%20Profile-WEB.pdf.

³¹ DFAT (n.d.) Pacific risk profile: Fiji. Available at: https://www.dfat.gov.au/sites/default/files/pacific-risk-profile_fiji.pdf.

³² Depths Unknown | Magazine Articles | WWF - World Wildlife Fund, <https://www.worldwildlife.org/magazine/articles/depths-unknown>

³³ thecommonwealth.org, <https://thecommonwealth.org/news/blog-how-fiji-turning-nature-cope-climate-change#:~:text=To%20enhance%20their%20climate%20resilience,in%20Dakuinuku%20village%20in%20Tailevu.>

³⁴ Balancing climate resilience and adaptation for Caribbean Small Island Developing States (SIDS): Building institutional capacity | Integrated Environmental Assessment and Management | Oxford Academic, <https://academic.oup.com/ieam/article/20/5/1237/7821705>

The GSR's ability to withstand and recover from disturbances suggests that it could serve as a climate refuge for corals, offering hope for the survival of these vital ecosystems in the face of ongoing climate change. While the GSR has demonstrated resilience in the past, projected climate changes pose significant threats to its long-term health and the communities that depend on it. Climate change impacts are escalating, and even resilient communities can be overwhelmed if adaptation efforts stagnate.³⁵ Continued investment is crucial to maintain momentum and enhance existing resilience to withstand future climate shocks. These threats include:

- **Sea Surface Temperature (SST) Increases:** Rising SSTs can cause coral bleaching, leading to coral mortality, declines in coral cover, and shifts in the populations of other reef-dwelling organisms. Climate projections suggest that thermal thresholds for corals will be exceeded annually after 2050, if not sooner.³⁶
- **Sea-Level Rise (SLR):** Projected sea-level rise threatens coastal infrastructure and communities, with potential inundation of shoreline areas.³⁷ Additionally, rising sea levels and more frequent extreme weather events increase the risk of coastal flooding, which can impact both the reef and nearby communities.³⁸
- **Ocean Acidification:** Increasing ocean acidity reduces the availability of carbonate ions, hindering coral growth and potentially leading to the erosion of reef structures³⁹. Ocean acidification can also affect the growth and survival of other marine organisms, disrupting the food web and impacting the overall health of the reef ecosystem.⁴⁰
- **Increased Riverine Flooding:** Changes in rainfall patterns due to climate change can lead to increased riverine flooding, carrying sediment, pollutants, and nutrients into the coastal waters surrounding the GSR.⁴¹ This influx of land-based pollutants can smother corals, reduce water quality, and promote the growth of algae, further stressing the reef ecosystem.⁴²

The GSR is also impacted by Developmental threats. These locally originating threats include overfishing, ecosystem clearing for agriculture and tourism, pollution, and sedimentation, while 'global' climate threats include ocean warming, sea level rise, and acidification (IPCC, AR6). Fiji's GSR has been estimated to contribute approximately FJD 47.5 million (\$US 20.9 million) in economic value to Fiji's economy or roughly FJD 1 million (\$US 0.44 million) for every hectare of the reef system⁴³. Subsistence food provision from inshore fisheries and coastal resources has been valued at FJ\$ 88.08 million (US\$ 44.09 million) and a total national gross value of FJ\$ 59.04 million (US\$ 29.56 million) annually. Tourism accounted for FJD 1,367.30 per hectare (US\$ 684.52/ha) for coral reefs and lagoons; FJ\$ 5,952.33 per hectare per year (US\$ 2,979.89/ha/yr.) for mangroves and total gross value of FJ\$ 1,145.82 (US\$ 573.63) million per year⁴⁴. These include:

- **Overfishing:** Overfishing is a significant threat to the GSR, with evidence of a 33% decline in key fisheries since the 2000s.⁴⁵ Overfishing not only depletes fish stocks but also leads to a decline in fish sizes, disrupting the ecological balance of the reef.⁴⁶ This can further reduce the reef's resilience to climate change impacts.
- **Land-Based Pollution:** Land-based pollution, including agricultural runoff, sedimentation from deforestation, and industrial discharge, poses a major threat to the GSR.⁴⁷ These pollutants degrade water quality, smother

³⁵ *Balancing climate resilience and adaptation for Caribbean Small Island Developing States (SIDS): Building institutional capacity | Integrated Environmental Assessment and Management | Oxford Academic*, <https://academic.oup.com/ieam/article/20/5/1237/7821705>

³⁶ *Warming Seas - Reef Resilience Network*, <https://reefresilience.org/climate-and-ocean-change/warming-seas/>

³⁷ *Climate change and coastal resiliency of Suva, Fiji: a holistic approach for measuring climate risk using the climate and ocean risk vulnerability index (CORVI)*, Shiiba et al 2023, <https://pmc.ncbi.nlm.nih.gov/articles/PMC9838293/>

³⁸ *Nature-Based Solutions Inventory for Fiji, Climate Adaptation and Protected areas Initiative*, 2024, <https://www.iisd.org/system/files/2024-09/nature-based-solutions-inventory-fiji.pdf>

³⁹ *Ocean acidification: Decline of Great Barrier Reef likely to be worse than feared*, <https://www.carbonbrief.org/ocean-acidification-decline-of-great-barrier-reef-likely-to-be-worse-than-feared/>

⁴⁰ *Mainstreaming Ocean Acidification into national Policies - SPREP*,

https://www.sprep.org/sites/default/files/documents/publications/MainstreamingOAIintoNationalPolicies_PacificIslandsHandbook_0.pdf

⁴¹ *The Great Sea reef Weaving Together Communities for conservation - Panda.org*,

https://www.fint.awsassets.panda.org/downloads/great_sea_reef_case_study.pdf

⁴² *Preserving the integrity of Fijis Great Sea Reef | WWF*, <https://www.wwf.mg/?343010/Preserving-the-integrity-of-Fijis-Great-Sea-Reef>

⁴³ WWF (n.d.) *Global seafood redistribution report*. Available at:

https://www.fint.awsassets.panda.org/downloads/gsr_valuation_report_watermark_annex_3_1_1.pdf

⁴⁴ Audrius, S., et al. 2020. *Impact Assessment of Climate Change on Storm Surge and Sea Level Rise Around Viti Levu, Fiji*. *Frontiers in Climate* <https://www.frontiersin.org/journals/climate/articles/10.3389/fclim.2020.579715>

⁴⁵ *2019 Ecological Survey of Fiji's Great Sea Reef - Marine Conservation Evidence*, <https://www.marineconservationevidence.org/great-sea-reef-survey>

⁴⁶ *Fiji: WWF study shows fish decline on Fiji's Great Sea Reef - Islands Business*, <https://islandsbusiness.com/news-break/fiji-great-sea-reef/>

⁴⁷ *Preserving the integrity of Fijis Great Sea Reef | WWF*, <https://www.wwf.mg/?343010/Preserving-the-integrity-of-Fijis-Great-Sea-Reef>

corals, and disrupt the delicate balance of the reef ecosystem⁴⁸. Addressing land-based pollution is crucial for maintaining the GSR's health and resilience.

- **Deforestation and Sedimentation:** Increased sedimentation from deforestation and poor land use practices can smother coral reefs, reducing light availability and causing habitat destruction.⁴⁹

1.3. Relationship Between Coral Reef Health and Community Well-being

The health of the GSR is inextricably linked to the well-being of coastal communities in Fiji. Direct quantitative measures in Fiji may be limited⁵⁰, but global studies demonstrate a strong correlation between coral reef health and community well-being.⁵¹ Healthy coral reefs provide food security, economic opportunities, coastal protection, and cultural identity. Reef degradation can lead to declines in fish stocks, impacting food security and nutrition; a decline in tourism revenue, impacting livelihoods and economic stability; increased coastal vulnerability to storms and erosion, leading to damage to infrastructure and loss of property; and the erosion of cultural connections and community well-being.

The relationship between the GSR and coastal communities extends beyond economic or ecological dependencies. The reef is deeply intertwined with the cultural identity of Fijians, shaping their traditions, beliefs, and sense of place⁵². For generations, coastal communities have relied on the GSR for sustenance, income, and cultural practices⁵³. This interconnectedness highlights the importance of considering the social and cultural dimensions of reef conservation, recognizing that the well-being of communities and the health of the reef are inseparable.

1.4. Fiji's National Plan for GSR Conservation

Fiji has made significant strides in economic growth and development over recent years. However, the country continues to grapple with challenges such as climate change (e.g., warming, sea level rise, storms), natural disasters, and limited resources. The degradation of terrestrial, coastal, and marine ecosystems in Fiji is driven by various non-climatic factors, leading to a decline in the health of coral reefs, mangroves, and seagrass meadows. This decline weakens their ability to provide essential services that protect vulnerable local communities from climate change (i.e., sea level rise, intensifying storms, elevated soil erosion, heat stress). The Fijian government has recognized the importance of the GSR and is committed to its conservation. Fiji's national plan for GSR conservation includes several initiatives and targets aimed at protecting and managing this vital resource.

- **Ecosystem-based adaptation:** The government is implementing ecosystem-based adaptation (EbA) within the GSR and connected coastal ecosystems to enhance resilience to climate change.⁵⁴ This includes reducing local-scale impacts such as vital ecosystem destruction, overfishing, unsustainable production, and solid and chemical waste.
- **Marine protected areas:** Fiji is working towards establishing a network of marine protected areas (MPAs) that will cover 30% of the country's waters by 2030.⁵⁵ This commitment aligns with international conservation targets and will contribute to the long-term protection of the GSR.

⁴⁸ How coral reefs benefit from healthy watersheds - WCS Fiji - Wildlife Conservation Society, <https://fiji.wcs.org/Blog/articleType/ArticleView/articleId/13221/How-coral-reefs-benefit-from-healthy-watersheds.aspx>

⁴⁹ Nature-Based Solutions Inventory for Fiji, Climate Adaptation and Protected areas Initiative, 2024, <https://www.iisd.org/system/files/2024-09/nature-based-solutions-inventory-fiji.pdf>

⁵⁰ New Report on Fiji's Reefs - Living Oceans Foundation Living, <https://www.livingoceansfoundation.org/global-reef-expedition/pacific-ocean/fiji-islands/new-report-on-fijiis-reefs/>

⁵¹ Coral reef ecosystems | National Oceanic and Atmospheric Administration, <https://www.noaa.gov/education/resource-collections/marine-life/coral-reef-ecosystems>

⁵² The Surprising Connections Between Coral Reefs and Human Health, <https://coral.org/en/blog/the-surprising-connections-between-coral-reefs-and-human-health/>

⁵³ Fiji's Great Sea Reef: The first marine biodiversity survey | WWF - Panda.org, <https://www.wwf.panda.org/es/?102860/Fijis-Great-Sea-Reef-The-first-marine-biodiversity-survey>

⁵⁴ Coral Reef Resiliency Program - Green Climate Fund, <https://www.greenclimate.fund/document/coral-reef-resiliency-program>

⁵⁵ Depths Unknown | Magazine Articles | WWF - World Wildlife Fund, <https://www.worldwildlife.org/magazine/articles/depths-unknown>

- **National Hub for Coral Reef Conservation:** In collaboration with the Wildlife Conservation Society, Fiji has launched the National Hub for Coral Reef Conservation.⁵⁶ This hub serves as a platform for coordinating conservation efforts, sharing knowledge, and promoting sustainable management of coral reefs.
- **Environmental policies:** Fiji has implemented various environmental policies relevant to the GSR, including those related to marine protected areas, water quality management, and sustainable fisheries.⁵⁷ These policies contribute to the overall conservation framework for the GSR and aim to address both local and global threats.

Given the critical importance of the GSR and the escalating threats it faces, interventions are urgently needed to increase its resilience. Investing in areas with proven resilience offers a higher likelihood of success and a greater return on investment.⁵⁸ Building on existing strengths is more efficient and effective than starting from scratch in highly vulnerable areas. This approach allows for targeted interventions that address specific vulnerabilities and leverage existing adaptive capacities.

Investing in adaptation in the GSR safeguards these gains and ensures continued sustainable development.⁵⁹ By investing in further resilience-building, Fiji can position the GSR as a leader in climate adaptation. Showcasing innovative approaches and best practices in the GSR can provide valuable lessons for other SIDS facing similar challenges.⁶⁰ This leadership role can contribute to regional and global knowledge sharing on effective adaptation strategies and reduce the risk of unintended negative consequences.⁶¹

The resources and actions provide essential coastal ecosystem services, such as protection from storms and coastal erosion, and support a range of livelihoods, including fishing and tourism. However, these coastal resources are also vulnerable to the impacts of climate change, such as ocean warming and acidification, sea level rise, and increasing storm intensity. The degradation of coral reefs, mangroves, and seagrass can have significant consequences for the people who depend on these resources for their livelihoods and well-being. Looking to the future, Fiji must take further steps to protect and manage its coastal resources in the face of climate change to ensure the ecosystem services and climate adaptation benefits are sustained and amplified in the future.

These interventions should address both climate change impacts and developmental pressures.⁶² Locally, adaptation measures can implement EbA measures to enhance the resilience of the GSR to climate change impacts. This includes restoring degraded habitats and managing land-based pollution to improve water quality.⁶³ Implementing a Nature-based Solutions (NbS) approach can effectively conserve and enhance the resilience of these ecosystems. By restoring and preserving these habitats, we improve their health and strengthen their capacity to buffer climate-related threats. Investing in NbS will create a sustainable pathway for adaptation, ensuring that both ecosystems and local communities thrive in the face of climate change (e.g., ocean warming and acidification, coastal erosion, and coastal protection).

Additionally, addressing developmental pressures is crucial to reducing local stressors on the GSR. This includes promoting sustainable fishing practices, controlling pollution from agriculture and industry, and managing coastal development to minimize impacts on the reef ecosystem.⁶⁴ This may involve developing and expanding sustainable fisheries practices, restoring degraded coastal habitats, and promoting sustainable tourism practices that do less harm to these often-fragile ecosystems. By taking these steps, Fiji can help to ensure the long-term sustainability of its coastal resources and the livelihoods that depend on them.

⁵⁶ Fiji's commitment to coral reef conservation by IW:LEARN - Exposure, <https://news.iwlearn.net/fijis-commitment-to-coral-reef-conservation>

⁵⁷ Preserving the integrity of Fijis Great Sea Reef | WWF, <https://www.wwf.mq/?343010/Preserving-the-integrity-of-Fijis-Great-Sea-Reef>

⁵⁸ Balancing climate resilience and adaptation for Caribbean Small Island Developing States (SIDS): Building institutional capacity | Integrated Environmental Assessment and Management | Oxford Academic, <https://academic.oup.com/ieam/article/20/5/1237/7821705>

⁵⁹ COP29 Side Event - Building a Resilient Future: Strengthening Partnerships for Climate Finance in Small Island Developing States - the United Nations, <https://www.un.org/ohrrls/events/building-resilient-future-strengthening-partnerships-climate-finance-sids>

⁶⁰ COP29 Side Event - Building a Resilient Future: Strengthening Partnerships for Climate Finance in Small Island Developing States - the United Nations, <https://www.un.org/ohrrls/events/building-resilient-future-strengthening-partnerships-climate-finance-sids>

⁶¹ Balancing climate resilience and adaptation for Caribbean Small Island Developing States (SIDS): Building institutional capacity | Integrated Environmental Assessment and Management | Oxford Academic, <https://academic.oup.com/ieam/article/20/5/1237/7821705>

⁶² Fiji: Ocean temperature record unlocked from coral - Oceanographic Magazine, <https://oceanographicmagazine.com/news/ocean-temperature-record-unlocked-from-coral-in-fiji/>

⁶³ Coral Reef Resiliency Program - Green Climate Fund, <https://www.greenclimate.fund/document/coral-reef-resiliency-program>

⁶⁴ Preserving the integrity of Fijis Great Sea Reef | WWF, <https://www.wwf.mq/?343010/Preserving-the-integrity-of-Fijis-Great-Sea-Reef>

Interventions however to remain sustainable will need to balance potential trade-offs and challenges between economic development, local livelihoods, and conservation goals. This requires careful planning and integrated approaches that balance these competing interests. Continued monitoring and evaluation of adaptation activities is essential to track the effectiveness of interventions, adapt strategies as needed, and ensure the long-term health and resilience of the Great Sea Reef.

In addition to this governmental work engaging local communities in conservation efforts is essential for the long-term success of interventions. This includes providing communities with the knowledge, skills, and resources to manage their marine resources effectively; educating communities about the importance of reef conservation and the threats facing the GSR; supporting the development of alternative livelihood opportunities to reduce pressure on the reef and promote sustainable economic activities; and fostering collaboration between communities, government agencies, NGOs, and other stakeholders to ensure coordinated and effective conservation efforts.

The Great Sea Reef is a vital resource for Fiji, providing economic, social, and environmental benefits. However, climate change and developmental pressures pose significant threats to its resilience. Urgent interventions are needed to mitigate these threats and ensure the long-term health of the GSR. By integrating climate change ecosystem-based adaptation, sustainable development, and community engagement, Fiji can safeguard this invaluable resource for future generations.

The Great Sea Reef (Cakaulevu or GSR) is an extraordinary asset and is an extensive storehouse of biodiversity and complexity, as well as a testament to Fiji's environmental resilience. The GSR epitomises the possible harmonious coexistence of humans and nature, underscoring the possibility of sustainable interaction without mutual destruction. Despite its majesty and significance, the GSR is not immune to human activities (both global and local), and signs of deterioration are evident. Now more than ever, there is an urgent need for comprehensive conservation strategies that address both immediate threats and long-term challenges exacerbated by climate change. This strategy addresses ecological preservation while enhancing community resilience, offering a holistic solution to the challenges and threats posed by a rapidly changing climate in Fiji. This endeavour is not just for Fiji but a global urgency to preserve this underwater sanctuary for future generations. This Project goes a long way in establishing the infrastructure that will be needed as climate change begins to bite and efforts to manage localised stresses are affected.

This Feasibility Study (FS) identifies critical and strategic opportunities for alleviating stress from local issues such as nutrient and sediment pollution, deforestation, unsustainable fishing, land use disturbances, erosion, and deforestation. Having identified these opportunities to alleviate local origin stresses, there are targeted remedies emphasising the use of Nature-based Solutions (NbS) interventions in the priority Provinces (Ba, Ra, Bua, and Macuata) which can be scaled up across Fiji. The Feasibility Study also explores harmonising policy and regulatory mechanisms to establish current policies and regulations related to climate change, coral reefs, coastal ecosystems, and connected inland ecosystems. It identifies the regulatory gap-filling and harmonisation needs to operationalise these policies in Fiji's GSR.

2. Status quo

Fiji's GDP per capita stands at USD 5,317, with a total GDP of USD 5.0 billion. However, challenges persist due to its remoteness, natural hazards, and climate change, and are amplified by both extrinsic and extrinsic factors such as Fiji's history of ethnic divisions, pandemic and political shifts that shape its journey toward independence and stability. Over the past six decades, Fiji's population has experienced significant growth, with a remarkable 136.3% growth from 1960 to 2022. The highest surge occurred in 2015, with a 5.86% increase, while the most substantial decline was recorded in 2019 at -0.06%⁶⁵. With a population growth rate projected to decrease by -0.407% by 2100, Fiji faces challenges related to its demographic dynamics.

Approximately 60% of the population is under the age of 30, and nearly a third live below the international poverty line. Moreover, literacy rates are at 58%, exacerbating the strain on infrastructure and access to essentials like food and water. The World Bank reports that the poverty rate in Fiji is 29.9%⁶⁶ for its 889,993 or more citizens. Considering the lower-middle-income poverty rate (US\$3.2 per day), the World Bank projects a poverty rate of 39.3% in 2020-21,

⁶⁵ Wikipedia (n.d.) Macuata Province. Available at: https://en.wikipedia.org/wiki/Macuata_Province.

⁶⁶ World Data (n.d.) Fiji population growth. Available at: <https://www.worlddata.info/oceania/fiji/populationgrowth.php>.

39.2% in 2021-22, and 37.9% in 2022-23^{33 34}. The country must address these challenges to ensure the well-being of its citizens, and that economic development is sustainable, especially given costs of climate-related disasters mentioned in the sections above are exacerbating Fiji's economic vulnerability.

The Gender Inequality Index (GII) for Fiji stands at 0.65, highlighting gender-based disparities across three crucial dimensions: reproductive health, empowerment, and the labour market⁶⁷. This index measures the potential reduction (or improvement) in human development resulting from inequalities between female and male achievements in these areas. Ranging from 0 to 1, a higher GII value signifies more inequality between women and men. Women and youth remain the most vulnerable groups. Women in Fiji continue to encounter significant discrimination due to the country's patriarchal norms, resulting in limited access to critical economic roles. Currently, women constitute only 22.7% of the labour force, with many working as unpaid labourers or domestic workers under more challenging conditions and for meagre wages. However, there is progress in women's rights overall, with more women gaining access to education and achieving literacy.

Fiji faces significant challenges in balancing economic development with protecting and managing its environmental resources. According to recent data, the distribution of economic recourses among its major categories is as follows (based on 2017 data):

- Agriculture: 13.5%
- Industry: 17.4%
- Services: 69.1%

Fiji's arable land constitutes about 4.2%⁶⁸ of its territory⁶⁹ and is a crucial sector in Fiji, employing up to 42% of the workforce⁷⁰. Agriculture has been a cornerstone of Fiji's economy, contributing around 9% of its GDP. Crops like sugarcane, coconuts, and pineapples are cultivated by local farmers, and used locally, with exports to other nations. Sugarcane is an important crop for Fiji, contributing approximately 0.9% of its GDP but coming with impacts like agricultural pollution and erosion. The cultivation and processing of sugarcane play a significant role in the Fijian economy. However, global market fluctuations pose challenges for Fiji's agricultural sector.

In addition, more than 800 local communities heavily rely on coastal fisheries⁷¹, and commercial fishing contributes 7.2% to total exports for the country, with nearly 16,000 people directly employed by the sector²². However, significant challenges persist for Fiji, in areas such as Poverty and Undernourishment with approximately 24.1% of Fiji's population living below the national poverty line, and with an additional 12.3% suffering from undernourishment. The pressure on natural ecosystems in Fiji has also been increasing over time. For example, local communities have reported a significant decrease in the size and number of fish captured as well as declining crop yield in coconuts and many vegetables. These figures underscore the need to improve the sustainability of industries such as agriculture, fisheries, as well as tourism.

The drivers of such changes result from climate change (i.e., extreme events and tropical cyclones) and local threats (reduced water quality, and overfishing). Continued environmental change will likely put additional strain on natural resources that many coastal populations rely on for their food, livelihoods, and cultural values⁷². Despite its small contribution to global greenhouse gas emissions, Fiji is likely to face destructive impacts per capita and should be 'out-front' regarding emission advocacy.

Nationally Determined Contributions (NDCs) are climate action plans submitted by countries to outline their commitments to reduce greenhouse gas emissions and adapt to climate impacts under the Paris Agreement. The Fijian Government is committed to the full, effective and transparent implementation of the Paris Agreement in accordance with its provisions and the relevant Decisions of the Conference of the Parties to the United Nations Framework

⁶⁷ Database Earth (n.d.) Fiji population growth rate. Available at: <https://database.earth/population/fiji/growth-rate>.

⁶⁸ Trading Economics (n.d.) Fiji arable land (% of land area). Available at: <https://tradingeconomics.com/fiji/arable-land-percent-of-land-area-wb-data.html>.

⁶⁹ UNFCCC (n.d.) Fiji case study: Climate-resilient food systems for Africa. Available at: https://unfccc.int/sites/default/files/resource/CRFSA_Fiji_Case_Study.pdf.

⁷⁰ World Bank (n.d.) Fiji labor force. Available at: <https://data.worldbank.org/indicator/SL.TLF.TOTL.IN?locations=FJ>.

⁷¹ Gillett, R. (2015) 'An overview of Fiji fisheries', ResearchGate. Available at: https://www.researchgate.net/publication/279861585_An_Overview_of_Fiji_Fisheries.

⁷² Mangubhai, S. et al. 2019. Chapter 35 - Fiji: Coastal and Marine Ecosystems. *World Seas: an Environmental Evaluation (Second Edition)*, Pages 765-792, <https://doi.org/10.1016/B978-0-08-100853-9.00044-0>.

Convention on Climate Change (UNFCCC) and the Conference of the Parties (COP) serving as the meeting of the Parties to the Paris Agreement (CMA).

Fiji's Government Updated NDC Commitments are:

- Emissions Reduction Target: Fiji has committed to reducing its greenhouse gas emissions by 30% by 2030 compared to a business-as-usual scenario.
- Net Zero Goal: Fiji has set a target to achieve net zero greenhouse gas emissions by 2050.
- Renewable Energy: Fiji aims to increase the share of renewable energy in electricity generation to approach 100% by 2030, up from around 60% in 2013.
- Energy Efficiency: An additional 10% reduction in CO₂ emissions is targeted through economy-wide energy efficiency improvements.
- Climate Change Bill: Fiji committed to enacting its Climate Change Bill.
- National Adaptation Plan: The country has pledged to operationalize its National Adaptation Plan.

Fiji's NDC Implementation Strategy involves:

- Unconditional actions using domestic resources to achieve 10% of the emission reduction target.
- Conditional actions require external funding of US\$500 million to achieve the remaining 20% reduction.
- Fiji recognizes the need for international support and market-based mechanisms to fully achieve its conditional goals. The country is also developing sectoral monitoring and reporting systems to track progress on its commitments.

2.1. Economic profile

Fiji's economy is characterized by a diverse range of sectors, each with unique contributions and interconnections. Tourism draws visitors to the nation due to its renowned natural beauty, particularly its coral reefs. This sector's success directly benefits other industries, like transportation and restaurants. However, tourism's reliance on pristine environments creates a potential feedback mechanism: environmental damage, such as coral bleaching or pollution, can deter tourists and harm the very attractions that drive the industry.

Agriculture, while historically focused on sugarcane, has diversified to encompass a broader range of crops, horticulture, and livestock. This shift aims to enhance food security and reduce dependence on a single crop. The health of the agricultural sector is closely tied to the sustainability of land use practices and climate impacts. Forestry, for instance, plays a crucial role in soil conservation and watershed protection. Unsustainable forestry practices can lead to soil erosion, which negatively impacts agricultural productivity and, in turn, food security. Similarly, mining activities, while contributing to the economy, pose ecological risks that can harm both agricultural lands and vital fishing grounds.

Fisheries represent a significant contributor to Fiji's GDP and export earnings, providing livelihoods for many coastal communities. This sector's sustainability is intrinsically linked to the health of marine ecosystems. Overfishing or habitat degradation can deplete fish stocks, jeopardizing food security and economic stability. The tourism sector also relies on healthy marine ecosystems, highlighting the interconnectedness of these industries and the importance of sustainable practices.

The country's strategic priorities include addressing climate-related issues, and building international partnerships are crucial. As Fiji looks ahead, maintaining sustainable growth while safeguarding its unique environment remains a critical focus.^{73 74 75} The vulnerability of Fiji has increased when combined with other geopolitical drivers. Major sectors of the Fijian economy include Tourism, Agriculture, Fisheries, Manufacturing, Services, Sugar Production, Mining, Forestry, Fishing, Garment Manufacturing, and IT Services. Major sectors of the Fijian economy are emphasising tourism, agriculture diversification, and sustainable fishing practices.

⁷³ UNDP (n.d.) *Socio-economic impact assessment of COVID-19 in Fiji*. Available at: <https://www.undp.org/pacific/publications/socio-economic-impact-assessment-covid-19-fiji>.

⁷⁴ FBC News (n.d.) *AFD bolsters Fiji partnership for sustainability*. Available at: <https://www.fbcnews.com.fj/news/afd-bolsters-fiji-partnership-for-sustainability/>.

⁷⁵ FBC News (n.d.) *Fiji's economic growth expected to normalize post-pandemic*. Available at: <https://www.fbcnews.com.fj/news/fijis-economic-growth-expected-to-normalize-post-pandemic/>.

The GDP of Fiji has fluctuated over the years. For 2019 and 2020, different sources of economic activity provide slightly varying figures regarding the GDP growth rate. According to Macrotrends⁷⁶, the growth rate in 2019 was -0.58%, while it was -17.00% in 2020. On the other hand, a press release from the Reserve Bank of Fiji mentions a contraction of 15.2% for 2020⁷⁷. The average annual growth rate from 1971 until 2022 is reported to be 2.34% by Trading Economics⁷⁸. The figures here suggest that the COVID-19 pandemic significantly impacted the economic downturn in 2020, as was the case in many other countries globally. Fiji's economy has experienced notable fluctuations over the past two decades. In 2022, despite the impact of the COVID-19 pandemic⁷⁹, Fiji's Gross Domestic Product (GDP) exhibited an impressive rebound, expanding by 20% compared to the previous year. This increased growth was primarily driven by the service sector and net indirect taxes, followed by Industry (17.4%) and Agriculture (13.5%). The service sector, contributing to more than half of Fiji's GDP, played a pivotal role in this economic resurgence. However, it's essential to acknowledge the challenges climate change poses, significantly affecting Fiji's sustainability and resilience.

Fiji's economic progress faces significant challenges from climate change. Extreme weather events, rising temperatures, and sea-level rise threaten all sectors, including tourism, agriculture, and fisheries. Recognizing these challenges, Fiji has implemented policies and initiatives to promote sustainable practices, renewable energy, and climate resilience. The nation's commitment to environmental conservation underscores the understanding that economic growth and environmental well-being are inextricably linked.

2.1.1. Agriculture

Agriculture is vital for Fiji, as it is for many Pacific countries. It constitutes 10.6% of Fiji's Gross Domestic Product (GDP) and sustains the livelihoods of 27% of the population. Notably, 83% of Fiji's rural populace relies directly on agriculture as their primary source of employment⁸⁰.

Over time, Fiji's agricultural landscape has evolved, with sugarcane less dominating. Declining sugar production has prompted Fiji to focus on enhancing non-sugar sectors such as coconut, cassava, rice, and various fruits and vegetables⁸¹. Instead, other crops, horticulture, livestock production, and the subsistence sector have gained prominence. In recent years, Fiji has made significant strides in promoting sustainable agriculture and diversifying its crop portfolio. To stimulate growth in this sector, the Fijian government prioritises assisting small and marginalised farmers while fostering innovative technologies for sustainable agricultural development.⁸² Organic farming practices have gained traction, emphasising soil health, biodiversity, and reduced chemical inputs. Farmers increasingly cultivate root crops such as taro, cassava, and yams, staples of the Fijian diet⁸³. Additionally, horticulture has grown, with fruits like pineapples, papayas, and bananas finding their place alongside traditional crops. The livestock sector has expanded, focusing on poultry, dairy, and beef production⁸⁴. Furthermore, the subsistence sector, which includes small-scale backyard gardens and family farms, remains crucial for local food security and self-sufficiency (Figure 2-1). Fiji's commitment to sustainable practices ensures a resilient and thriving agricultural sector.

Sugar production however has been the backbone of the Fijian economy for over a century, contributing significantly to the gross domestic product (GDP) and generating substantial employment. It has been the principal export of Fiji, accounting for 58% to 65% of Fiji's domestic export earnings in the years 1983-1987. Despite challenges, the sugar industry continues to support, directly and indirectly, the livelihoods of more than 200,000 Fijians^{85 86}, although many sectors include significant food insecurity and undernourishment, poverty, and gender inequality. Natural disasters

⁷⁶ China.org.cn (2024) China-Fiji relations. Available at: http://www.china.org.cn/world/Off_the_Wire/2024-03/06/content_117043384.htm.

⁷⁷ Macrotrends (n.d.) Fiji GDP growth rate. Available at: <https://www.macrotrends.net/countries/FJI/fiji/gdp-growth-rate>.

⁷⁸ Macrotrends (n.d.) Fiji GDP growth rate. Available at: <https://www.macrotrends.net/countries/FJI/fiji/gdp-growth-rate>.

⁷⁹ UNDP (n.d.) Gender inequality index. Available at: <https://hdr.undp.org/data-center/thematic-composite-indices/gender-inequality-index#/indicies/GII>.

⁸⁰ Macrotrends (n.d.) Fiji GDP growth rate. Available at: <https://www.macrotrends.net/countries/FJI/fiji/gdp-growth-rate>.

⁸¹ Igbal, MR. 2022. The Economic Impact of Climate Change on the Agricultural System in Fiji. *Journal of Agricultural Science*; Vol. 14, No. 2. <https://doi.org/10.5539/jas.v14n2p144>

⁸² FAO (n.d.) Agricultural statistics in Fiji. Available at: <https://www.fao.org/asiapacific/perspectives/agricultural-statistics/global-strategy/results-in-the-region/fiji/en/>.

⁸³ Fiji Ministry of Agriculture (n.d.) Homepage. Available at: <http://www.agriculture.org.fj>

⁸⁴ SPC (2023) Launch of organic learning fahttp://www.agriculture.org.fj. for Fiji. Available at: <https://www.spc.int/updates/news/media-release/2023/07/launch-of-organic-learning-farm-centres-provides-major-boost-for>.

⁸⁵ Wikipedia (n.d.) Economy of Fiji. Available at: https://en.wikipedia.org/wiki/Economy_of_Fiji.

⁸⁶ Dean, M.R.U. 2022. The Fiji Sugar Industry: Sustainability Challenges and the Way Forward. *Sugar Tech* 24, 662–678. <https://doi.org/10.1007/s12355-022-01132-4>

have exacerbated the high level of poverty and insufficient food, with changes in food supply observed following major tropical cyclone events and periods of heavy rain and flooding.



Figure 2-1. Market in Labasa, Fiji (OHG, February 2024)

Fiji is divided into regions ultimately driven by local conditions (Table 2-1):

- Coastal plains are low-lying areas found along the islands' coasts and are characterised by fertile alluvial soils. They have a warm and humid climate and are suitable for growing crops such as sugarcane, bananas, pineapples, and vegetables.
- The Uplands regions are in the central and eastern parts of the islands and are characterised by steep hills and mountains. The climate is cooler and wetter than the coastal plains, and the soils are generally less fertile. The uplands are suitable for growing crops like root vegetables, fruits, and coffee.
- Dry Western Plains are found on the western part of the main island of Viti Levu, a dry region that receives less rainfall than other parts of Fiji. The soils are generally sandy and less fertile, but irrigation allows for the cultivation of sugarcane, tobacco, and other crops.
- Outer Islands consist of many smaller islands that are characterised by coral reefs, sandy beaches, and clear blue waters. These islands have a warm and humid climate that is suitable for growing coconuts, tropical fruits, and vegetables.

Table 2-1. Agroecological climate regions in Fiji showing examples of associated foods. ^{87 88}

Agro-Ecological Climate	Location	Characteristics	Suitable Crops
1. Tropical Maritime Climate (Coastal Lowlands)	Coastal areas and lowlands	Warm temperatures, high humidity, abundant rainfall	Coconut palms, bananas, papayas, taro
2. Subtropical Highland Climate (Interior Highlands)	Central mountainous regions	Cooler temperatures (due to elevation), moderate rainfall	Sweet potatoes, yams, ginger
3. Dry Climate (Leeward Side of Islands)	Leeward (sheltered) side of islands	Lower rainfall, drier conditions	Cassava, drought-resistant fruits
4. Wet Climate (Windward Side of Islands)	Windward (exposed) side of islands	High rainfall, lush vegetation	Taro, breadfruit, water-loving crops

⁸⁷ Fiji Ministry of Agriculture (n.d.) Homepage. Available at: <http://www.agriculture.org.fj>.

⁸⁸ Jupiter, S. (2017) 'Melanesia's oceans are worth us \$4-billion-but-are-at-environmental-crossroads', *The Conversation*. Available at: <https://theconversation.com/melanesias-oceans-are-worth-us-5-4-billion-but-are-at-environmental-crossroads-67545>.

5. Agroforests	Throughout Fiji	Traditional land-use systems with trees, crops, and livestock	Coconuts, breadfruit, medicinal plants
6. Savanna Climate (Grasslands)	Interior grasslands	Moderate rainfall, grass-dominated landscapes	Livestock grazing, hay production
7. Montane Forest Climate (Mountain Slopes)	Mountain slopes	Cool temperatures, misty conditions	Coffee, tea, avocados
8. Mangrove Swamp Climate (Coastal Wetlands)	Coastal mangrove areas	Brackish water, tidal influence	Mangroves, mud crabs, fish
9. Coral Atoll Climate (Island Atolls)	Low-lying coral atolls	Limited freshwater, sandy soils	Coconut palms, pandanus, fishing
10. Volcanic Soil Climate (Volcanic Islands)	Volcanic islands	Rich volcanic soils	Pineapples, root crops, vanilla

2.1.2. Fisheries

Fiji's marine ecosystems are productive, particularly when pelagic fish species such as tuna are the target, making the fisheries sector a central contributor to the nation's economy (Figure 2-2). The industry provides employment opportunities for many Fijians, particularly in coastal communities where fishing is often the primary source of income. Beyond its economic significance, fishing is vitally important in providing food to local communities. The sector provides employment opportunities for many Fijians, particularly in coastal communities where fishing is often a primary source of income, which adds about 2.8% to Fiji's GDP and 9.7% to total export earnings.

In addition to its economic significance, fishing also plays a vital role in providing food for local communities, contributing to community members' nutritional and caloric needs. About a third of all protein consumed in Fiji comes from fish. Moreover, the fisheries sector is potentially crucial in ensuring food security⁸⁹, particularly given the demand for growing Pacific populations. As the demand for food increases, the pressure on marine resources also intensifies. This makes it even more critical to manage these resources sustainably to ensure their availability for future generations⁵³.

Monitoring the health of Fiji's coastal and marine ecosystems is crucial for understanding their vitality and ensuring sustainable fishing practices. Regular assessments provide valuable insights into the state of these ecosystems. Local fisheries communities can make informed management decisions by identifying overfished species and tracking any shift in the distribution of fish populations. Implementing sustainable fishing practices is equally vital. Measures such as setting catch limits, restricting fishing during breeding seasons, and promoting bycatch-minimizing gear contribute to resource protection. Additionally, safeguarding marine habitats, such as coral reefs and mangroves, plays a pivotal role. These habitats serve as food sources, breeding grounds, and shelters for many fish species, making their preservation essential for Fiji's fisheries⁹⁰.



Figure 2-2. Fish at Labasa market (Feb 2024, OHG)

Fijian fisheries are particularly important given the rapidly growing populations of Western Pacific nations. The pressure on marine resources also intensifies as the demand for food increases. This makes it even more critical to

⁸⁹ Ruskin Felix Consulting (n.d.) Fiji: Its sugar industry. Available at: <https://www.ruskinfelix.com/country-highlights/fji/fiji-its-sugar-industry/>.

⁹⁰ Harding, S. et al. 2022. Marine resources and their value in Kadavu, Fiji. *Ambio* 51, 2414–2430. <https://doi.org/10.1007/s13280-022-01794-0>

manage these resources sustainably to ensure their availability for future generations⁹¹. Monitoring these trends is essential to understanding marine ecosystems' health and fishing practices' sustainability. Regular assessments can help identify overfished species, detect changes in fish populations, and inform management. Furthermore, implementing sustainable fishing practices is crucial to protect these vital resources. This includes setting catch limits, restricting time and space fishing during breeding seasons, and promoting fishing gear that minimizes bycatch. In addition, protecting marine habitats like coral reefs and mangroves can help maintain the productivity of Fiji's fisheries. These three habitats are crucial for many tropical species by providing food, shelter, and breeding grounds.

2.1.3. Tourism

The tourism sector plays a pivotal role in Fiji's economy, contributing significantly to its Gross Domestic Product (GDP). Fiji's pristine natural beauty and vibrant culture have increasingly attracted visitors from around the world. Ecotourism has gained significant momentum and popularity worldwide in recent years. In 2018, the tourism industry's direct contribution to Fiji's GDP was approximately FJD 2,700 million, equivalent to 23% of the country's GDP⁹². This sector generates revenue and provides employment opportunities for local communities. Tourists are strongly drawn to Fiji to explore its coral reefs, indulge in water sports, and immerse themselves in the Fijian culture. Visitors contribute to the vibrancy of Fiji's economy while enjoying its natural wonders.

The Great Sea Reef (GSR) tourism in Fiji contributes significantly to the country's economy (Figure 2-3). It supports at least a tenth of the population of Fiji as a primary revenue source. The reef is estimated to have produced FJD 47.5 million (USD \$21.5 million) for the Fijian economy in the past decade. The GSR is an essential natural resource that provides 65% of foreign exchange earnings, mainly from tourism and fisheries. However, tourism also has impacts on the reef. While it presents opportunities for conservation efforts, it also poses challenges. For instance, large resorts have been allowed to remove sections of the reef to create marinas and swimming pools. Overfishing is also a problem. Furthermore, the health of these reefs is vital for sustaining the tourism sector, but coral bleaching poses a significant threat to Fiji's marine ecosystem. On the positive side, Fiji has been making efforts to balance tourism with environmental conservation. Initiatives focused on education, sustainable tourism, and active conservation are gaining momentum. These efforts ensure that reefs continue to thrive and protect their natural beauty and ecological balance.

Tourism exceeds expectations, earning \$2.09 billion (April to December 2022). Most 587,406 holidaymakers came from Australia, New Zealand, and the United States. Key revenue sources include accommodation, contributing \$801 million (38% of total earnings), international and domestic airfares accounting for \$427 million (20.4% of tourism revenue), and restaurants and bars bringing in \$148 million, mainly through pre-paid package meals. This exceptional recovery occurred despite the unprecedented challenges posed by the COVID-19 pandemic. Fiji's commitment to sustainable tourism and the protection of its natural features.



Figure 2-3. Tourism is a primary economic sector in Fiji, although intensifying storms represent a growing risk.

Coral reef tourism on the north coast of Viti Levu and Vanua Levu significantly stresses coral reefs through activities like fishing and diving, which is facilitated by hotels, companies and operators⁹³. These activities result in the breakage of coral reef structures from the direct contact from divers and snorkelers, as well as anchor damage from boats, which can physically break and damage coral structures⁵⁹.

⁹¹ Harding, S. et al. 2022. Marine resources and their value in Kadavu, Fiji. *Ambio* 51, 2414–2430. <https://doi.org/10.1007/s13280-022-01794-0>

⁹² Ministry of Finance, Fiji, 2024. Fact Sheet: Tourism. Available at: <https://www.finance.gov.fj/wp-content/uploads/2024/02/Fact-Sheet-Tourism.pdf>

⁹³ Women in Ocean Science, 2020. The unintended impacts of tourism on coral reefs. Available at: <https://www.womeninoceanscience.com/blog/2020/5/26/the-unintended-impacts-of-tourism-on-coral-reefs>

2.1.4. Forestry

Forestry is another industry that is very important to Fiji, with deforestation and land degradation being aggravated by the environmental problems and management changes that Fiji faces⁹⁴. The Pine and Mahogany plantations play a significant role in Fiji's economy, contributing to increased export earnings, foreign and local investment, employment, and economic growth⁹⁵. The Mahogany industry is a pillar of the forest industry in Fiji⁹⁶. The plantations were initiated by the British Colonial Government in the early 1950s. The forestry sector, which includes these plantations, contributes around 0.3% to Fiji's GDP. The Fiji Hardwood Corporation, a government commercial company, was established to develop the Mahogany Industry in Fiji, including the harvesting and processing of mahogany forest. The plantations have also had social impacts, with leasing arrangements allowing both landowners and tenants to enjoy significant returns⁹⁷. However, they have also led to social and economic tensions.

On an environmental front, climate change impacts on these plantations are considered low in 2030 and 2050 but may become medium for Mahogany and Pine later in the century. Local communities also cite the mahogany plantations as a major source of Climate Change Impacts. The forestry sector, including mahogany plantations, has become more vulnerable to climate change impacts such as:

- Extreme weather events
- Changes in rainfall patterns
- Rising temperatures
- Increased risk of forest fires

These factors can affect tree growth, timber quality, and overall plantation productivity due to their potential impacts on the watershed and erosion^{98 99}.

Unsustainable land use can significantly impact local livelihoods and the natural filtration role of forests. Fiji is losing over 50 tons of invaluable soil per hectare each year¹⁰⁰, four times the average in tropical areas and extremely valuable in terms of farm soils and opportunity lost to river run-off (Figure 2-4). This highlights the importance of sustainable practices in sectors such as forestry and mining to preserve the crucial ecosystem services provided by Fiji's forests. The soil loss degrades the land and affects ecosystems' water quality, biodiversity, and climate regulation. Therefore, it is imperative to implement effective soil conservation measures and promote sustainable land management practices to mitigate sediment losses and thereby ensure the long-term health and productivity of Fiji's ecosystems.

⁹⁴ FAO, 2023. *Fiji: Forest and Landscape Restoration Mechanism*. Available at: <https://www.fao.org/in-action/forest-landscape-restoration-mechanism/our-work/countries/fiji/en/>

⁹⁵ Invest in Fiji, 2024. *Sector opportunities: Forestry*. Available at: <https://www.investinfiji.org/sector-opportunities/forestry>

⁹⁶ Ministry of Finance, Fiji, 2024. *Fact Sheet: Forestry*. Available at: <https://www.finance.gov.fj/wp-content/uploads/2024/02/Fact-Sheet-Forestry.pdf>

⁹⁷ Chang, H., 2014. *Forest management in the Pacific*. *Proceedings of the FIG Congress*, pp. 185-197. Available at: https://www.fig.net/resources/proceedings/fig_proceedings/fig2014/papers/TS07D/TS07D_chang_6859.pdf

⁹⁸ Chang, H., 2014. *Forest management in the Pacific*. *Proceedings of the FIG Congress*, pp. 185-197. Available at: https://www.fig.net/resources/proceedings/fig_proceedings/fig2014/papers/TS07D/TS07D_chang_6859.pdf

⁹⁹ Secretariat of the Pacific Regional Environment Programme (SPREP), 2014. *Fijian forests: Conservation and management*. Available at: <https://library.sprep.org/sites/default/files/14-fijian-forests.pdf>

¹⁰⁰ FAO, 2023. *Action Against Desertification: Fiji*. Available at: <https://www.fao.org/in-action/action-against-desertification/countries/pacific/fiji/ar/>



Figure 2-4. Sediment-laden creek near Vatutandova, Vanua Levu, Fiji (February 2024, OHG). As soils are disturbed, sediments increasingly enter the rivers and streams flowing into coastal regions, reducing the health of coral reefs, which are sensitive to being smothered. Changes in land use, erosion, storms and landslides are a number of contributing factors.

2.1.5. Manufacturing

The manufacturing sector in Fiji encompasses industries such as food processing, textiles, and wood products. The Fijian garment industry experienced rapid early growth and became a critical part of the country's financial structure. However, political instability and the cessation of preferential trade arrangements have seen the industry struggle, with the current focus being on niche markets such as ladies' fashionwear, uniforms, and sportswear¹⁰¹. Although it is considered a smaller sector than others, such as tourism and agriculture, it still plays a vital role in Fiji's economy. Fiji, particularly as an outsourcing industry, has grown rapidly, contributing approximately AUD160 million per annum to the Fijian economy. This growth has been supported by the Fijian Government's efforts in containing the COVID-19 virus, allowing businesses in Fiji's outsourcing industry to continue without many disruptions plus the advantage of tax incentives after COVID-19^{102 103}.

2.1.6. Mining

Mining is integral to Fiji's economy, with gold representing one of the country's most significant exports, along with silver and cement contribute heavily to Fiji's GDP. Deep-sea mining for rare earth metals and other minerals is also attracting interest despite the ecological risks, including disruption of deep-sea ecosystems, pollution, and potential damage to deep ocean carbon stores¹⁰⁴. Therefore, some countries, including Fiji, have called for a halt to deep-sea mining until its effects are better understood^{105 106}.

2.1.7. GHG emissions

Fijians currently emit approximately 1.2 tonnes of CO₂e per person yearly, a decrease of +~0.3 tonnes over the last five years. Fiji's 2030 NDC goal is to reduce emissions from the energy sector by 30%. Importantly, Fiji is already making

¹⁰¹ Press Files ANU, 2023. *Climate Change and Adaptation: Pacific Islands*. Available at: <https://press-files.anu.edu.au/downloads/press/p55871/pdf/ch118.pdf>

¹⁰² FAO, 2023. *Fiji: Forest and Landscape Restoration Mechanism*. Available at: <https://www.fao.org/in-action/forest-landscape-restoration-mechanism/our-work/countries/fiji/en/>

¹⁰³ Invest in Fiji, 2024. *Fiji's growing outsourcing industry*. Available at: <https://www.investinfiji.today/news-publication/fijis-growing-outsourcing-industry/>

¹⁰⁴ The Guardian, 2023. *Deep-sea mining for rare metals will destroy ecosystems, say scientists*. Available at: <https://www.theguardian.com/environment/2023/mar/26/deep-sea-mining-for-rare-metals-will-destroy-ecosystems-say-scientists>

¹⁰⁵ The Guardian, 2021. *Mining's new frontier: Pacific nations caught in the rush for deep-sea riches*. Available at: <https://www.theguardian.com/world/2021/jun/23/minings-new-frontier-pacific-nations-caught-in-the-rush-for-deep-sea-riches>

¹⁰⁶ Asia Pacific Report, 2022. *Fiji, Palau, and Samoa call for deep-sea mining moratorium at UN conference*. Available at: <https://asiapacificreport.nz/2022/06/30/fiji-palau-and-samoa-call-for-deep-sea-mining-moratorium-at-un-conference/>

strides towards renewable energy with ambitious targets to achieve 100% renewable energy use by 2036. The country has made significant progress towards this goal, with renewable energy sources contributing approximately 60% of its electricity generation as of 2021. GHG emissions within Fiji's borders are primarily based on the burning of fossil fuels, and cement production, among other activities.

Fiji's contribution to global CO₂ emissions is relatively small, accounting for approximately 0.004% of global emissions in 2021. Fiji's per capita methane and nitrous oxide emissions remain low compared to other countries. In 2021, the per capita methane emissions in Fiji were approximately 0.72 tons while per capita nitrous oxide emissions were approximately 0.208 metric tons¹⁰⁷.

Fiji's GHG emissions are dominated by energy and agriculture, accounting for 81% of total emissions in 2021 (Table 2-2). Other significant sources of emissions in Fiji include land-use change and forestry, which resulted in negative emissions due to forest carbon sequestration), transport, and waste.

Table 2-2. Annual greenhouse gas emissions in 2021 by sector in Fiji

SOURCE	ANNUAL EMISSIONS (GTCO ₂)	TOTAL EMISSIONS (%)
Energy	1,500	59%
Agriculture	557	22%
Forestry	380	15%
Waste	130	4%

However, emissions from industry, manufacturing and construction, electricity and heat, buildings, fugitive emissions, other fuel combustion, and aviation and shipping were relatively small. Fiji's carbon (CO₂) emissions for 2020 were 1,028.20 kilotons, a 26.21% decline from 2019. This was followed by a 0.45% increase from 2018, a 4.21% increase from 2017, plus an 11.05% increase from 2016¹⁰⁸. These trends were similar for GHG emissions¹⁰⁹.

Fiji has committed to reducing its emissions under the Paris Agreement, aiming to reduce emissions by 30% below business-as-usual (BAU) levels by 2030 or 20% below 2013, whichever is more ambitious. Fiji's NDC is conditional on international support, and the country has identified several barriers to achieving its emissions reduction goals, including limited financial and technical capacity.

2.2. Environmental status

The Great Sea Reef (GSR or Cakaulevu) is Fiji's most prominent marine asset to the people of Fiji and the global environment at large¹¹⁰. It lies off the northern shore of the main islands of Viti Levu and Vanua Levu, Fiji. It extends over 200 kilometres from western Viti Levu to the north-eastern point of Vanua Levu and contains over 1,200 km² of reef systems. The marine zones within the reef are partitioned into 'qoliqoli', which are traditional fishing territories governed by Fijian communities and recognized under Fijian law. This large marine ecosystem ranks as the third longest continuous barrier reef globally, behind the Great Barrier Reef in Australia and the Mesoamerican Barrier Reef off Central America¹¹¹.

Coral reefs in Fiji are extensive, covering nearly 12,000 square kilometres. These vibrant ecosystems are home to over 1,500 fish and 390 coral species. The GSR stands out as Fiji's ecological masterpiece and 'breadwinner', providing habitat for more than half of Fiji's fish and corals. Scientific analyses indicate that hard coral cover has remained stable

¹⁰⁷ Pacific R2R, 2021. *Regional Guidelines for Implementing the Ridge to Reef Science to Policy Strategic Framework*. Available at: <https://www.pacific-r2r.org/sites/default/files/2021-02/GEF-R2R-RSTC-TC2%20Inf.06%20Regional%20Guidelines%20for%20Implementing%20the%20%28modified%29%20R2R%20Science%20to%20Policy%20Strategic%20Framework.pdf>.

¹⁰⁸ Wikipedia, 2023. *Climate Change in Fiji*. Available at: https://en.wikipedia.org/wiki/Climate_change_in_Fiji.

¹⁰⁹ World Bank, 2017. *New Report Projects US\$45 Billion Cost to Reduce Fiji's Vulnerability to Climate Change*. Available at: <https://www.worldbank.org/en/news/press-release/2017/11/10/new-report-projects-us45-billion-cost-to-reduce-fijis-vulnerability-to-climate-change>.

¹¹⁰ Beyer, H.L. et al. 2018. *Risk-sensitive planning for conserving coral reefs under rapid climate change*. *Conservation Letters*, Volume 11, Issue 6. <https://doi.org/10.1111/conl.12587>

¹¹¹ Spalding, M., and Grenfell. 1997. *A. New estimates of global and regional coral reef areas*. *Coral Reefs* 16, 225–230. <https://doi.org/10.1007/s003380050078>

since the early 2000s, with a regional average of 31%. Macro-algae (seaweed) cover remains low, but there has been a slight increase from 4% to 5% in 2019. Despite overall good health in coral reef benthic communities, disturbances are evident. Rubble on GSR reefs increased significantly from 5% to 17% while fish populations have become smaller, with growing evidence that these are due to recent growing disturbances.

The Great Sea Reef holds immense cultural significance for Fiji's indigenous communities. Passed down through generations, stories and legends connect the GSR to Fiji's rich cultural heritage. It is considered a sacred place and a repository of traditional knowledge and practices. Approximately 60% of Fijians rely on coral reefs for sustenance, income, coastal protection, and cultural practices. Despite its enormous value, however, the GSR faces threats from overfishing, pollution, and climate change. In the latter case, this has involved ocean warming, increased death from thermal stress, more violent storms and reef breakage, and reduced calcification hence habitat for thousands of species).

The University of Queensland, supported by Bloomberg Foundation Philanthropies, assembled a team of 20 international coral reef experts to develop a risk-sensitive planning framework. This initiative was aimed at identifying and protecting reefs experiencing lower rates of exposure to climate change than the global average. This collaborative effort led to the identification of 50 coral reef areas, referred to as 'Bioclimatic Units' or BCUs, which have had relatively lower exposure to climate change. These BCUs provide a 'head start' in aiding coastal communities to begin recovering as soon as conditions are stabilised. The team evaluated the relative risk and value of different coral reef sites (minimum size of at least 500 by 500 km²) based on this lower exposure, vulnerability, and conservation potential. The '50 reef strategy' was formulated, which involves identifying and protecting less exposed yet well-connected coral reefs (in developing countries) from local factors. This strategy aims to build the strategic resilience of tropical coastal ecosystems and communities to climate change by identifying and reducing local-scale pressures in the short term. In the long term, planned protection of coral reefs in less exposed BCUs (with high regenerative capacity and connectivity) is expected to help 'nurture' impacted reefs until global conditions stabilise once again. The outcome of the selection of BCU plus associated methods is detailed in Beyer¹¹², Hoegh-Guldberg¹¹³ and colleagues. The Coral Reef Rescue Initiative (CRRRI) aim to protect and regenerate reefs with 'low' climate change exposure (Figure 2-5). CRRRI collaborates with international partners (e.g., WWF, WCS, RARE, CARE, U Arizona, and others) involving six countries: Fiji, Solomon Islands, Tanzania, Madagascar, the Philippines, and Indonesia (Beyer et al., 2018; Hoegh- Guldberg et al., 2018; see map). This is the basis of the Coral Reef Resilience Initiative, which is led by WWF and UQ, which is an alliance of six countries and six NGOs¹¹⁴. Note: Cuba (7th) is an observer.



Figure 2-5. Nations that represent the Coral Reef Rescue Initiative and 70% of least-exposed coral reefs on Earth

Fiji has a wealth of natural resources that span a wide array of opportunities, especially if combined with strategies that involve their sustainable use. Fiji's forests, for example, hold significant ecological and economic value. They also

¹¹² Beyer, H.L. et al. 2018. Risk-sensitive planning for conserving coral reefs under rapid climate change. *Conservation Letters*, Volume 11, Issue 6. <https://doi.org/10.1111/conl.12587>

¹¹³ Hoegh-Guldberg, O. et al. 2018. Securing a Long-term Future for Coral Reefs, *Trends in Ecology & Evolution*, 33(12), pp. 936–947. <https://doi.org/10.1016/j.tree.2018.09.006>

¹¹⁴ Coral Reef Rescue Initiative (n.d.) Homepage. Available at: <https://coralreefrescueinitiative.org>.

contribute to biodiversity conservation, carbon sequestration, and soil stabilisation. These forests cover approximately 56% of Fiji's land area, with varying types such as tropical rainforests, mangroves, and hardwood forests. Their uses include timber production for construction, furniture, and paper industries. Additionally, non-timber forest products, such as medicinal plants, resins, and edible fruits, play a role. Ecotourism benefits from these lush environments, attracting tourists interested in hiking, birdwatching, and experiencing pristine natural landscapes. Fiji's coastal and oceanic regions also have enormous marine resources and ecosystems that are invaluable for food security, livelihoods, and tourism. The country's Exclusive Economic Zone (EEZ) spans over 1.3 million square kilometres, encompassing diverse marine habitats. Coral reefs, mangroves, seagrass beds, and open ocean areas are abundant.

These marine resources serve several purposes:

- (1) Fisheries: Fiji relies on marine resources for protein consumption and market export. Pelagic fish (i.e., tuna), reef fish, and crustaceans (e.g., prawns, shellfish) are productive industries;
- (2) Coral Reefs and coastal ecosystems such as mangroves, provide food, carbon storage, and coastal protection
- (3) seaweed cultivation for agar production and pharmaceutical applications;
- (4) domestic livelihoods from small-scale fisheries and intertidal gleaning, and
- (5) the potential expansion of the extraction of deep-sea minerals for Fiji's economy, sustainable energy generation, and industrial processes¹¹⁵.

Fiji's economy is powered by mining, tourism, sugar, and foreign remittances. Fiji is, however, actively seeking to diversify and strengthen economic and ecological resilience in the face of growing environmental pressures. As a nation, Fiji receives many ecosystem services from the marine environment, including food, livelihoods, and coastal protection. The GSR contributes to ecosystem services and climate adaptation. The GSR is the world's third-largest barrier coral reef and the third-longest reef in the southern hemisphere. It has also been identified as a coral reef climate change refuge that may play a significant role in reseeding coral reefs globally once environmental pressures have been reduced and/or stabilised¹¹⁶. To ensure that marine and coastal ecosystems continue to provide economic, social, environmental, and climate change adaptation benefits into the future, local pressures on these systems must be reduced where possible¹¹⁷.

Coastal and marine ecosystems provide numerous benefits for human use and resilience, let alone their intrinsic value for supporting and protecting biodiversity. Maintaining coral reefs is a climate adaptation measure in and of itself (e.g., fisheries habitats, coastal protection). Despite this value, coral reefs are under threat (Figure 2-6). The Great Sea Reef is challenged by tourism, fishing, coastal development, and land-based pollution¹¹⁸. Fiji's coastal and marine ecosystems, resources, and threats are discussed below. Not surprisingly, these resources vary in terms of the pressure that is placed on them by human activities and by responses to opportunities and challenges.

¹¹⁵ SAS, 2023. Seabed mining: To mine or not to mine – Legal rights in Pacific Island countries. Available at: <https://www.sas.com.fj/ocean-law-bulletins/seabed-mining-to-mine-or-not-to-mine-a-trending-topic-for-the-pacific-island-countries- but-what-are-the-legal-rights-and-implications-for-goo-15385323>

¹¹⁶ Beyer, H.L. et al. 2018. Risk-sensitive planning for conserving coral reefs under rapid climate change. *Conservation Letters*, Volume 11, Issue 6. <https://doi.org/10.1111/conl.12587>

¹¹⁷ Wikipedia, 2024. Economy of Fiji. Available at: https://en.wikipedia.org/wiki/Economy_of_Fiji

¹¹⁸ Zhang, S., et al., 2021. Changes in coastal ecosystem services in Fiji due to warming. *BioRxiv*, Available at: <https://www.biorxiv.org/content/10.1101/2021.04.03.438313v1.full.pdf>

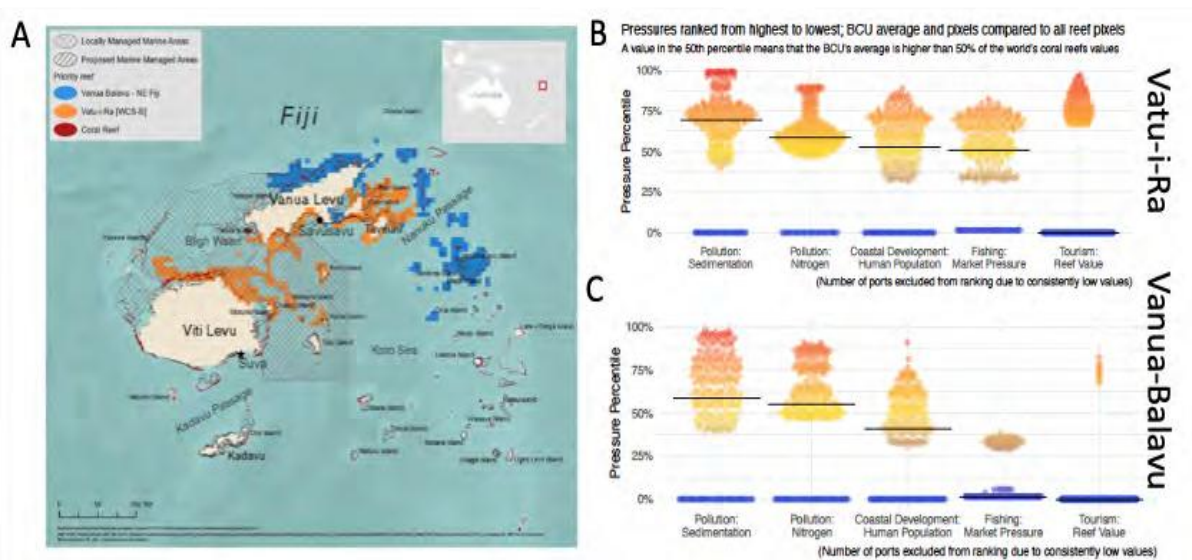


Figure 2-6. Dominant pressures across two main areas bioclimatic units (BCUs) of Fiji adapted from Andrello et al. 2021 A) Map of coral reefs and two primary regions of Fiji - Vanu-i-Ra and Vanua-Balavu. B) Dominant pressures across Vatu-i- Ra. C) Dominant pressures

2.2.1. Coral Reef Ecosystems

Fiji's coral reef provides habitat for many marine species, which contribute significantly to the protection of global biological diversity and its highly productive waters, as well as providing numerous benefits to the people and visitors to Fiji¹¹⁹. The GSR is a prime example¹²⁰, housing over three-quarters of known coral species and over half of the recorded fish species, a function of the extensive and complex habitat (Figure 2-7; Figure 2-8; Figure 2-9; Figure 2-10). From an economic perspective, Fiji's coral reefs contribute significantly to the country's economy through tourism, fisheries, and medicines¹²¹. The Great Sea Reef (GSR) region alone generates over FJD 1.1 billion annually (about \$500 million USD) and accounts for more than 25% of Fiji's GDP¹²². More often, these reefs also hold deep cultural significance for the indigenous Fijian communities. They are integral to the identities of coastal and island communities and are traditionally managed through a system of qoliqoli¹²³, or customary fishing areas, and are, therefore, the conservation of these complex and diverse ecosystems is of paramount importance for both ecological and human well-being in Fiji¹²⁴. Coral reefs in Fiji face key threats from local and global sources, with the deterioration of marine biodiversity and some coral reef areas.

¹¹⁹ Roberts, C.M. et al. 2002. Marine Biodiversity Hotspots and Conservation Priorities for Tropical Reefs. *Science*, Vol 295, Issue 5558, pp. 1280–1284. <https://doi.org/10.1126/science.1067728>

¹²⁰ World Wildlife Fund (WWF), 2020. Status and trends of coral reefs and associated coastal habitats in Fiji's Great Sea Reef. Available at: <https://www.worldwildlife.org/publications/status-and-trends-of-coral-reefs-and-associated-coastal-habitats-in-fiji-s-great-sea-reef>

¹²¹ Roberts, C.M. et al. 2002. Marine Biodiversity Hotspots and Conservation Priorities for Tropical Reefs. *Science*, Vol 295, Issue 5558, pp. 1280–1284. <https://doi.org/10.1126/science.1067728>

¹²² Wikipedia, 2024. Qoliqoli Bill. Available at: https://en.wikipedia.org/wiki/Qoliqoli_Bill

¹²³ Titumir, R.A.M., and Pasha, M.W. 2022. Traditional Knowledge and Customary Sustainable Practices in Coastal and Marine Ecosystem. In: Titumir, R.A.M. (eds) Sundarbans and its Ecosystem Services. Sustainable Development Goals Series. Palgrave Macmillan, Singapore. https://doi.org/10.1007/978-981-19-3000-3_5

¹²⁴ Amaral Camara Lima, M. et al. 2023. A review of seagrass ecosystem services: providing nature-based solutions for a changing world. *Hydrobiologia* 850, 2655–2670. <https://doi.org/10.1007/s10750-023-05244-0>



Figure 2-7. Coral reefs off Labasa (Macuata) show diverse coral communities

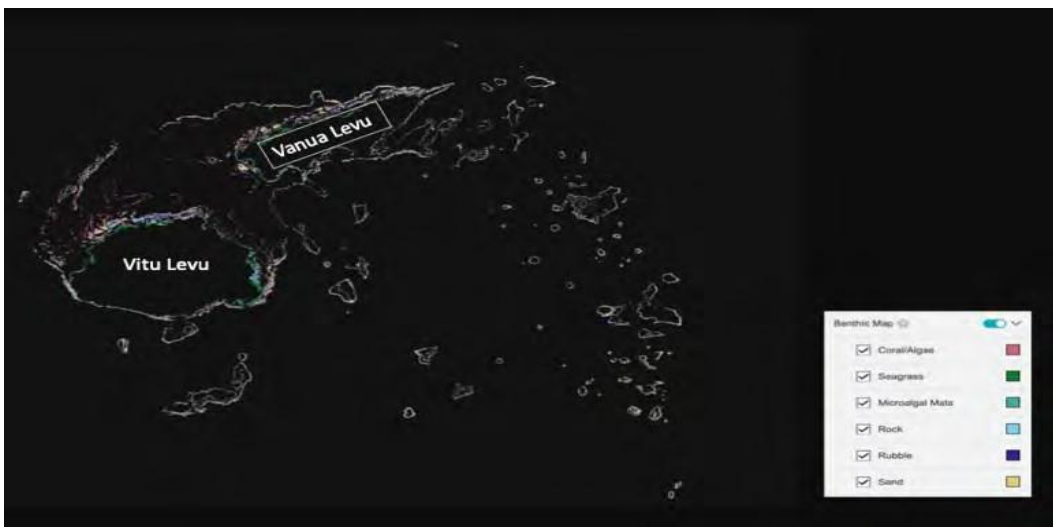


Figure 2-8. A Benthic map of coastal components such as coral/algae, sea grass, microalgal mats, rock, rubble and sand.¹²⁵



¹²⁵ Allen Coral Atlas- <https://www.allencoralatlas.org>, accessed January 14, 2024)

Figure 2-9. Coral reefs include many other non-coral species such as calcareous algae, sponges, and reef-building corals.

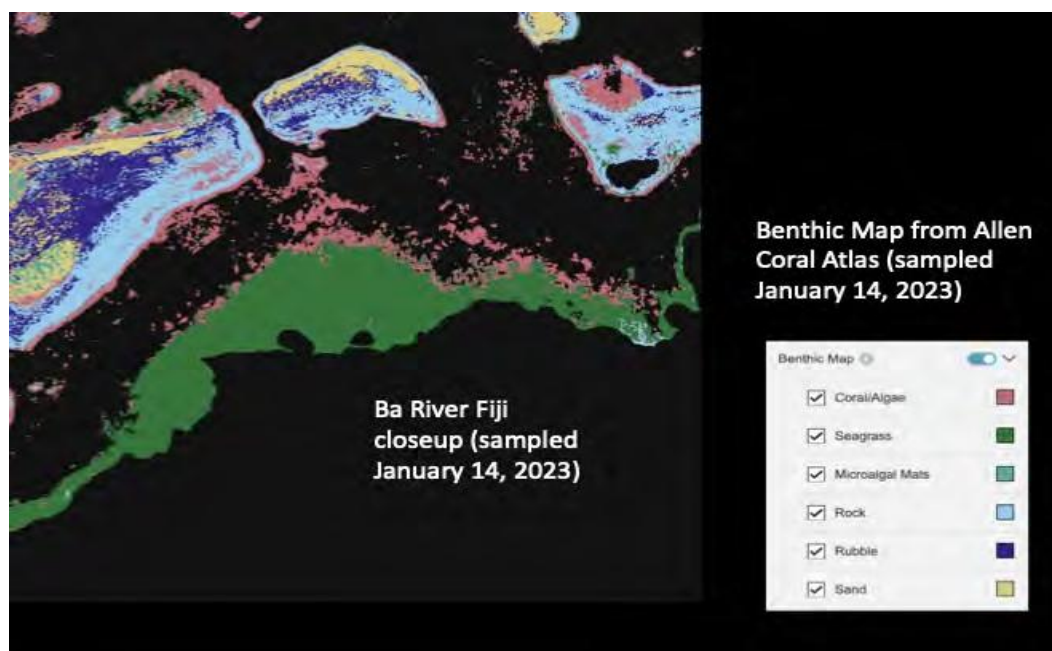


Figure 2-10. Distribution and abundance of benthic habitat classes in the Ba estuary

Field visit photos above show coral reefs at 5-10 meters off Ba, illustrating coral reefs and other organisms that inhabit this sub-tidal habitat. Figures above provide another perspective, featuring sponges, algae, and corals. In this case, reefs are being degraded by decalcifying organisms, a process stimulated by ocean acidification, which has significant implications for reef development and maintenance. These maps introduce a technological approach to understanding these changes. It presents a basic habitat map of the benthic component, derived from satellite data. These technologies show changes occurring in the reef ecosystem, providing valuable insights for assessments and offering a detailed view at larger scales of the different components of the marine environment. It encodes various elements for easy understanding: seagrass, microalgal mats, mangroves (green), coral reefs (pink), and bare rock areas affected by the tides.

2.2.2. Seagrass meadows

Seagrass meadows are a critically endangered marine ecosystem and are found in shallow and brackish coastal waters of estuaries. They are a diverse group of flowering plants (Angiosperms: have 'true' leaves and flowers) that have returned over evolutionary time to live in the ocean. They form dense underwater meadows and are among the world's most productive marine ecosystems^{126 127}. As a result, seagrasses play a significant role in providing valuable ecosystem services. These ecosystem services contribute heavily to the health of the world's coastal ecosystems, people, and the security of coastal communities¹²⁸. Seagrass meadows stabilise sediment and provide habitats and food for a diversity of marine life comparable to coral reefs. This includes invertebrates like shrimp and crabs, cod and flatfish, 5 out of 7 species of turtles, and seabirds as well as marine mammals such as dugong and whales. They provide refuge for endangered species such as seahorses, turtles, and dugongs. They function as nursery habitats for shrimps, scallops, and many commercial fish species¹²⁹. Seagrass meadows provide coastal storm protection by how their leaves absorb energy from waves as they hit the coast (i.e., enhancing coastal protection). They keep coastal waters healthy by absorbing bacteria, nutrients, and inorganic nutrients, and by slowing climate change by sequestering carbon dioxide (blue carbon) into the sediments.

Seagrass meadows are also dominated by angiosperms known as '*veivutia*' to Fijians and are found intertidal and in the shallow subtidal waters of protected and soft shores throughout Fiji (Figure 2-11)⁹⁰. They play an important role

¹²⁶ Wikipedia, 2024. Seagrass meadow. Available at: https://en.wikipedia.org/wiki/Seagrass_meadow

¹²⁷ Len J. McKenzie, L.J., and Yoshida, R.L. 2020. Over a decade monitoring Fiji's seagrass condition demonstrates resilience to anthropogenic pressures and extreme climate events, *Marine Pollution Bulletin*, Volume 160, 111636, <https://doi.org/10.1016/j.marpolbul.2020.111636>

¹²⁸ do Amaral Camara Lima, M. et al. 2023. A review of seagrass ecosystem services: providing nature-based solutions for a changing world. *Hydrobiologia* 850, 2655–2670. <https://doi.org/10.1007/s10750-023-05244-0>

¹²⁹ Len J. McKenzie, L.J., and Yoshida, R.L. 2020. Over a decade monitoring Fiji's seagrass condition demonstrates resilience to anthropogenic pressures and extreme climate events, *Marine Pollution Bulletin*, Volume 160, 111636, <https://doi.org/10.1016/j.marpolbul.2020.111636>

2-13). These plants are very significant resources for aquatic life, such as food, reproductive habitat, and coastal protection¹⁴⁰. On the other hand, there are many areas in Fiji where the integrity of seagrass meadows is deteriorating at a largely unmatched rate^{141 142 143}).

Healthy seagrass meadows are pivotal for maintaining coastal water quality, binding sediments, and slowing erosion, supporting diverse marine communities, recycling nutrients, and providing valuable ecosystem services such as carbon sequestration, fishing nursery habitats, and coastal protection. The degradation of these meadows leads to a loss of these services, including a reduction in biodiversity, a decline in fish populations, and a loss of carbon sequestration capacity, all of which can contribute to exacerbating climate change^{144 145 146}. Given these challenges and impacts, conservation efforts for seagrass meadows are of the utmost importance to many, if not all, effective coastal management strategies^{147 148}. Climate is a growing issue for seagrass meadows. Different tropical seagrass species show varying tolerances to increased temperatures, turbidity with thermal stress being found to significantly impact seagrass growth and survival. Sea level rise: Rising sea levels are accelerating coastal erosion and threatening shoreline stability, which can negatively impact seagrass beds in nearshore areas.

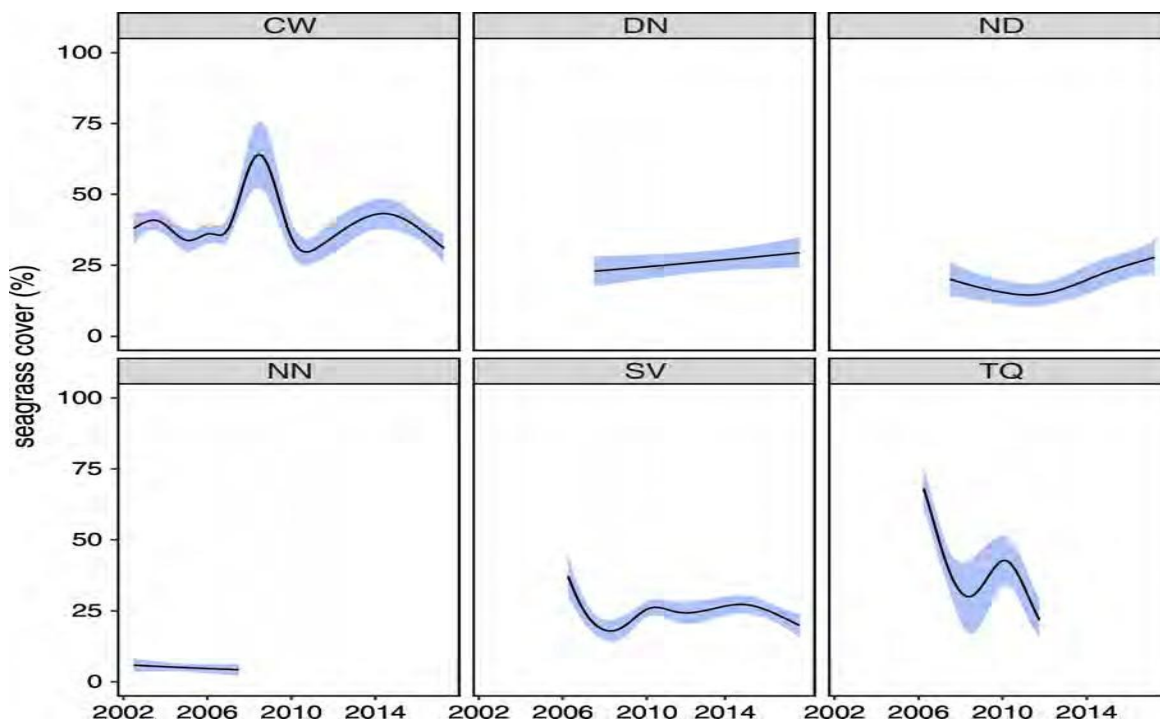


Figure 2-12. Relabelled from Figure 5 in McKenzie and Yoshida (2020): Trends in seagrass abundance (% cover) represented by a GAMM plot for each long-term monitoring location: CW = Cawaci, Ovalau; DN = Denarau; ND = Natadola; NN = Cuvu Harbour, Nadroga Navosa.

¹⁴⁰ UNEP, 2023. Seagrass meadows and climate resilience. Available at: <https://www.unep.org/topics/ocean-seas-and-coasts/blue-ecosystems/seagrass-meadows>

¹⁴¹ Joseph, L., et al., 2019. Implications of Seagrass Ecosystem Degradation on Marine Resources and People's Livelihood: A Case Study from Komave Village, Fiji. *Asian Journal of Fisheries and Aquatic Research*, 2(3), 1-13. Available at: <https://journalajfar.com/index.php/AJFAR/article/view/29>

¹⁴² Singh, S. 2019. Importance of Seagrasses: A Review for Fiji Islands. *International Journal of Conservation Science; Iasi* Vol. 10, Iss. 3, 587-602. Available at: <https://www.proquest.com/docview/260693527>

¹⁴³ <https://www.seagrasswatch.org/fiji/>

¹⁴⁴ Singh, S., et al. 2022. A. Blue carbon storage in Fijian seagrass meadows: First insights into carbon, nitrogen and phosphorus content from a tropical southwest Pacific Island. *Mar Pollut Bull.* Available at: <https://pubmed.ncbi.nlm.nih.gov/35217418/>

¹⁴⁵ Dunic, J.C., et al. 2021. Long-term declines and recovery of meadow area across the world's seagrass bioregions. *Glob Chang Biol.* Available at: <https://pubmed.ncbi.nlm.nih.gov/33993580/>

¹⁴⁶ Githaiga, M.N., et al. 2019. Seagrass Removal Leads to Rapid Changes in Fauna and Loss of Carbon. *Front. Ecol. Evol., Sec. Conservation and Restoration Ecology*, Volume 7. <https://doi.org/10.3389/fevo.2019.00062>

¹⁴⁷ McKenzie, L.J. and Yoshida, R.L. 2020. Over a decade monitoring Fiji's seagrass condition demonstrates resilience to anthropogenic pressures and extreme climate events, *Marine Pollution Bulletin*, Volume 160, 111636, <https://doi.org/10.1016/j.marpolbul.2020.111636>

¹⁴⁸ Spalding, M.D., et al. 2014. The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards, *Ocean and Coastal Management*, Volume 90, pp. 50-57, <https://doi.org/10.1016/j.ocecoaman.2013.09.007>

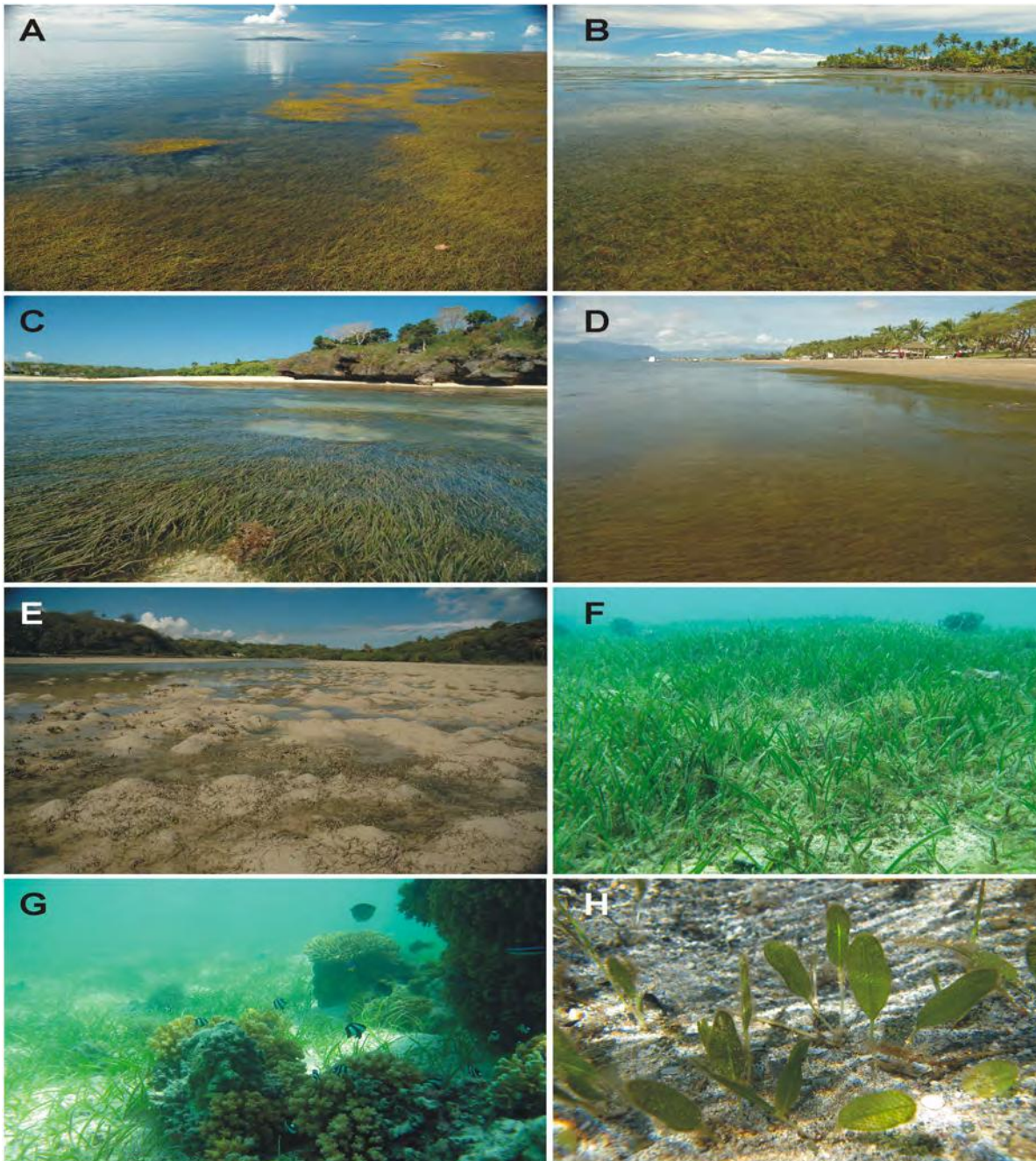


Figure 2-13. Photos relabelled from Fig. 4 of McKenzie and Yoshida (2020). Seagrass meadows in the Fiji Islands occur in a variety of habitats: A *Syringodium isoetifolium* with *Halodule uninervis* meadow, Cawaci, July 2014; B mixed *Halodule uninervis*/*Halodula* or pucker-like structures) present on the leaf blades, Tagaqe, May 2006.^{149 150}

2.2.3. Mangroves

Mangroves are coastal ecosystems typically found in the intertidal zones of tropical and subtropical regions worldwide. They are characterised by their dense networks of roots and branches, which provide an enormous and complex habitat for a diverse array of organisms, including various species of mammals, birds, invertebrates, plants and algae which rely on the mangroves for reproduction, food, and shelter¹⁵¹. Fiji has 65 recognised species of mangrove plants belonging to 20 families¹⁵². Mangroves in Fiji comprise seven main species of trees and several associated plants. The

¹⁴⁹ ARS, 2020. Seagrass ecosystems in the Pacific: Spatial analysis. Available at: <https://ars.els-cdn.com/content/image/1-s2.0-S0025326X20307542-mm3.kmz>

¹⁵⁰ Seagrass Watch, 2007. Seagrasses of the Fiji Islands. Available at: https://www.seagrasswatch.org/wp-content/uploads/Resources/Publications/2007/PDF/Seagrasses_of_the_Fiji_Islands_2007.pdf

¹⁵¹ Mangroves for Fiji, 2025. Mangroves in Fiji. Available at: <https://www.mangrovesforfiji.com/mangroves/mangroves-in-fiji>.

¹⁵² Mangrove Ecosystem Services Fiji, 2025. Mangrove and wetland ecosystems. Available at: <https://mesfiji.org/resources/environment/mangrovetwetland-ecosystems>.

trees can be categorised into three functional groups depending on the growth and reproductive habits: (a) propagule dispersers, (b) viviparous mangroves, and non- dispersers.^{153 154}

Understanding how this complex region is changing because of climate change and other more local factors is critically important. In this respect, Global Mangrove Watch (GMW) is an international program that provides remote sensing data and tools for monitoring mangroves, offering universal access to near real-time information on changes to mangroves across the world. According to the GMW, the global extent of mangroves was 152,604 km² in 1996. However, this decreased by 5,245 km², resulting in a total extent of 147,359 km² by 2020. This represents an estimated loss of 3.4% over the 24-year period. Mangroves are a prominent component of coastal ecosystems, with the total area of mangroves in Fiji being 488.14 km² in 2020, representing 47.55% of the 4,890.72 km of this coastline¹⁵⁵. Nearly 60% of the total mangrove area is found on Viti Levu – particularly in Ba, Rewa and Labasa Delta areas – and on Vanua Levu.

Photographic and satellite tools enable a rich and detailed understanding of how mangroves have and have not changed across over 100 nations that include mangroves, corals and seagrass. An in-depth examination of mangrove extent and condition has recently been conducted in Fiji (Figure 2-14). Landsat imagery was employed to evaluate changes in the Normalised Difference Vegetation Index (NDVI) as an indicator of mangrove degradation. Between 2020 and 2021, Fijian mangroves experienced a decrease of around 42 ha, reaching a total area of 40,702 ha. The proportion of degraded mangroves rose from 5.7% to 9.5% of the total mangrove area. Heightened mangrove degradation was observed in the northwest region of Vanua Levu Island, which was associated with Cyclone Yasa's impact in 2020. Ba contracted by 697 hectares (a 9% decrease) in Rewa between 2000 and 2020¹⁵⁶.

The impacts of the net mangrove area reduction in the two deltas - Ba and Rewa and the subsequent economic and environmental consequences are comprehensive. The net annual economic loss, estimated at \$335,000 USD, and the loss of mangroves' function as an anthropogenic CO₂ reservoir, calculated to be 202 t-C, highlight the significant role of mangroves in the economy and the environment. The equivalent of the CO₂ loss to the emissions of approximately 300 Fijians, or around half of the residents in the two deltas, underscores the urgency of conservation efforts. The suggestion to introduce economic incentives to local communities, such as the pricing of blue carbon, could be a viable strategy for mangrove conservation. Both natural and anthropogenic factors impact the mangrove area, species distribution, dominance, and dynamics. Identifying these underlying issues is crucial for taking appropriate measures. Baseline information for mangrove areas is important for improving conservation and rehabilitation work on mangrove ecosystems¹⁵⁷.

¹⁵³ Mangroves for Fiji, 2025. Mangroves in Fiji. Available at: <https://www.mangrovesforfiji.com/mangroves/mangroves-in-fiji/>.

¹⁵⁴ Global Mangrove Watch, 2025. Global Mangrove Watch: Monitoring global mangrove distribution and change. Available at: <http://www.globalmangrovetwatch.org/>

¹⁵⁵ Global Mangrove Watch, 2025. Global Mangrove Watch: Monitoring global mangrove distribution and change. Available at: <http://www.globalmangrovetwatch.org/>

¹⁵⁶ Avtar, R., et al. 2021. Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey. Coastal Engineering Journal, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

¹⁵⁷ Avtar, R., et al. 2021. Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey. Coastal Engineering Journal, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

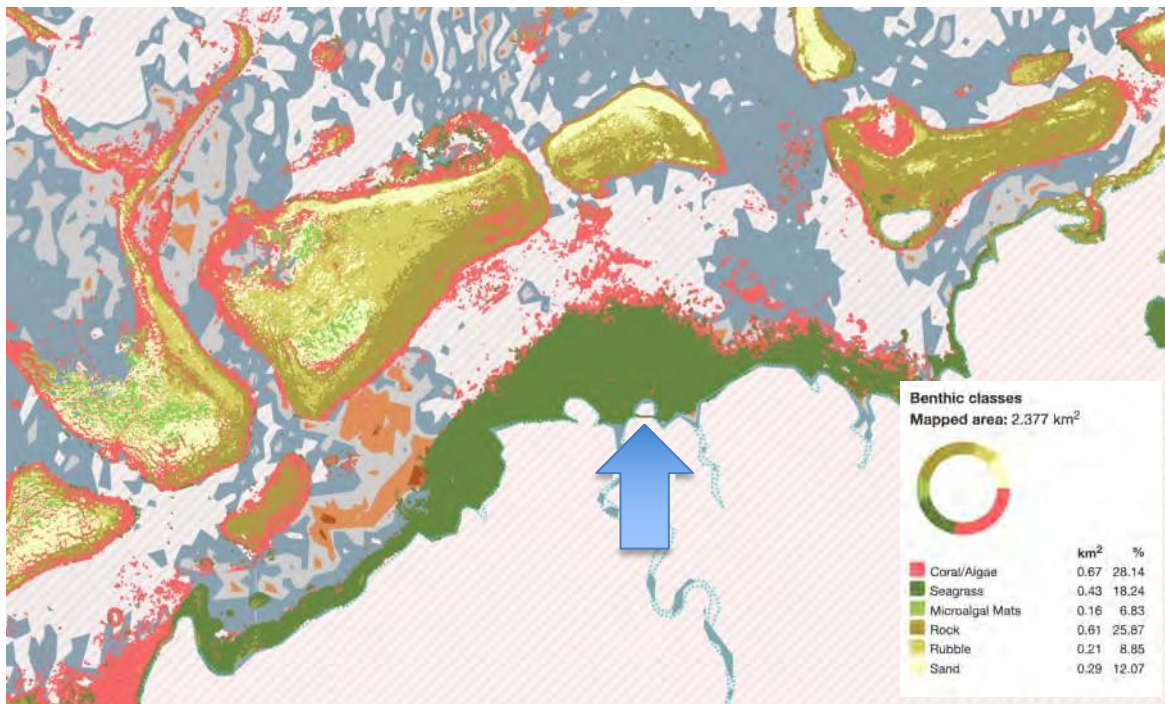


Figure 2-14. The distribution of mangroves (green; seagrass; Note mangroves treated in this analysis as forests) relative to other ecosystems such as coral communities (orange) and sand (yellow) near the potential Ba River study sites, Fiji¹⁵⁸

In addition to their contribution to the habitat for hundreds of species and significant ecological services, the complex root systems of mangroves act as natural ‘filters’, trapping pollutants and sediments from the water around them, thereby helping maintain the health of marine ecosystems¹⁵⁹. They also protect coastlines from erosion and buffer against extreme weather events, making them vital for coastal communities¹⁶⁰. Mangroves hold particular importance in Fiji for supporting local economies by bolstering fisheries and tourism. Moreover, they offer protection against coastal erosion and extreme weather events, which are particularly relevant given Fiji’s vulnerability and exposure to climate change. Cyclone Winston was one of the strongest cyclones in the southern hemisphere and struck Fiji in 2016. Fiji has the third-largest mangrove area in the Pacific after Papua New Guinea and the Solomon Islands which is mainly on the two main islands of Viti Levu and Vanua Levu. The largest area of mangroves is in the Rewa Delta on Viti Levu. The locations of the study area and villages surveyed in (a) the Ba Delta and (b) the Rewa Delta are represented by a red square (Figure 2-15 and Figure 2-16)¹⁶¹.

¹⁵⁸ Allen Coral Atlas - www.globalmangroveswatch.org accessed: January 14, 2023

¹⁵⁹ Mangroves for Fiji, 2025. Mangroves in Fiji. Available at: <https://www.mangrovesforfiji.com/mangroves/mangroves-in-fiji>.

¹⁶⁰ World Resources Institute (WRI), 2019. Mangrove conservation and sustainable use in Indonesia. Available at: <https://wri-indonesia.org/sites/default/files/FKP%20Arif%20Supam%20-%2029%20Jan%2019.pdf>.

¹⁶¹ Avtar, R., et al. 2021. Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey. Coastal Engineering Journal, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

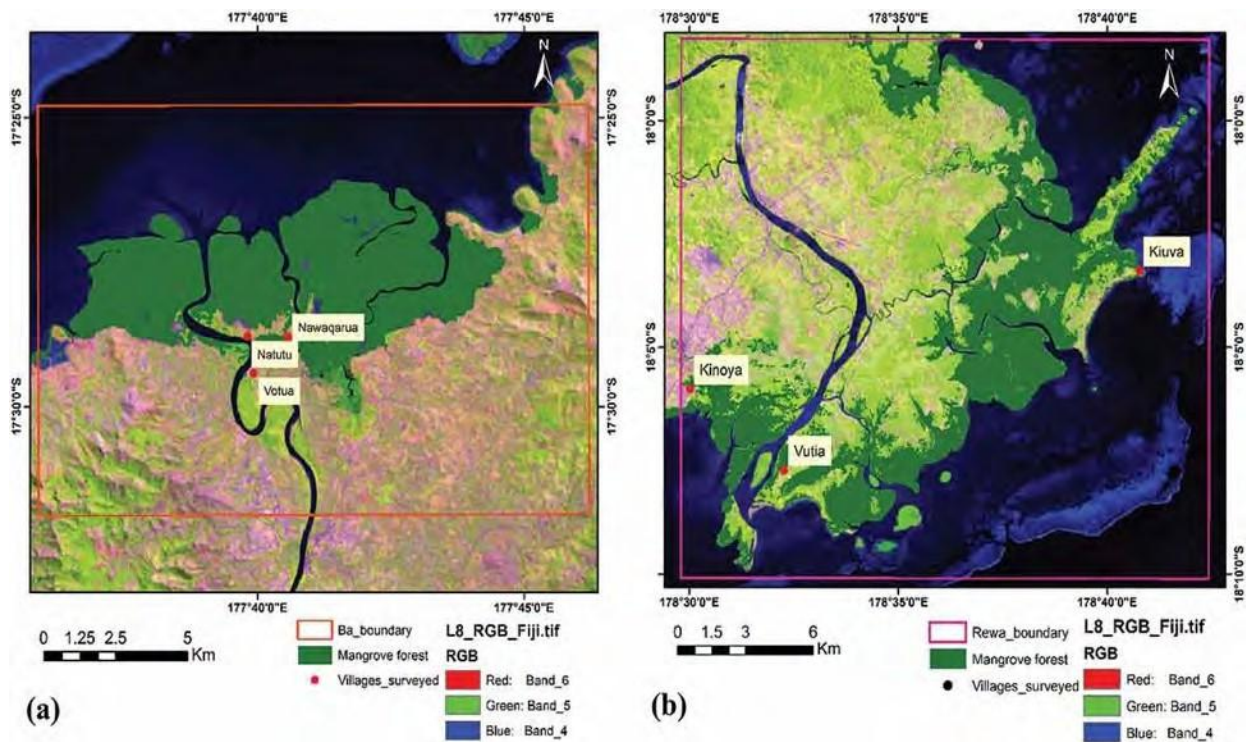


Figure 2-15. Adapted from Figure 2 from Avtar et al. (2021)¹⁶². Map showing the locations of the study area and villages surveyed in (a) the Ba Delta and (b) the Rewa Delta, Fiji. Each delta measured is represented with a red square.¹⁶²

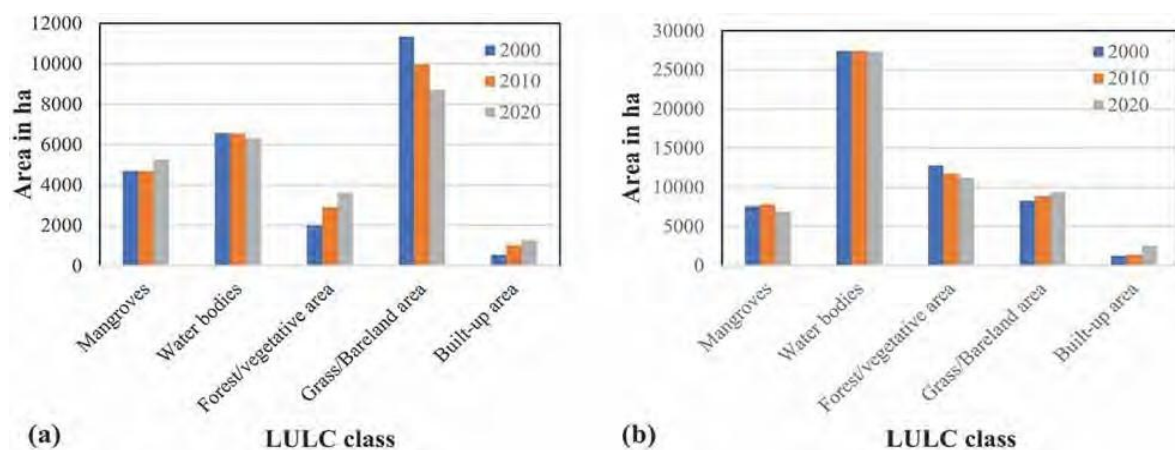


Figure 2-16. Land Use/Land Cover (LULC) classification maps for the Ba delta for (a) 2000, (b) 2010, and (c) 2020 and based on Landsat data for the Rewa delta for (a) 2000, (b) 2010, and (c) 2020¹⁶³.

Mangroves in Fiji are mainly threatened by human activities, including climate change (e.g., pollution, sea level rise, heat waves). In the latest report by the Global Mangrove Alliance, an estimated 67% of mangroves have been lost or degraded since measurements began, and an additional 1% is lost each year putting mangroves at the risk of being destroyed completely if trends continue¹⁶⁴. Storm damage was at the top of the list with deforestation, pollution, waste dumps, and coastal and urban development posing as significant threats to these valuable ecosystems. These activities lead to the loss of mangrove habitats, undermining their ecological integrity and the benefits they confer to natural habitats and human communities (Figure 2-17). Therefore, it is important to implement measures to protect

¹⁶² Avtar, R., et al. 2021. Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey. *Coastal Engineering Journal*, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

¹⁶³ Avtar, R., et al. 2021. Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey. *Coastal Engineering Journal*, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

¹⁶⁴ <https://www.mangrovealliance.org/gma/>

and conserve these vital ecosystems while also protecting them from intensifying storms, erosion, and rising sea levels¹⁶⁵.



Figure 2-17. Mangroves lining channels formed in the Labasa delta (Macuata)

Pollution, primarily from agricultural and industrial runoff, can lead to eutrophication, a process that involves too many nutrients that negatively affect the health of mangroves¹⁶⁶. Erosion, often intensified by the loss of mangroves, exposes coastal infrastructure to hazardous conditions, thereby increasing risks to human life and well-being¹⁶⁷. Dredging, trawling, logging, and anchoring physically damage these crucial ecosystems. Poor coastal development, propelled by urban expansion and changes in water courses, leads to habitat loss for mangroves¹⁶⁸. Overfishing disrupts the ecological balance within these environments, indirectly affecting their health and proliferation¹⁶⁹. Climate change exacerbates these challenges; extreme weather events (cyclones, heat waves) and temperature fluctuations impose additional stress on mangroves. Despite these adversities, mangroves remain pivotal and central role in protecting coastal communities against severe weather conditions and floods. Unregulated tourism development has led to extensive destruction of mangroves, making areas more vulnerable to environmental disasters¹⁷⁰. In some regions, large-scale reclamations and ecologically harmful developments have aggravated this issue¹⁷¹. While certain areas in Fiji are witnessing increasing degradation of mangrove ecosystems, others remain robust and thriving biodiversity sanctuaries¹³¹.

¹⁶⁵ Avtar, R., et al. 2021. Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey. *Coastal Engineering Journal*, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

¹⁶⁶ U.S. Geological Survey (USGS), 2004. Mangrove ecosystems and their conservation. Available at: <https://pubs.usgs.gov/publication/fs20043125>.

¹⁶⁷ Fauzi, A., et al. 2014. Eutrophication of mangroves linked to depletion of foliar and soil base cations. *Environ Monit Assess* 186, 8487–8498. <https://doi.org/10.1007/s10661-014-4017-x>

¹⁶⁸ World Wide Fund for Nature (WWF), 2023. Importance of sediment flow for mangrove conservation and restoration. Available at: https://www.panda.org/wwf_news/?358238/Importance-of-sediment-flow-for-mangrove-conservation-and-restoration.

¹⁶⁹ Ai, B., et al. 2019. The impact of rapid urban expansion on coastal mangroves: a case study in Guangdong Province, China. *Front. Earth Sci.* 14, 37–49. <https://doi.org/10.1007/s11707-019-0768-6>

¹⁷⁰ World Wildlife Fund (WWF), 2023. Overfishing as a threat to marine biodiversity. Available at: <https://www.worldwildlife.org/threats/overfishing>.

¹⁷¹ EcoNetwork Pacific, 2012. Coastal development and its impacts on mangroves in our environment. Available at: <https://www.econetworkps.org/2012/10/coastal-development-and-its-impacts-on-mangroves-in-our-environment/>.

2.3. Land use interactions with coastal and marine systems

Land use is complex in small island nations such as Fiji. Whether it is governance structure, ecosystems like coral reefs and mangroves, or climate change, the importance of land use and its interactions cannot be overestimated. Agricultural activities and changes in land use are primary contributors to land degradation and pollution (Figure 2-18). The runoff from agricultural regions can increase sedimentation, nutrient pollution, and pesticide contamination in water bodies and coastal soil, thereby reducing water quality¹⁷². Implementing appropriate land-use management practices, such as soil conservation, agroforestry, and integrated pest management, can mitigate the effects of agricultural activities on water quality and safeguard natural resources¹⁷³.

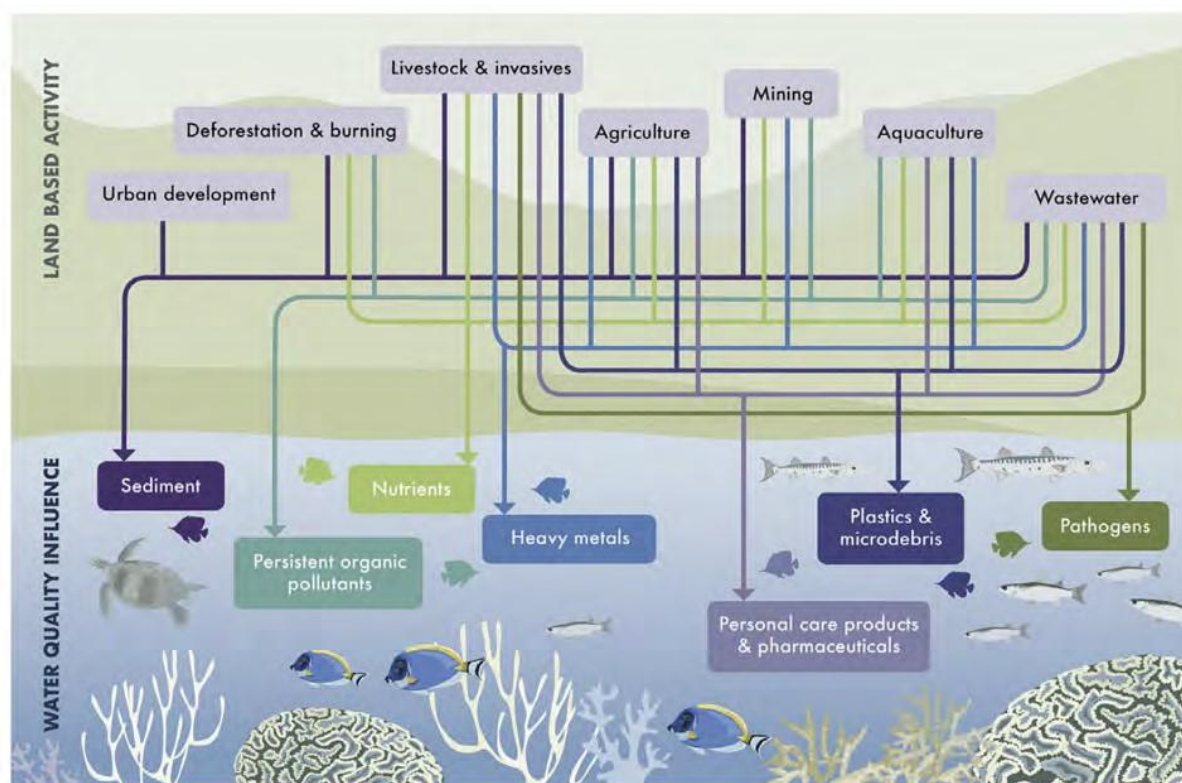


Figure 2-18 Land and sea-based interactions are active in processes that degrade water quality and system degradation (Figure adapted from Wakwella et al. 2022¹⁷⁴).

Forested regions also play a pivotal role in preserving water quality in Fiji¹⁷⁵. Forests serve as natural water filters, eliminating pollutants, sedimentation, and other contaminants, which leads to enhanced water quality downstream¹⁷⁶. Effective land-use management practices, including reforestation and rehabilitating degraded forested areas, can aid in maintaining water quality and minimising soil erosion.¹⁷⁷ Land-use management also plays a crucial role in managing carbon sources, sinks, and water quality¹⁷⁸.

Changes in land use, particularly deforestation, contribute significantly to greenhouse gas emissions, as many forests are substantial carbon sinks. Implementing appropriate land-use management practices, such as reforestation and

¹⁷² Numbere, A.O. 2020. The Impact of Landscape Reclamation on Mangrove Forest and Coastal Areas in the Niger Delta, Nigeria. *Landscape Reclamation - Rising From What's Left*. Available at: <https://www.intechopen.com/chapters/64407>

¹⁷³ Avatar, R., et al. 2021. Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey. *Coastal Engineering Journal*, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

¹⁷⁴ Fiji Ministry of Agriculture, 2020. Key statistics for the agricultural sector in Fiji. Available at: <https://www.agriculture.gov.fj/documents/stats/2020KEYSTATISTICS.pdf>.

¹⁷⁵ Di Bene, C., et al. 2022. Barriers and Opportunities for Sustainable Farming Practices and Crop Diversification Strategies in Mediterranean Cereal-Based Systems. *Front. Environ. Sci., Sec. Soil Processes*, Volume 10. <https://doi.org/10.3389/fenvs.2022.861225>

¹⁷⁶ Wakwella, A., et al. 2023. Integrated watershed management solutions for healthy coastal ecosystems and people. *Cambridge Prisms: Coastal Futures*, Volume 1, Article e27. <https://doi.org/10.1017/cft.2023.15>

¹⁷⁷ MIT Climate Grand Challenges, 2023. Managing greenhouse gases in terrestrial and coastal ecosystems. Available at: <https://climategrandchallenges.mit.edu/research/managing-greenhouse-gases-in-terrestrial-and-coastal-ecosystems/>.

¹⁷⁸ European PMC, 2023. Coastal ecosystems and climate change: Mitigation and adaptation strategies. Available at: <https://europepmc.org/article/CBA/524307>.

afforestation, can help reduce greenhouse gas emissions by enhancing the ability of forests to sequester carbon (hence 'green' carbon). Blue carbon, referring to carbon stored in the soils and biomass of coastal and marine ecosystems like mangroves, seagrass, and coral reefs, is also a sizable carbon sink in Fiji¹⁷⁹. Proper land-use management practices, including conserving and restoring these ecosystems, can help maintain and increase their capacity to store rather than release carbon¹⁸⁰.

Land-use management also plays a vital role in Fiji's hydrogeological profile, particularly in maintaining water quality and abundance and managing carbon sources and sinks. Implementing proper land-use management practices can help ensure the sustainability of natural resources, protect biodiversity, and mitigate the impacts of climate change. Communities rely on the land to provide a consistent source of food and freshwater and a variety of ecosystem-based functions and services. Therefore, it is a source and sink of GHGs and is vital in exchanging energy, water, and aerosols between the land surface and the atmosphere.

2.3.1. Ridge-to-Reef (R2R) management

R2R strategies extend from the ridges and high-altitude mountainous regions to the reefs and coastal areas. It considers the intricate connectivity between these diverse ecosystems, recognising their interdependence and their vital role in providing essential services such as water supply, food provision, and biodiversity conservation. This approach also underscores the interconnectedness of coastal ecosystems, acknowledging their collective contribution to providing indispensable services. These services include but are not limited to, the supply of clean water, the provision of food, coastal barriers, and the support of rich biodiversity. The R2R places a strong emphasis on the importance of maintaining healthy ecosystems. Healthy ecosystems, in turn, are instrumental in providing essential services such as a consistent supply of high-quality water and food and a supportive environment for biodiversity and ecological processes¹⁸¹. R2R management, associated with river catchment forests around the Ba River and other examples, is crucial in supporting the local ecosystem, regulating water flow, and providing habitats for a diverse range of flora and fauna.

Conservation efforts often focus on preserving and sustaining these valuable ecosystems, given their importance in maintaining good quality environmental water flow down the rivers and gullies to coastal regions. Water is not just a passive element within the Reef-to-Reef concept (R2R) but an active agent that connects different ecosystems and influences their health and productivity. The management of this water forms the basis of the R2R approach, emphasising the need for integrated, cross-sectoral coordination in the planning and managing of land, water, and coastal uses. The Ridge-to-Reef approach, a comprehensive and holistic management strategy, has been embraced in Fiji and many other island nations to manage the country's natural resources¹⁸². Water flows through the R2R, connecting different elements within the flow that is referred to as the 'Ridge to Reef' (R2R) management, which is associated with:

- **Freshwater Use:** Managing freshwater resources is a critical component of the R2R approach. This includes the sustainable use of water resources, ensuring water quality, and managing water-related hazards.¹⁸³
- **Sanitation and Wastewater Treatment:** Proper sanitation practices and effective wastewater treatment are essential to prevent pollution of water bodies, which can adversely affect both terrestrial and marine ecosystems¹⁸⁴.
- **Sustainable Land Use and Forestry Practices:** These practices protect water resources by preventing soil erosion, maintaining water quality and sedimentation and preserving natural water cycles.

¹⁷⁹ Food and Agriculture Organization (FAO), 2023. Forest and landscape restoration mechanisms in Fiji. Available at: <https://www.fao.org/in-action/forest-landscape-restoration-asia/flr-projects/project-detail/forest---landscape-restoration-for-climate-benefits---resilience-in-fiji/en>

¹⁸⁰ United Nations Framework Convention on Climate Change (UNFCCC), 2021. Nationally Determined Contributions for Fiji. Available at: <https://unfccc.int/resource/docs/natc/fjinc1.pdf>.

¹⁸¹ Fiji Department of Lands and Mineral Resources, 2023. Groundwater development in Fiji. Available at: <https://www.lands.gov.fj/index.php/departments-of-mineral-resources/geological-services/ground-water-development>.

¹⁸² Fiji Department of Lands and Mineral Resources, 2023. Groundwater development in Fiji. Available at: <https://www.lands.gov.fj/index.php/departments-of-mineral-resources/geological-services/ground-water-development>.

¹⁸³ Pacific Ridge to Reef (R2R), 2021. Mainstreaming Ridge to Reef in the Pacific. Available at: https://www.pacific-r2r.org/sites/default/files/2021-06/R2R_Mainstreaming_in_the_Pacific_Report.pdf.

¹⁸⁴ Fache, E., and Pauwels, S. 2022. The ridge-to-reef approach on Cicia Island, Fiji. *Ambio* 51, 2376–2388. <https://doi.org/10.1007/s13280-021-01669-w>

- Coastal Livelihoods and Biodiversity Conservation: The health of coastal and marine ecosystems (including coral reefs), which depend on the quality of water flowing into them, is vital for supporting coastal livelihoods and conserving biodiversity.

The R2R approach not only offers significant ecosystem benefits but also contributes to enhanced climate resilience. By managing our environment from the upland ridges down to coastal reefs, more robust and interconnected ecosystems are created that are better equipped to absorb and recover from climate impacts. For instance, healthy upland forests in the R2R approach act as carbon sinks, absorbing CO₂ emissions that contribute to global warming. These forests also regulate water flow to downstream ecosystems, reducing the impact of heavy rains and mitigating flood risks. The two regions are characterised by:

- In the mid-levels, sustainable agricultural practices reduce soil erosion and hence nutrient runoff, promoting soil health and productivity and maintaining water quality for downstream ecosystems. This not only helps in food security but also supports climate change adaptation by making agricultural systems more resilient to climate variability.
- In the coastal zone, protecting and restoring mangroves and coral reefs provide crucial buffers against storm surges and sea-level rise, a direct climate change impact. These ecosystems also serve as essential habitats for numerous marine species, supporting fisheries that many coastal communities rely on for livelihood and food security.

However, R2R management comes with challenges. The system is complex and requires effective coordination across boundaries (i.e., land-sea), ecosystems, communities, cultures, and jurisdictions (regional, national, etc.), to name but a few. Coordination across projects and jurisdictions was a key problem noted during stakeholder engagement, and it will be a priority in implementing the project. The R2R strategy ideally extends from the ridges or high-altitude mountainous regions to the reefs and coastal areas. It considers the intricate connectivity between these diverse ecosystems, recognizing their interdependence and vital role in providing essential services such as water supply, food provision, and biodiversity conservation¹⁸⁵.

Conservation efforts often focus on preserving and sustaining these valuable ecosystems, given their importance in maintaining good quality environmental water flow down the rivers and gullies to coastal regions. Water is not just a passive element within the Reef-to-Reef concept (R2R) but an active agent that connects different ecosystems and influences their health and productivity (Figure 2-19). The management of this water forms the basis of the R2R approach, emphasising the need for integrated, cross-sectoral coordination in the planning and managing of land, water, and coastal uses. The Ridge-to-Reef approach, a comprehensive and holistic management strategy, has been embraced in Fiji and many other island nations to manage the country's natural resources.¹⁸⁶

This approach also underscores the interconnectedness of coastal ecosystems, acknowledging their collective contribution to providing indispensable services. These services include, but are not limited to, the supply of clean water (i.e., low toxins and pathogens), the provision of food, coastal barriers, and the support of rich biodiversity. The R2R places a strong emphasis on the importance of maintaining healthy ecosystems. Healthy ecosystems, in turn, are instrumental in providing essential services such as a consistent supply of high-quality water and food and a supportive environment for biodiversity and ecological processes¹⁸⁷.

Catchment areas, typically characterised by dense forest cover, play an indispensable role in Fiji's hydrogeological profile. They function as natural reservoirs, storing and filtering water, which eventually feed into rivers, streams, and groundwater systems. However, the outcome of human activities such as deforestation, changes in land use, silviculture, and agricultural practices can disrupt the functioning of these catchment areas. This disruption can lead to increased runoff, soil erosion, and sedimentation in water bodies, harming the quality and availability of water resources and habitat. Reforestation and rehabilitation of degraded catchment areas are therefore critical for the sustainability of Fiji's water resources. These activities help to restore the natural functions of catchment areas, ensuring that they continue to provide their essential services and contribute to the overall health of Fijian coastal

¹⁸⁵ Fache, E., and Pauwels, S. 2022. The ridge-to-reef approach on Cicia Island, Fiji. *Ambio* 51, 2376–2388. <https://doi.org/10.1007/s13280-021-01669-w>

¹⁸⁶ Fiji Department of Lands and Mineral Resources, 2023. Groundwater development in Fiji. Available at:

<https://www.lands.gov.fj/index.php/departement-of-mineral-resources/geological-services/ground-water-development>.

¹⁸⁷ Pacific Ridge to Reef (R2R), 2021. Mainstreaming Ridge to Reef in the Pacific. Available at: https://www.pacific-r2r.org/sites/default/files/2021-06/R2R_Mainstreaming_in_the_Pacific_Report.pdf

ecosystems and people. In response to the challenges of managing water resources in Fiji, the Government has implemented several measures in collaboration with other stakeholders. These measures include the development of comprehensive water resource management plans, the regulation of groundwater extraction, the reforestation of catchment areas, and the implementation of awareness-raising programs. These programs aim to promote water conservation and efficient use among the population, fostering a culture of sustainability and respect for the environment.

Integrating the R2R approach into water resource management has been pivotal in ensuring the sustainable use of Fiji's water resources¹⁸⁸. By recognising the interconnectedness of ecosystems and the importance of maintaining their health, this approach has contributed significantly to the preservation and sustainable use of Fiji's precious water resources. This is a testament to the effectiveness of the Ridge-to-Reef approach and its potential to guide sustainable resource management efforts in Fiji and beyond^{189 190}.



Figure 2-19 Typical Ridge-to-Reef (R2R) geomorphology is found in continental or high islands throughout the Pacific (e.g., Fiji). Many islands have a rocky (continental) base around which coral reefs form, islands with significant forest cover on terrestrial sections. On the other hand, low-lying islands result from rising sea levels and the accumulation of calcium carbonate debris and sediments from calcifying organisms over thousands of years. In this case, many low-lying islands are only a few meters above high tide.

2.3.2. Extrinsic versus Intrinsic drivers.

Island nations like Fiji can be strongly influenced by intrinsic as well as extrinsic factors. Fiji is witnessing significant population growth that has led to increased pressure on the country's natural resources, particularly its forest and coral ecosystems¹⁹¹. The environment's capacity to support the growing population and their needs can sometimes be over-stretched.¹⁹² This over-utilization of resources can lead to degradation of the environment, loss of biodiversity, and reduced resilience to natural disasters and impacts. Moreover, climate change is the ultimate extrinsic factor which is exacerbating these pressures. Rising temperatures and sea levels, changing rainfall patterns and erosion, and increased frequency and intensity of extreme weather events are putting enormous strain on these already stressed systems¹⁹³. This is leading to the increasing abandonment of coastal villages, forcing residents to relocate to safer, higher ground¹⁹⁴.

¹⁸⁸ Pacific Ridge to Reef (R2R), 2021. What is Ridge to Reef? <https://www.pacific-r2r.org/help/faq/what-ridge-reef>

¹⁸⁹ <https://www.undp.org/pacific/projects/fiji-ridge-reef>

¹⁹⁰ <https://www.pacific-r2r.org/>

¹⁹¹ <https://newsroom.wcs.org/News-Releases/articleType/ArticleView/articleId/11569/Scientists-in-Fiji-Examine-How-Forest-Conservation-Helps-Coral-Reefs.aspx>

¹⁹² Pacific Ridge to Reef (R2R), 2021. Mainstreaming Ridge to Reef in the Pacific. Available at: https://www.pacific-r2r.org/sites/default/files/2021-06/R2R_Mainstreaming_in_the_Pacific_Report.pdf.

¹⁹³ Singh, S., et al. 2020. Coastal resource management and tourism development in Fiji Islands: a conservation challenge. *Environ Dev Sustain* 23, 3009–3027. <https://doi.org/10.1007/s10668-020-00764-4>

¹⁹⁴ UNFCCC, 2021. How Fiji is impacted by climate change. Available at: <https://unfccc.int/news/how-fiji-is-impacted-by-climate-change>.

Fiji¹⁹⁵ and other similar nations can build resilience to face these changes by developing strategies for sustainable resource management, disaster risk reduction, climate change adaptation and mitigation, and inclusive and participatory planning processes.

3. Problem Statement

Fiji's Climate Vulnerability Assessment (CVA) was prepared by the Government of the Republic of Fiji with the support of the ACP-EU Natural Disaster Risk Reduction Program¹⁹⁶. The assessment provides a significant new analysis of Fiji's vulnerability to climate change, with projections outlining potential impacts for Fiji over the coming decades¹⁹⁷. The CVA covers the effects of climate change on Fiji's economy, livelihoods, poverty levels, health, and food security with key industries, including agriculture and tourism, as well as the potential impacts of sea level rise on coastal areas and low-lying islands. The CVA report sets clear priorities and recommendations that can inform the national development priorities, particularly Fiji's sector investment plans for the short-, medium- and long-term. The report also identifies a major number of intervention areas to adapt to climate change:

- Ensuring serviced land and housing in safe areas.
- Strengthening infrastructure to meet the needs of the Fiji economy and population.
- Supporting agriculture and fisheries development in a manner that is smart for climate, the environment, and the economy, now and for the future.
- Implementing conservation policies to protect assets and reduce adaptation costs.

Fiji has a semi-industrialized economy with extensive natural resources and services for Fiji's people that are worth more than FJD2.5 billion per year (or USD1.1 billion per year) as of 2020. These values, however, are derived from the marketplace (i.e., tourism and commercial fishing) but do not reflect the total value of available resources. In the latter case, enormous value comes from benefits that are not necessarily part of the 'formal' economy¹⁹⁸ but come from important 'informal' sectors such as artisanal fishing, coastal protection, cultural heritage, and carbon storage, and which are not reflected in the 'direct' marketplace despite being extremely important to Fiji¹⁹⁹. Economic growth²⁰⁰ has led to environmental challenges such as deforestation, coastal soil erosion, pollution, and overfishing, adversely impacting Fiji's natural resources and their potential to tackle climate change. In response to these challenges, Fiji has embarked on initiatives to foster sustainable development and safeguard its environment²⁰¹.

Fiji has established protected areas²¹⁰ with a significant contribution from community-based environmental management in line with Fiji's immense wealth of traditional knowledge and cultural heritage. These efforts are crucial in maintaining the ecological balance, providing ecosystem-based climate adaptation, and preserving the country's natural beauty.

According to the IPCC consensus, Fiji will face significant impacts if global emissions of greenhouse gases from burning fossil fuels continue to grow unchecked (Table 3-1). Likely challenges included in even the best-case scenario of restricting global temperatures to 1.5°C above the pre-industrial period as listed below. The current climate policy trajectory, however, projects these thresholds to be breached, which will be disastrous for people, businesses and ecosystems.

¹⁹⁵ Government of Fiji, 2023. *Fiji's Climate Change Policies, Plans, and Strategies*. Available at: https://fijiclimatchangeportal.gov.fj/wp-content/uploads/2023/05/10.-Fiji_s-Climate-Change-Policies-Plans-and-Strategies.pdf.

¹⁹⁶ GW Project, 2021. *Land Subsidence and its Mitigation: Major Environmental Impacts*. Available at: <https://books.gw-project.org/land-subsidence-and-its-mitigation/chapter/major-environmental-impacts/>.

¹⁹⁷ Wikipedia, 2023. *Climate Change in Fiji*. Available at: https://en.wikipedia.org/wiki/Climate_change_in_Fiji.

¹⁹⁸ MacroTrends, 2021. *Fiji CO2 Emissions*. Available at: <https://www.macrotrends.net/global-metrics/countries/ranking/carbon-co2-emissions>

¹⁹⁹ MacroTrends, 2021. *Fiji Greenhouse Gas Emissions*. Available at: <https://www.macrotrends.net/global-metrics/countries/ranking/ghg-greenhouse-gas-emissions>

²⁰⁰ WWF, 2021. *Reviving Melanesia's Ocean Economy: Full Report*. Available at:

https://wwfasia.awsassets.panda.org/downloads/reviving_melanesia_s_ocean_economy_full_report_high_res.pdf

²⁰¹ Purcell, S.W., et al. 2018. *Small-scale fishing income and fuel consumption: Fiji's artisanal sea cucumber fishery*, ICES Journal of Marine Science, Volume 75, Issue 5, Pages 1758–1767, <https://doi.org/10.1093/icesjms/fsy036>

Table 3-1 Important changes in a sustainable pathway (IPCC Scenario Shared Socioeconomic Pathway [(SSP) 1-1.9] where gradual changes may be interspaced by immediate, rapid, and large-scale reductions in greenhouse gas emissions. Even so, long-term warming by the end of the century is estimated to be 1.1°C to 1.8°C above current industrial levels, with a best estimate of 1.4°C (IPCC AR6²⁰²).

Variable	General trends IPCC-SSP1: Sustainability ("Taking the Green Road")
A. Changes in climate	
Temperature (air and sea)	Higher average temperatures can lead to increased rates of heat stress and disease. Coral reefs are close to exceeding their threshold for being devastated by mass coral bleaching and mortality. Interactions play important roles when they interact, with the sum of the parts being much more significant than the parts alone. Much of the ocean, and indeed global biodiversity, is at risk of being lost or much reduced.
Storm Activity and Cyclones	Warmer global temperatures can lead to more frequent and intense cyclones, causing significant damage. This is due to the increased energy in the Earth's climate system, particularly sea temperature and storm activity breaking down the coral reefs, which house 25% of the biodiversity of ocean species and ecosystems.
Seasonality, size, and frequency of extremes	Changes in weather patterns could lead to more frequent flooding and drought events. This could disrupt the wet and dry seasons, impacting agricultural productivity, and coastal protection, and cause destructive coastal erosion among other impacts.
Challenging coastal conditions	Rising sea levels can lead to the loss of land, crops, and villages. This could lead to an even greater displacement of communities and loss of livelihoods.
Ocean acidification	Changing ocean chemistry is leading to a slowing of coral growth plus other calcified animals and plants, leading to the loss of reef infrastructure, plus the weakening of reef-building corals and the coastal protection they provide from their reefs.
B. Impacts	
Fisheries and aquaculture impacts	Elevated temperatures with heat waves that are increasing in length and intensity resulting in migration and/or mortalities (e.g. fish kills, loss of stock)
Impacts on Livestock	Changes in weather patterns and increased temperatures from Marine Heat Waves (MHW) can harm livestock health, productivity, and heat stroke.
Reduced agricultural Productivity	The intrusion of saltwater into freshwater sources can create water security issues in farmland and disrupt agriculture.
Declining Human Health	Higher average temperatures can lead to higher death rates from heat stress (stroke), disease, and expansion of the habitat of disease-carrying vectors such as mosquitoes.
Damage to Economic Growth	These factors could contribute to economic damages of up to \$52 million annually, or roughly 4-6% of Fiji's gross domestic product.

These are the main climate change pressures which would require implementing projects to increase resilience and adapt to these changes with support from international funds and organisations. However, there is a global need to reduce emissions much faster than presently to reduce the effects of climate change. If we effectively reduce emissions to limit global warming to 1.5°C, the impacts of climate change on Fiji would still result in the loss of 70-90% of reef-building corals^{203 204}. They would be less severe than with higher temperature increases. At 2°C, the effects would be

²⁰² UNFCCC, 2018. Fiji Low Emission Development Strategy 2018-2050. Available at: https://unfccc.int/sites/default/files/resource/Fiji_Low%20Emission%20Development%20Strategy%202018%20-%202050.pdf.

²⁰³ https://www.ipcc.ch/site/assets/uploads/sites/2/2022/06/SR15_Chapter_3_LR.pdf

²⁰⁴ Olson, D., et al. 2009. Priority Forests for Conservation in Fiji: landscapes, hotspots and ecological processes. *Oryx*. 2010;44(1):57-70. <https://doi.org/10.1126/science.1067728>

even more pronounced, with increased frequency and intensity of extreme weather events, more significant sea level rise and the loss of 99% of reef-building corals (IPCC SR1.5)²⁰⁵. If global warming reaches 3°C above the preindustrial period, according to our current international policy track, the impacts would be even more severe, with potentially devastating consequences for people, livestock, and agriculture. Regardless of the degree of warming, it's clear that adaptation and resilience-building measures will be crucial for Fiji's future.

The Fijian Government developed Fiji's first National Climate Change Policy (NCCP) in 2012. This policy serves as the overarching instrument for climate change in Fiji, encompassing local, national, and international issues (see section 11). However, since its launch in 2012, climate change priorities have significantly evolved, and ongoing research has provided new information, scientific data and models. As a response, the 2012 NCCP was reviewed and updated in the context of the latest available information, with the revised NCCP launched in 2018. It prioritises relevant and current issues related to climate change and provides objectives and strategies for protecting Fiji's people, environment, and economy.

Particularly impacted systems include but are not limited to:

- Coral reefs are marine biodiversity hotspots that are under severe threat from local impacts as well as climate change (e.g., ocean heating, acidification, more violent storms, coastal erosion). Over the past century, half of all tropical reefs have disappeared, and if current trends continue, we could lose up to 90% of corals and coral reefs by mid-century. This has included local human impacts (e.g., pollution, health, over-fishing) as well as climate change. This is also not just an environmental tragedy but a devastating humanitarian one, with the well-being of hundreds of millions of reef-dependent people at risk and experiencing impacts globally. Six developing coral reef nations have formed the Coral Reef Rescue Initiative (CRRI). Fiji is one of these nations. Several studies have confirmed that these reefs are also among the least exposed yet best-connected coral reef countries in the world. The CRRI, with its partners, is pursuing the idea that these least exposed yet better-connected reefs will be in a better position to launch recovery on a stabilised planet.
- Tourism as a major driver of Fiji's economy, heavily relies on the country's pristine natural beauty, especially its coral reefs. However, climate change-induced threats like coral bleaching, rising sea levels, and intensifying storms endanger these attractions. These impacts can diminish the appeal of Fiji as a tourist destination, leading to reduced visitor numbers and substantial economic losses.
- Agriculture, while undergoing diversification, remains vulnerable to climate change. The sources point to the risks posed by extreme weather events like cyclones and floods, changes in rainfall patterns, and rising temperatures. These factors can disrupt crop production, damage infrastructure, and reduce agricultural yields, ultimately impacting food security and rural livelihoods.
- Fisheries are a vital source of food and income but are also under threat. Climate change can alter the distribution and abundance of fish stocks, leading to potential declines in catches. Rising sea temperatures and ocean acidification, both consequences of climate change, pose significant risks to marine ecosystems, including coral reefs that provide critical habitat for many fish species.

Therefore, adaptation to these increased climate change impacts is fundamental to climate-sensitive communities. The GSR provides a significant source of climate adaptation potential due to its role in food provision, coastal protection, and economic value. Increasing the condition and potential for the GSR to continue and increase these climate adaptation benefits is crucial for the many people relying on its resources for survival. Adaptation is, therefore, designed to reduce local threats to the GSR and ecosystem and community vulnerability to future climate risks.

The purpose of this Feasibility Study is to:

- Assess the feasibility of EbA and GI interventions to provide adaptation benefits to coastal communities in Fiji and the ecosystems they depend on.
- Add to Fiji's existing policy and regulatory environment related to climate change, coral reefs, and coastal ecosystems and identify areas where the project can support the government of Fiji in improving the management of the GSR.
- Enhance the regulatory environment to support the improved management of seascapes in the GSR.

²⁰⁵ Wikipedia, 2023. Shared Socioeconomic Pathways. Available at: https://en.wikipedia.org/wiki/Shared_Socioeconomic_Pathways.

Efforts to harness and more effectively manage the GSR will benefit local communities, fisheries, agricultural, tourism, and natural sectors. For example, reducing run-off and erosion can enhance soil fertility and availability, improve crop productivity and livelihoods, and protect local communities from the effects of water-related disasters, all while improving water quality while measures to capture flows in upper catchments can be used to support irrigation and for pasture and rangeland development.

Fiji's commitment to addressing climate change is not just an environmental imperative but an economic necessity. Investing in adaptation measures is crucial for safeguarding the country's economic future, protecting livelihoods, and ensuring the well-being of its people.

The problem statement, therefore, is: Although the GSR is an important natural climate asset for reducing the economic and social costs of climate change in Fiji, it remains unprotected from threats of overfishing, coastal development, and sedimentation from degraded watersheds. These threats are reducing these "super reefs" capacity to continue providing the valuable adaptation service of protecting coastal communities. Without urgent measures to reduce these threats to the GSR, climate change impacts will surpass its capacity to provide essential buffering and resilience benefits to coastal communities in Fiji and become increasingly vulnerable to future climate change.

4. Project Areas: Priority Provinces

Priority project areas were identified through a GIS-based multiple criteria decision analysis (MCDA), which overlaid a comprehensive range of climate and local threats where marine environment management interventions in response to climate change can be focused.

The spatial intersections between the Fijian main basins and Tikinas were used to select priority project areas. Main basins provide insights into the ecological connections between land and the Great Sea Reef (GSR) via rivers and waterways, while Tikinas inform jurisdictional levels where decision-making for implementing interventions can be targeted. Main basins were obtained from HydroBASINS (Lehner & Grill 2013) and Suárez-Castro (In prep. 2024), while Tikinas were obtained from The Humanitarian Data Exchange website (2019). See Sections 9.9, 9.10, and 9.11 for further details on the information used to inform site selection.

The geography of Fiji is dominated by two large islands, Viti Levu and Vanua Levu, which account for more than 85% of the country's total land area (Figure 4-1). Fiji is known for its tourism (176-178°E; 16-22°S). Fiji is divided into four major administrative areas: the Western Division, Central Division, Eastern Division, and Northern Division. Four provinces, Ra, Ba, Bua, and Macuata face the Great Sea Reef and hence were picked for the FS study sites. These provinces have shown high vulnerability to climate impacts and increasing pressure from development activity and livelihoods. Fiji is divided into administrative units called Tikinas, composed of several districts and numerous villages²⁰⁶.

²⁰⁶ Wikipedia (n.d.) Ra Province. Available at: https://en.wikipedia.org/wiki/Ra_Province.

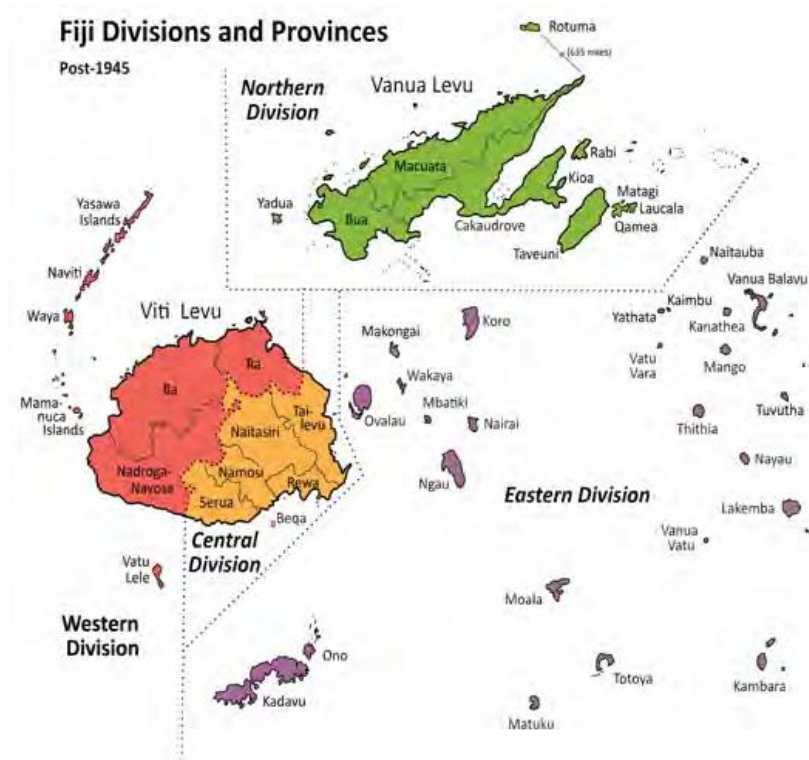


Figure 4-1. Divisions and Provinces of Fiji

Fiji includes diverse geological formations, including volcanic, sedimentary, and limestone rocks, all of which characterise Fiji's hydrogeological profile (Figure 4-2). The country comprises more than 300 islands, with topographies ranging from volcanic mountains to flat coral atolls. These geological and topographical features play a significant role in the distribution and quality of Fiji's groundwater resources and underpinning environmental management concepts such as "Ridge-to-Reef", which will be discussed later in this feasibility study (Figure 4-3).

Hydrogeological maps and models are available for Fiji, specifically for the two largest islands, Viti Levu and Vanua Levu.

- The Hydrogeological map of Viti Levu was compiled by I.N. Gale as part of the series of reports and maps produced by the Groundwater Resources Assessment and Development Unit (GRADU) in Fiji. The map shows topographical, geological, and hydrogeological features of Viti Levu. It includes text, 2 graphs, a table of hydrogeological stratigraphy, and a table of groundwater quality.^{207 208}
- The Hydrogeological map of Vanua Levu and Taveuni was also compiled by I.N. Gale²⁰⁹. This map shows the topographical, geological, and hydrogeological features of Vanua Levu and Taveuni. It includes text, 2 graphs of annual rainfall at Labasa airfield, average monthly rainfall and potential evapotranspiration at Labasa 1957-1980, 2 tables of groundwater quality and annual rainfall, and hydrogeological stratigraphy.

²⁰⁷ National Library of Australia, 2021. Catalogue Entry: Mangrove Ecosystems of Fiji. Available at: <https://catalogue.nla.gov.au/catalog/6294251>.

²⁰⁸ SPREP, 2021. Fiji Country Chapter. In: Pacific Islands Adaptation Report. Available at: https://www.sprep.org/attachments/bem/Fiji_Country_Chapter.pdf.

²⁰⁹ SPREP, 2021. Fiji Country Chapter. In: Pacific Islands Adaptation Report. Available at: https://www.sprep.org/attachments/bem/Fiji_Country_Chapter.pdf.

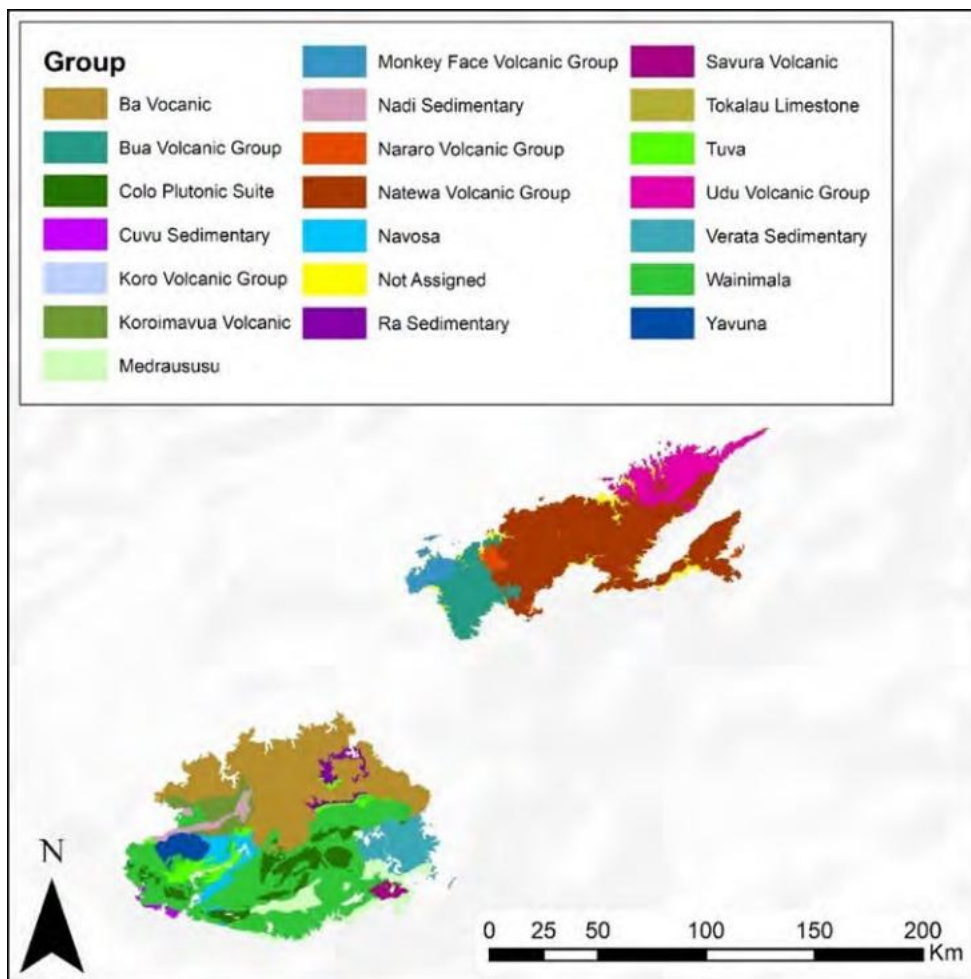


Figure 4-2. Main geological groups in Fiji

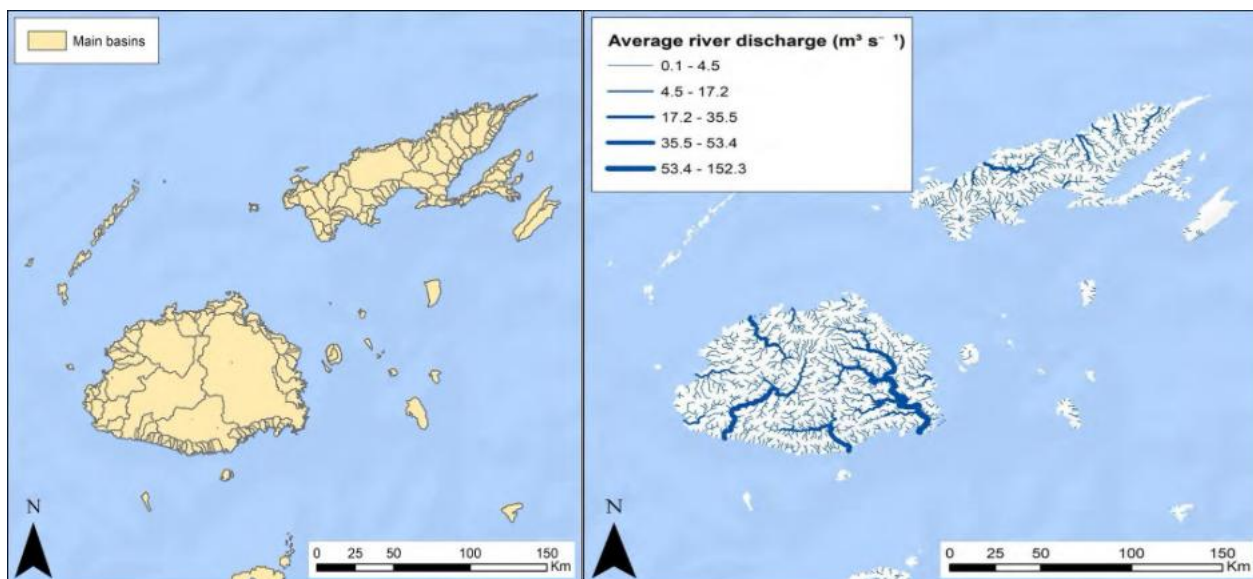


Figure 4-3. Main basins in Fiji, identified from the HydroATLAS dataset (see previous 187) (left), and Average long-term discharge estimate for river reach (obtained from hydroRIVERS 188 via Lehner et al (2019) Global River network delineation derived from HydroSHEDS data at 15 arc-second resolution (right))

Groundwater is the primary source of freshwater in Fiji, with the volcanic islands having extensive aquifer systems that provide significant amounts of water for various uses. However, groundwater resources are vulnerable to

agricultural, industrial, and domestic contamination, particularly in areas with intensive land use²¹⁰. The high demand for water, particularly in urban areas, has also led to over-extraction of groundwater resources, resulting in declining water levels accompanied by the intrusion of sea water in coastal aquifers²¹¹. Fiji's water resources predominantly rely on rainfall, which varies significantly across the country and consists of a dry side and wet side of the island. The islands receive an average annual rainfall of approximately 3,000 mm, with rainfall intensity varying with altitude, aspect and location. Climate variability and change pose a significant threat to the availability and reliability of freshwater resources in Fiji. Increasing frequency and intensity of extreme weather events such as cyclones, floods, and droughts can disrupt water supply systems, damage infrastructure, and affect water quality.

Population size and access to watersheds also vary greatly in Fiji. As of 2015, 94% of Fiji's population had access to basic drinking water, comprising 89% rural and 98% urban.²¹² However, many remote and rural communities in the Fiji Islands face barriers to accessing fresh water. The challenges of freshwater accessibility are not only present in small remote islands but in the two main islands of Fiji as well. These disparities highlight the need for effective watershed management to ensure equitable access to clean water for all Fijians.²¹³

Fiji includes hundreds of low-lying islands that are particularly vulnerable to sea-level rise, erosion, and associated coastal impacts. Climate change is already causing significant problems for the people and environment there. Warmer global temperatures have led to higher tides, resulting in the loss of land, crops, and even entire villages. This has also led to devastating storms and coral bleaching.²¹⁴ ²¹⁵ In addition to global sea-level rise, local factors such as uplift, subsidence, and erosion have shaped Fiji's coastal landscape and problems²¹⁶ ²¹⁷. For instance, areas of Fiji have experienced predominant uplift and perhaps vertical creep, while other areas have seen subsidence dominate between intermittent bursts of uplift.

Flooding and land loss are severe issues in Fiji, affecting livelihoods, agriculture, and infrastructure¹⁹⁵. For example, the village of Vunidogoloa had to be relocated due to the impacts of climate change, including flooding, erosion, and exposure to extreme weather. Moreover, saltwater inundation, floods, and beach erosion have strongly affected agriculture and tourism in coastal communities²¹⁸ ²¹⁹. Subsidence is another multifaceted issue requiring integrated approaches to address its impacts on land, communities, and ecosystems²²⁰. When the land sinks, many coastal ecosystems are affected. Subsidence (plus sea level rise) also increases the possibility of inland flooding, which damages foundations and other infrastructure.

The Ba Province in Fiji is divided into 8 Tikinas. These are: Ba, Magadro, Nadi, Naviti, Nawaka, Tavua, Vuda, and Yasawa. The Ra Province is divided into 4 Tikinas. These correspond to Nakorotubu, Nalawa, Rakiraki, and Saivou. Bua Province in Fiji is divided into three Tikinas. These correspond to Bua, Vuya, and Wainunu²²¹, the Macuata Province in Fiji is divided into five Tikinas. These correspond to Cikobia, Dogotuki, Labasa, Macuata, and Sasa²²².

The provinces Ra, Ba, Bua, and Macuata are four of Fiji's fourteen provinces, each with its unique characteristics (Figure 4-4). They were identified as the priority provinces for the project because of their proximity to, and inter-

²¹⁰ HydroSHEDS, 2021. Global River Network Dataset: GLORIC. Available at: <https://www.hydrosheds.org/products/gloric>.

²¹¹ Liu, J., et al. 2021. A review of groundwater sustainability crisis in the Pacific Island countries: Challenges and solutions, *Journal of Hydrology*, Volume 603, Part D, 127165, <https://doi.org/10.1016/j.jhydrol.2021.127165>

²¹² Ministry of Waterways and Environment, Fiji, 2021. Watershed Management. Available at: <https://www.mowe.gov.fj/watershed-management/>.

²¹³ WISH Fiji, 2021. Watershed Interventions for Systems Health in Fiji. Available at: <https://wishfiji.sydney.edu.au/>

²¹⁴ BBC News, 2020. How climate change affects our oceans. Available at: <https://www.bbc.co.uk/newsround/53556377>.

²¹⁵ Li, P., et al. 2021. Sources and Consequences of Grhttps://www.bbc.co.uk/newsround/53556377.am Toxicol 80, 1–10. <https://doi.org/10.1007/s00244-020-00805-z>

²¹⁶ ABC News, 2023. Fiji's climate change: Moving villages to adapt. Available at: <https://www.abc.net.au/news/2023-04-06/fiji-climate-change-moving-villages-vunidogoloa/102186670>.

²¹⁷ Magnan, A.K., et al. 2022. Sea level rise risks and societal adaptation benefits in low-lying coastal areas. *Sci Rep* 12, 10677. <https://doi.org/10.1038/s41598-022-14303-w>

²¹⁸ Florida Journal of Coastal Research, 2021. Assessment of Mangrove Ecosystems in the Pacific Islands. Available at: <https://journals.flvc.org/jcr/article/view/77932>.

²¹⁹ Pacific R2R, 2021. Mainstreaming Ridge to Reef in the Pacific Report. Available at: https://www.pacific-r2r.org/sites/default/files/2021-06/R2R_Mainstreaming_in_the_Pacific_Report.pdf.

²²⁰ Pacific R2R, 2021. Regional Guidelines for Implementing the Ridge to Reef Science to Policy Strategic Framework. Available at: <https://www.pacific-r2r.org/sites/default/files/2021-02/GEF-R2R-RSTC-TC2%20Inf.06%20Regional%20Guidelines%20for%20Implementing%20the%20%28modified%29%20R2R%20Science%20to%20Policy%20Strategic%20Framework.pdf>.

²²¹ City Population (n.d.) Fiji administrative divisions. Available at: <https://www.citypopulation.de/en/fiji/admin/>

²²² Wikipedia (n.d.) Macuata Province. Available at: https://en.wikipedia.org/wiki/Macuata_Province.

reliance on, the GSR (Table 4-1). Each of these provinces contributes to the rich cultural and geographical diversity of Fiji. Fiji includes a significant number of river watersheds within its borders. The largest among them is the Rewa River watershed, covering an area of 3,092 km², which is about one-third of the total area of Viti Levu. Healthy watersheds are fundamental to human health and well-being²²³. In Fiji, rural communities largely depend on nearby water sources for consumption and other household activities. However, increasing development and poor land-management practices around watersheds can contribute to declines in water quality²²⁴. Poor land practices can contribute to the spread of waterborne diseases such as typhoid, leptospirosis, and dengue. These same poor land practices also negatively impact downstream freshwater and marine resources on which local people rely for food, livelihoods, and cultural practices²²⁵.

A summary of each province follows:

- **Ba Province:** The Ba River in this province has been studied for water quality, including pH, over 88.4 km. The river's pH showed significant spatial variability during the sugarcane season²²⁶. Groundwater development is a government initiative recognising groundwater resources as a potential water source in rural areas²²⁷.
- **Ra Province:** Similar to Ba, Ra also benefits from the government's groundwater development initiative²²⁸. However, specific hydrogeological studies or data for Ra province are not readily available.
- **Bua Province:** Located in the west of the northern island of Vanua Levu, Bua has a land area of 1,379 square kilometres. As with other provinces, Bua is included in the government's groundwater development initiative.
- **Macuata Province:** Macuata, occupying the north-eastern 40% of Vanua Levu, has a land area of 2,004 square kilometres²²⁹. It is also part of the government's groundwater development initiative. Flooding in the Wainikoro and Bucaisau River valleys in Macuata in April 2000 reached the highest levels since at least 1950.

²²³ Hoegh-Guldberg, O., et al. 2019. The human imperative of stabilizing global climate change at 1.5 °C. *Science*, Volume 365, Issue 6459. <https://doi.org/10.1126/science.aaw6974>

²²⁴ IPCC, 2018. Special Report on Global Warming of 1.5°C. Available at: <https://www.ipcc.ch/sr15/>.

²²⁵ WISH Fiji, 2021. Watershed Intervent^h<https://www.ipcc.ch/sr15/>. Fiji. Available at: <https://wishfiji.sydnev.edu.au/>

²²⁶ Holbrook, N.J., et al. 2022. Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities. *Global and Planetary Change*, Volume 208, 103680. <https://doi.org/10.1016/j.gloplacha.2021.103680>

²²⁷ Metherall, N., et al. 2021. Characterisation of pH variations along the Ba River in Fiji utilising the GEF R2R framework during the 2019 sugarcane season. *Environmental Monitoring and Assessment*, 2021. Volume 193, article number 828. <https://doi.org/10.1007/s10661-021-09423-1>

²²⁸ Ministry of Rural Development, Fiji, 2021. Groundwater Development in Fiji. Available at: <https://www.mrd.gov.fj/index.php/groundwater>.

²²⁹ Ministry of Rural Development, Fiji, 2021. Groundwater Development in Fiji. Available at: <https://www.mrd.gov.fj/index.php/groundwater>.

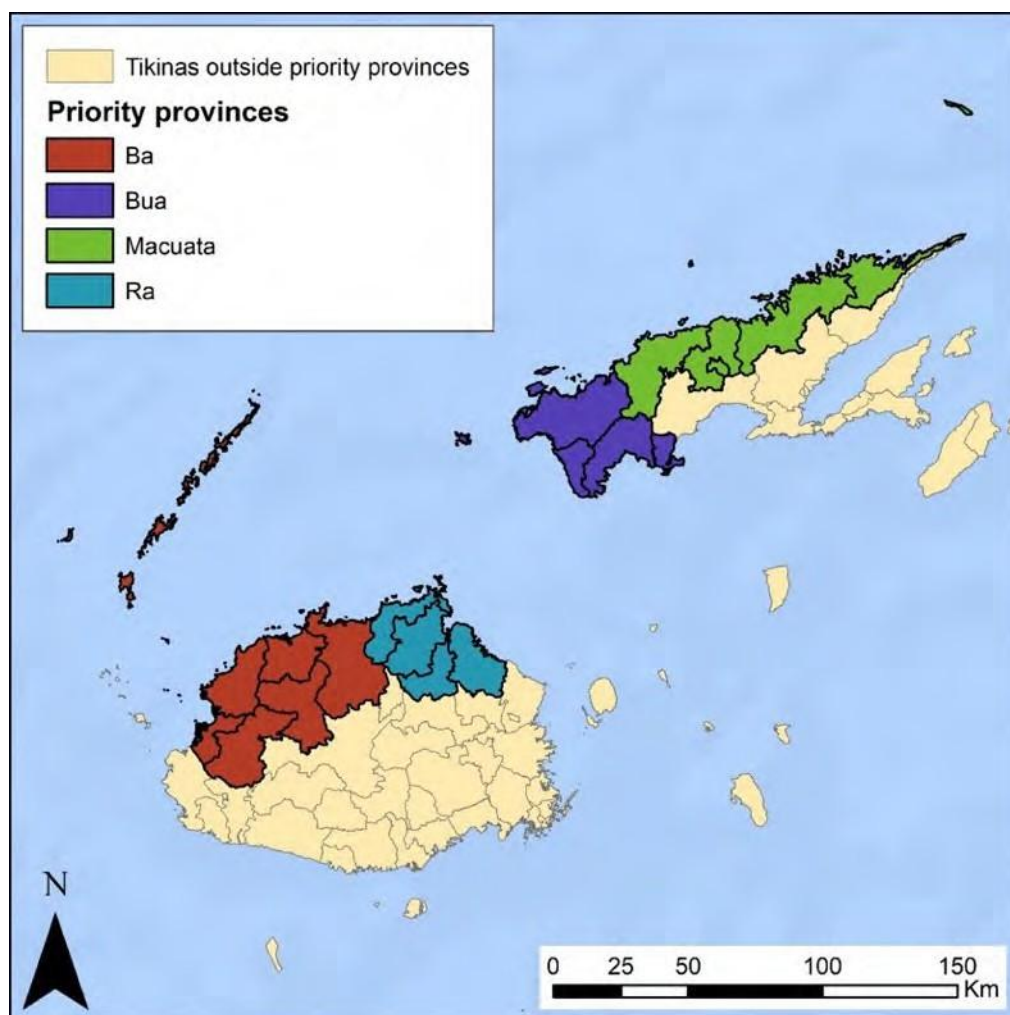


Figure 4-4. Priority Provinces and Tikinas of Fiji. Priority provinces in the current studies are shown as (1) Ba (Brown), (2) Ra (Green), Bua (Purple), and Macuata (light green), and are key elements of the Great Sea Reef. Tikinas outside of priority provinces are in cream colour and were not part of the main study.

Table 4-1. Districts and villages of the priority provinces of Ba, Ra, Bua and Macuata that face the spectacular Great Sea Reef. Note that only a subset of districts and villages are listed, with a link in the complete list in the first column with numbers in the third column indicating the total number of villages in each Priority Province.

Province	Total number of villages in the Province	District (Tikinas, e.g.)
Ba	109	Ba
		Magodro
		Nalotawa
		Nadi
		Naviti
		Rakiraki
		Tavua
Ra	86	Nakauvadra
		Nalawa
		Saivou
		Rakiraki
Bua	54	Bua
		Dama
		Vuya
		Wainunu
Macuata	114	Cikobia
		Dogotuki

		Labasa
		Macuata
		Sasa

There are significant differences between Provincial watersheds in Fiji. These differences can be attributed to various factors such as geographical location, land use, access, and management practices²³⁰. For instance, land-based impacts are particularly problematic in areas where logging is prevalent and unmanaged and where village and urban waste management systems are rudimentary.

Several ecosystems provide an intricate network of tropical coastal areas. Coral reefs, seagrass meadows, and mangroves can be accurately mapped using Geographic Information Systems²³¹. These measurements were done over most of Fiji at 5-10 metres and reveal a complex array of interlocked ecosystems that are very important to many ecosystem services, such as fisheries for food and coastal protection.

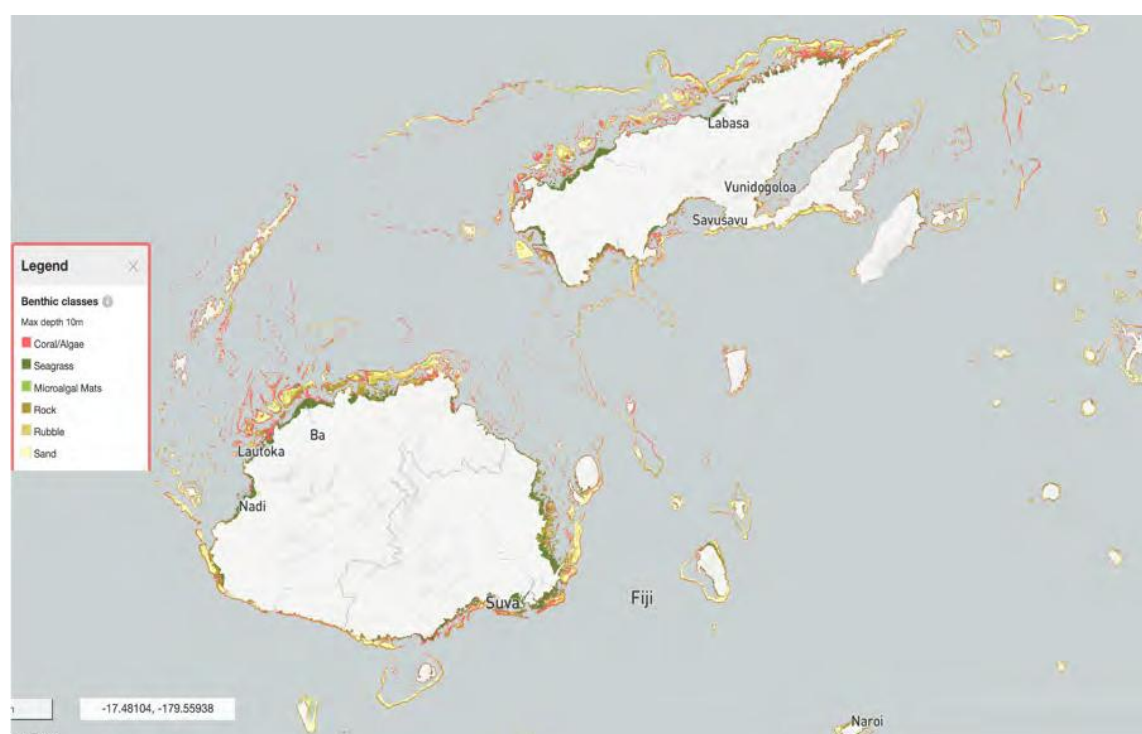


Figure 4-5 Coral reefs, seagrass meadows, and mangrove forests play a crucial role in coastal protection and benthic classes across much of Fiji at depths of less than 10 metres. They provide food and coastal protection via their role as physical barriers, reducing wave energy, filtering catchment water, and protecting shorelines from erosion during storms. Data from the Allen Coral Atlas²³².

Similarly, GIS aided in monitoring coastal pollution, allowing for strategies to control pollution and restore habitats. Similarly, GIS can also be used to monitor coastal pollution discharge. Pollution from industrial activities, agricultural runoff, or urban waste significantly threatens marine habitats. By integrating various data sets, such as water quality measurements, locations of pollution sources, and ocean currents, within a GIS framework, researchers can track the movement of pollutants and predict their impact on marine habitats. This information can be used to develop strategies for pollution control, conservation access and habitat restoration.

²³⁰ WISH Fiji, 2021. Watershed Interventions for Systems Health in Fiji. Available at: [Watershed Interventions for Systems Health in Fiji - WISH Pacific](#)

²³¹ Allen Coral Atlas. (n.d.). Global Coral Reef Monitoring. Retrieved from <https://allencoralatlas.org/>

²³² Allen Coral Atlas. (n.d.). Global Coral Reef Monitoring. Retrieved from <https://allencoralatlas.org/>

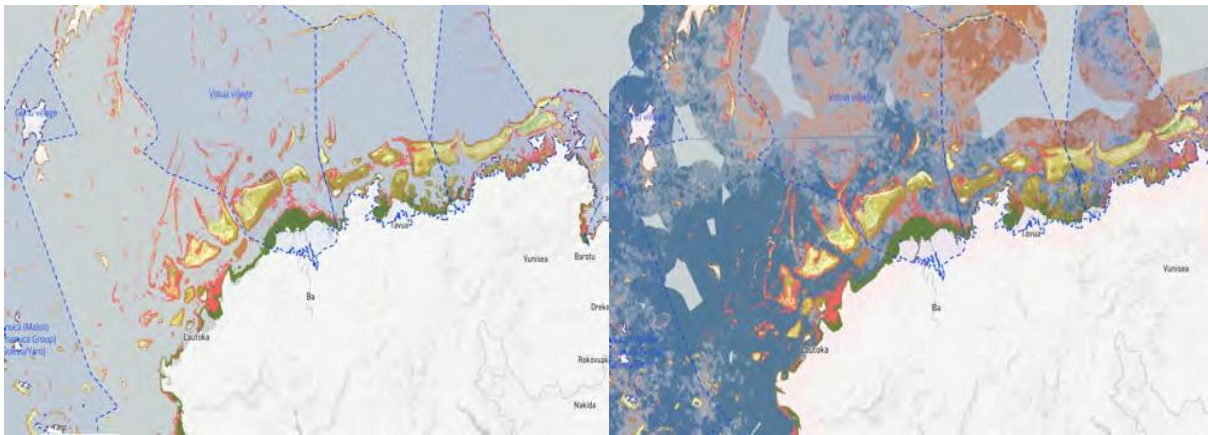


Figure 4-6 Assessment of vital ecosystems such as coral reefs, seagrass beds, and mangroves utilizing data and analysis through Geographic Information Systems (GIS) for the north coast of Viti Levu. These assessments were conducted across a significant portion of Fiji with measurements taken at depths of 10- meters or less. Blue lines represent the boundaries of village reserves (left) and the Northern coast of Vita Levu week after heavy rainfall showing heavy flow of sediments measured by satellite (from Allen Coral Atlas)²³³. These types of technology will be used to automate measurements of key driver impacts and the monitoring of the condition (right)

Reef ecosystems along the northern coast of Viti Levu, Fiji, experienced intense sediment flow after heavy rainfall, as observed by satellite imagery from the Allen Coral Atlas. This advanced technology not only captures environmental conditions but also automates measurements of key driver impacts. The monitoring of these sediment dynamics is crucial for understanding and managing ecological changes in the region.

Measurements of this nature facilitate a comprehensive and much-needed understanding of rivers and catchments and the effects of these landscape and seascape elements on the health and operation of coral reef ecosystems. Such viewpoints are indispensable as the team endeavoured to pinpoint and safeguard crucial aspects of this precious coastal and reef system. They allow us to recognise and protect regions within various systems that demonstrate heightened resilience to alterations induced by climate change, or importance as carbon stocks. Moreover, these measurements can be configured as alarm systems to detect sudden year-to-year or month-to-month (depending on satellite) changes. For instance, they can reveal unauthorised tree removals that lead to increased sediments, which can be detected from satellite measurements²³⁴.

These types of assessments were across a significant portion of Fiji, and measurements were taken at 5-10-meter intervals. Blue lines represent the boundaries of villages. Heavy rain fell over the region triggering the heavy soil loss from mountains into surrounding river catchments across Macuata provinces. This is exacerbated by riverbank erosion, driven by the destruction of riparian strips, deforestation, and unsustainable agricultural activities. The sediments can move following rain (25-50 km offshore²³⁵) demonstrating the large filtering capacity which shows little capacity in the east and substantial capacity to reduce sediment from escaping in the west, where mangroves (i.e. 'filter') have degraded.

One of the most pressing concerns is the exposure of nearshore coral reefs to these sediments. Coral reefs, often called the "rainforests of the sea," are ecosystems that support diverse marine life. When these reefs are exposed to excessive sediments, they can become smothered. Smothering blocks sunlight, impeding coral growth, and leading to the death of corals and coral reefs. The impact is not just limited to the corals themselves; it can disrupt entire marine ecosystems that depend on these reefs.

This situation underpins the importance of R2R management. The management of these areas is crucial in controlling the amount and quality of water that reaches our rivers and, subsequently, the amount of sediment that can be carried to other areas like coral reefs. The role of coastal rivers in this scenario is also significant. These rivers act as the primary pathways for the transportation of sediments from land to sea. Any changes in these rivers, whether due to natural processes or human activities, can significantly impact the amount and type of sediments reaching the coral reefs.

²³³ Allen Coral Atlas. (n.d.). Global Coral Reef Monitoring. Retrieved from <https://allencoralatlas.org>

²³⁴ Allen Coral Atlas. (n.d.). Global Coral Reef Monitoring. Retrieved from <https://allencoralatlas.org/>

²³⁵ Allen Coral Atlas. (n.d.). Global Coral Reef Monitoring. Retrieved from <https://allencoralatlas.org/>

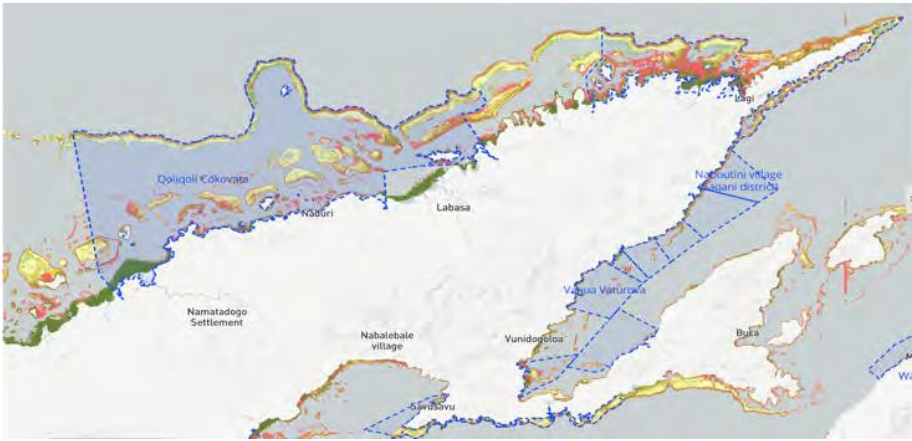


Figure 4-7 Assessment of coastal ecosystems such as coral reefs, seagrass beds, and mangroves accessed for a large part of Vanua Levu, utilising data and analysis by Geographic Information Systems (GIS). Shown is the same information but for the second largest is island, Viti Levu²³⁶.



Figure 4-8 A. General distribution and abundance of mangroves and seagrass as measured by GMW (left). B. Close-up of the Ba Delta study site showing the extent of mangrove/seagrass ecosystems (right).

Project areas were identified using a systematic method that combined information on climate disaster risk and local environmental threats to the Great Sea Reef and the potential for climate adaptation impact. This approach aimed to prioritise areas to improve the resilience of the most vulnerable people and communities, and the resilience of the ecosystem and ecosystem services provided by the Great Sea Reef (GSR) in alignment with the primary goals of the Green Climate Fund (GCF).

This process yielded a series of options that ranged from oceanography, forestry, coastal biology, weather, economy, livelihoods, and tourism (among others). Information on disaster risk was obtained through the Fiji Climate Change Division Decision Support System for Enhanced Disaster Risk Reduction. These tools use a composite, spatially explicit index of climate-related disaster risk that combines information on hazard, exposure, vulnerability, and lack of coping capacity across human populations at the division level. The cumulative index of local threats impacting the Great Sea Reef included spatial estimates of sediment run-off, nutrient pollution from human sanitation, mining, agriculture (plus livestock and crops as a proxy for nutrient pollution), fishing pressure, and mangrove degradation.

The climate disaster risk and local threat composite indices were then overlaid to identify project areas with very high climate disaster risk and high local threats impacting the Great Sea Reef. To do this, all 4 northernly focused (i.e., Ba, Ra, Bua, and Macuata) provinces bordering the Great Sea Reef were divided by watershed (level 9) to capture the ridge-to-reef process impacting reef health, and the indices summarised within each Division-watershed. The observational and modelling analysis section discusses each index and the raw data in more detail.

²³⁶ Allen Coral Atlas. (n.d.). Global Coral Reef Monitoring. Retrieved from <https://allencoralatlas.org>



Figure 4-9 Building plans with representatives of Marou, Naiyaca, Lewa, and Waikubukubu Villages (February 2024)

Priority project sites were identified using a GIS-based multiple criteria decision analysis (MCDA) by overlying a comprehensive array of climate and local threats. A final composite index, ranging from 1 to 10, indicated areas with the highest combined climate and local threats (higher values showing higher composite values), where interventions to manage marine environments in the face of climate change can be targeted. Climate threats were obtained from the INFORM Risk Index platform for Fiji at the Tikina jurisdictional level²³⁷. Following the INFORM index, climate threats were divided into three categories, corresponding to exposure to hazard, vulnerability, and lack of coping capacity. Local threats were collated from the highest level of available spatial resolution, thus ranging from the Province to the Tikina and pixel levels.

The intersections between the main basins and Tikinas were used to select the priority project areas. Main basins provide information on the ecological connection between land and the GSR via rivers and waterways. In contrast, Tikinas provides information on the jurisdictional levels at which decision-making for enforcing interventions can be directed. In each of these basin-Tikina intersections, values of climate and local threats were aggregated and normalised to calculate the final composite index. A composite index based on the normalisation of each variable at the country's level was developed within priority provinces with influence on the GSR (provinces of Ba, Bua, Macuata, and Ra). After dividing the climate and local threats by quantiles, the top third of areas with high values in local threats (which can be targeted by interventions) within each priority province were selected as the priority project areas.

²³⁷ Figshare. (2020). Status and Trends of Coral Reefs in Fiji's Great Sea Reef. Figshare. Retrieved from <https://figshare.com/s/eeb03368d14cedc5d19b>

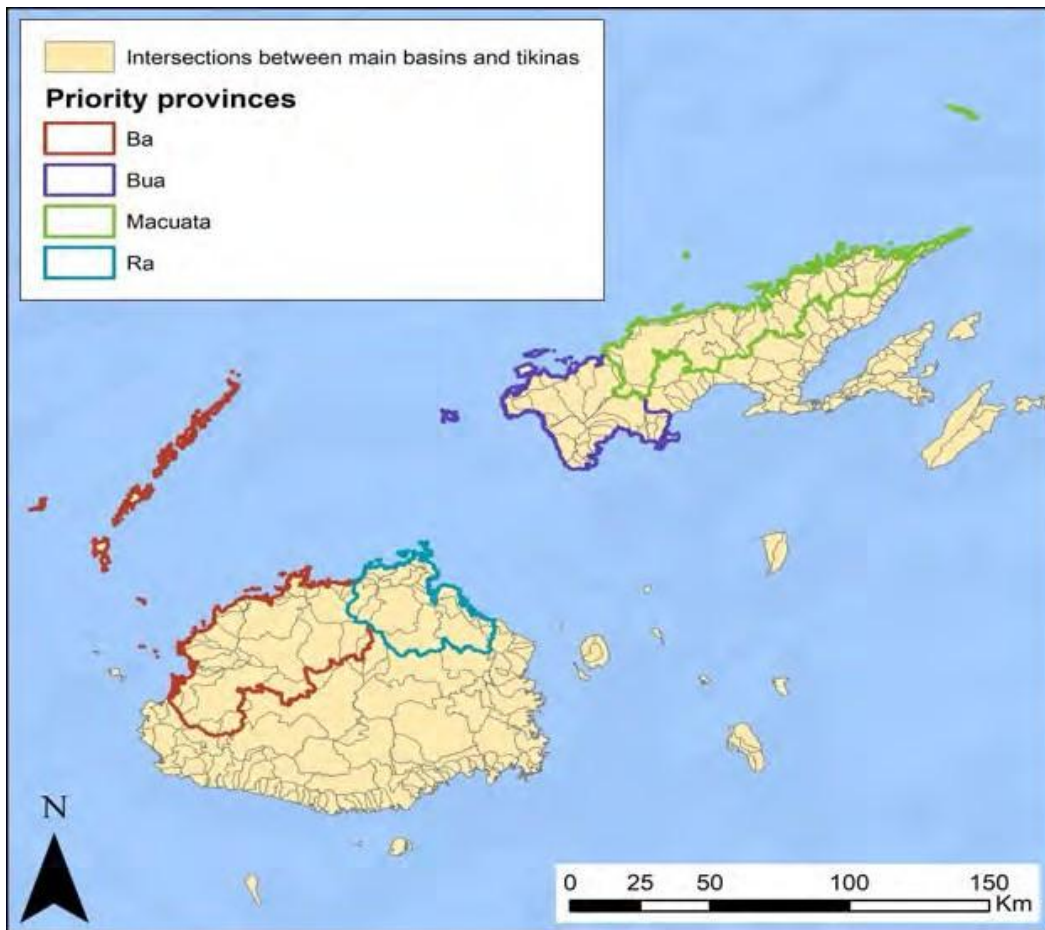


Figure 4-10 Intersections between main basins and Tikinas across Fiji are used to select priority project areas. Main basins were identified based on newly available high-resolution data and models adapted to Fiji from Suárez-Castro et al (in prep).

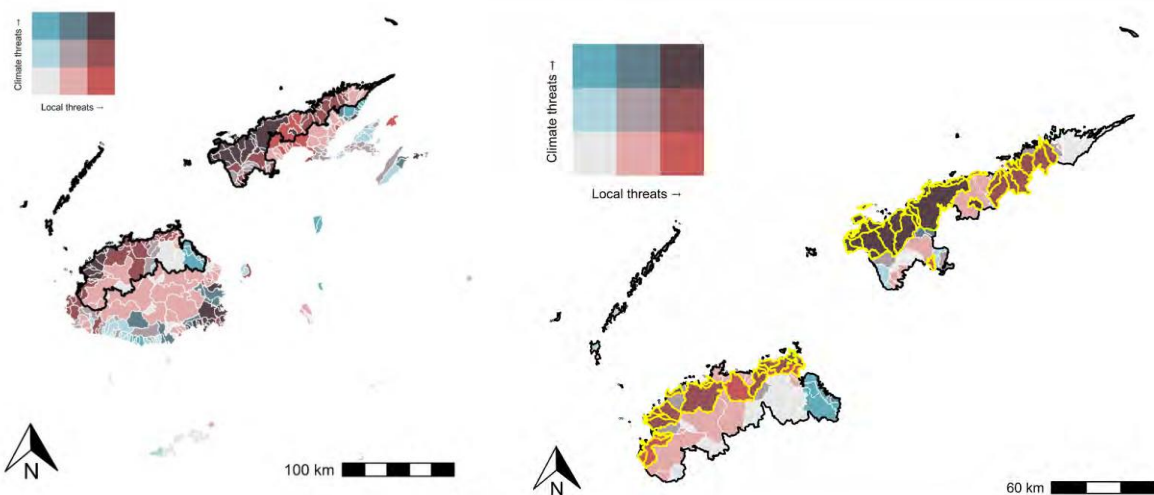


Figure 4-11 Composite indexes between climate and local threats, based on the normalisation of each variable across Fiji. The figure highlights the provinces that influence the GSR (black border). Note that the northwestern regions of Viti Levu and Vanua L Levu score high on climate and local threats while also overlapping on the four priority provinces (Ba, Bua, Macuata, and Ra), hence making them ideal as candidate areas for implementing interventions to manage threats. (left), and the composite index between climate and local threats, based on the normalisation of each variable within priority provinces (Ba, Bua, Macuata, and Ra, outlined in black). Priority project areas are outlined in yellow and represent areas with above-average local threats across all levels of climate vulnerability (top third of bivariate map). (right)

The provinces of Ba, Ra, Bua, and Macuata in Fiji were selected for their unique geographical and ecological characteristics, including their direct reliance on and proximity to the GSR. The GSR is home to a high-value coral reef biodiversity area and significantly contributes to Fiji's economy through fishing and tourism. The rivers in these provinces, particularly in Ba and Labasa, consist of mangrove systems and seagrass, which are crucial for fish nursery grounds, food and economic security, and the protection of coastal communities from erosion and extreme weather

conditions. However, these areas are also prone to erosion, particularly along the riverbanks where erosion was already in action. This erosion is exacerbated by heavy downpours, which the team experienced first-hand, leading to large, sediment-laden rivers that flow into the coastal regions.

Fiji is highly²³⁸ susceptible to flooding. This is due to a combination of factors, including heavy rainfall, the geography of the islands, and the impacts of climate change. The northern coast of the two large islands, where the four provinces are located, is particularly flood prone. The risks these provinces face include increased vulnerability to natural disasters such as cyclones and floods and long-term threats from climate change such as sea-level rise²³⁹. Additionally, there are concerns about the impact of human activities on these fragile ecosystems. For instance, the deterioration of coastal areas has been linked to high amounts of chemicals such as nutrients and pesticides/herbicides.

Biological systems play a crucial role in maintaining healthy water systems. They contribute to the ecosystem's balance and help filter and clean the water. However, the health of these organisms and the overall ecosystem is threatened by pollution, habitat destruction, and climate change²⁴⁰. The selection of the provinces of Ba, Ra, Bua, and Macuata for study and conservation efforts is based on their unique ecological characteristics, the challenges they face from both natural and human-induced changes, and the crucial role they play in Fiji's economy and the health of the planet's oceans.

4.1. Ba Province

Ba Province, located in the north-western sector of Viti Levu, is the largest and most populous province in Fiji, with a population of 247,708, accounting for over a quarter of the nation's total²²⁰. The province is home to 109 villages and 152 settlements across 21 districts, including the city of Lautoka and the Yasawa Archipelago²⁴¹. Much of the Ba province is covered by open land/grassland (41%), forest (34%), and sugar cane production (22.5%). Pine plantations are common on grasslands in the Ba province with a reported 356 ha of harvested area, in addition to several forest reserves (>10,000 ha) and nature reserves (>1,500 ha)²⁴².

Ba was a target area for the 4MT4Y (four million trees in four years) Initiative launched in 2019, which resulted in >380,000 tree seedlings being planted within the province²⁴³. The Ba River and catchment area is one of Fiji's longest rivers. Many industries utilise water from the Ba River, including the sugar industry (e.g., Rarawai Sugar Mill is located just a kilometre upstream and uses the water in its boilers) and several wastewater stations. The remaining land has settlements, water resources, and other agriculture, including coconut and cassava.

The socio-economic state of Ba Province consists largely of agricultural and commercial activities. The province is renowned for its sugar cane farming, which forms the backbone of the local economy. The Ba Sugar Mill, a significant regional employer, underscores the importance of sugar cane farming to the local economy²⁴⁴. In addition to agriculture, Ba Town, located within the Ba Province, serves as a commercial hub and is known for fostering some of the largest business houses in the country. The town's population mainly consists of Indo-Fijians, adding to its cultural diversity and attraction for tourists. Despite these economic activities, the province faces challenges. Like other regions in Fiji, climate change poses significant threats to the province's agricultural sector and overall socio-economic stability. The impacts of climate change could potentially disrupt the farming activities that many residents depend on. The socio-economic context of Ba Province is characterised by its agricultural focus, commercial activities, cultural diversity, and the challenges posed by climate change. This context shapes the lives of the residents of Ba Province and influences the province's development trajectory.²⁴⁵

²³⁸ SPREP. (2021). *Annual Report 2021*. Secretariat of the Pacific Regional Environment Programme. Retrieved from [Cir#22/88: 2021 SPREP Annual Report | Pacific Environment](#)

²³⁹ SPREP. (2020). *Forest Restoration in the Pacific: A Regional Initiative*. Secretariat of the Pacific Regional Environment Programme. Retrieved from [State of Environment and Conservation in the Pacific Islands: 2020 Regional Report](#)

²⁴⁰ IUCN. (2020). *Water and Conservation in Fiji: An Overview*. International Union for Conservation of Nature. Retrieved from <https://www.iucn.org/resources/issues-briefs/water-fiji>

²⁴¹ CEGOT, 2016. *Management of Coastal Zones in Fiji*. *Global Oceanography and Technology*, 9(2), pp. 100-110. Available at: <http://cegot.org/ojs/index.php/GOT/article/view/2016.09.010>.

²⁴² Wikipedia, 2023. Ba Province. Available at: https://en.wikipedia.org/wiki/Ba_Province.

²⁴³ Ministry of Forestry. (2022). *Ministry of Forestry 2019–2020 Annual Report*. Parliament of Fiji. Retrieved from [Ministry-of-Forestry-2019–2020-Annual-Report.pdf](#)

²⁴⁴ Wikipedia contributors. (n.d.). Ba (town). Wikipedia. Retrieved January 30, 2025, from https://en.wikipedia.org/wiki/Ba_%28town%29

²⁴⁵ Wikipedia contributors. (n.d.). Ba Province. Wikipedia. Retrieved January 30, 2025, from https://en.wikipedia.org/wiki/Ba_Province

Ba contains three wastewater treatment plants to service its growing population: Natabua, Navakai, and Votua. Together these plants treat upwards of 175 tonnes of sewage annually. Septic tanks and pit latrines are also common sanitation types in the Ba province with >540 tonnes of human wastewater nutrient treated via septic tanks and 81 tonnes treated via pit latrines (summarised in Keumpel et al. 2024). Ba Province is also an agricultural and fishing hotspot. The province contains one of the largest qoliqoli in Fiji- the Vanua Votua Qoliqoli. A "qoliqoli" in Fiji refers to a traditional fishing ground or fishing rights area that is owned by a local community or tribe. The concept is rooted in the traditional Fijian system of communal ownership of marine resources. Qoliqoli areas are typically defined by geographic boundaries, and the communities that own them have customary rights to fish and manage the resources within those boundaries.

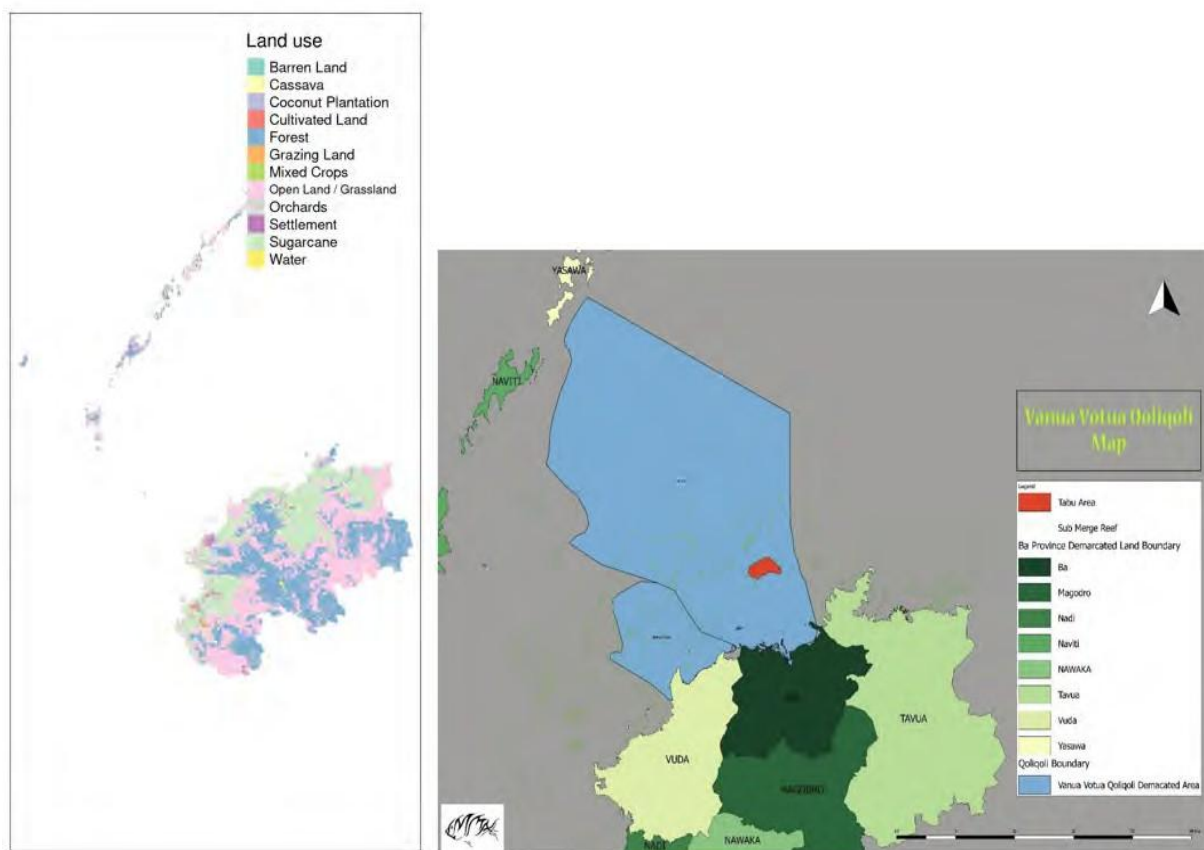


Figure 4-12 Land uses across the Ba province Created for this report using GIS (left), and Map of the Vanua Votua Qoliqoli (right).

Some major threats identified by locals within the Vanua Votua are as follows.²⁴⁶

1. Deforestation,
2. Lack of equipment like phones, engines & boats,
3. Speeding of boats near shorelines,
4. Dredging
5. Black sand mining project
6. Lack of awareness and educational workshops
7. Poaching and overfishing.
8. Negligence of Village By-laws
9. Lack of communication between stakeholders
10. Lack of proper monitoring and evaluation.
11. Lack of financial capacity.
12. Lack of sound inclusiveness in pre- and post-implementation monitoring
13. Lack of income-generating activities and lack of pre- and post-implementation plans.

²⁴⁶ UNDP. (n.d.). Desktop Review: Votua, Ba with logos. United Nations Development Programme. Retrieved from info.undp.org/docs/pdc/Documents/FJI/DESKTOP%20REVIEW%20%20VOTUA%20%20BA%20WITH%20LOGOS.pdf

Ensuring a continuous connection between the freshwater and marine environments is crucial for the natural regenerative process that sustains fish stocks in rural inland communities within the Ba catchment. Although oceanic freshwater systems exhibit lower productivity than the marine environment, the resources they contain remain significant for many rural villagers in Fiji²⁴⁷.

Local (non-climate-change) factors can increase the resilience of organisms and ecosystems to climate change, thereby increasing survival and persistence. The Ba River (Western Division) and surrounding areas face various environmental challenges due to human activities, including pollution from waste disposal, agricultural runoff, mining activities, and deforestation. The improper disposal of waste is a significant concern for the Ba River and its environs²⁴⁸. Landfills and dumpsites near the riverbanks can lead to the leakage of toxic substances and contaminants, affecting the water quality and aquatic organisms. Moreover, untreated sewage and industrial waste released into the river system can cause eutrophication, leading to an overgrowth of algae and the depletion of oxygen in the water at night, which can result in persistently low oxygen levels and the death of fish and other aquatic species.

In Nadi, the town council representative mentioned that solid waste management poses significant challenges, with limited public awareness about the 3Rs (Reuse, Reduce, Recycle). There are jurisdictional overlaps concerning drainage management, with different entities responsible for waterways upstream, drainage along roads, and within the town itself. Waterways upstream are overseen by the Ministry of Water, drainage along roads falls under the jurisdiction of the Fiji Road Authority, and within the town, management is handled by the Town Council. Recycling and waste management remain limited, compounded by a lack of education and cultural barriers to recycling. The pollution from rubbish leakage into wells further exacerbates groundwater contamination.

Deteriorating water quality (in areas such as rivers and coasts) is a significant issue due to large amounts of extraction, polluting activities, and the release of agrichemicals (for example, nutrients, pesticides, and herbicides). The Ba River region is also home to mining activities, which release heavy metals used in extraction processes, such as mercury and arsenic, into the river system. These contaminants can cause long-term damage to the aquatic ecosystem, as they can accumulate in sediments and be taken up by marine organisms. Furthermore, mining activities can lead to habitat destruction and increased sedimentation, which can negatively affect water quality, increase the risk of flooding, and exacerbate soil erosion.

Deforestation in the Ba coastal region of Fiji contributes to soil erosion and increased sedimentation in coastal waters. The removal of vegetation indeed reduces the land's ability to retain water and stabilize soil, leading to increased runoff and sediment transport to the coast²⁴⁹. This sedimentation can smother coral reefs and seagrass beds, degrading essential habitats for marine life and reducing the coastal ecosystem's resilience. Indeed, between 2000 and 2018, 120 hectares of mangroves were destroyed by tourism development in Ba province. This accounted for a third of all mangrove deforestation in the region (ibid). The destruction of these mangroves has left nearby communities more vulnerable to environmental disasters.

While coastal agriculture plays a vital role in the region's economy surrounding the Ba River, the excessive use of fertilisers, pesticides, and herbicides in agricultural practices has led to nutrient-rich runoff entering the river. Also, poor management of waterways and land use has led to significant challenges from issues such as riverbank erosion. This runoff can contribute to eutrophication, causing algal blooms and depleting dissolved oxygen levels, adversely affecting aquatic life.

In addition, pesticides, and herbicides can be toxic to aquatic organisms. They may accumulate in the food chain, posing a risk to both wildlife and human populations that rely on the river for their food and water supply. Unsustainable farming practices have also led to soil erosion and environmental damage. Poor agricultural practices have contributed to the degradation of agricultural lands and their productivity. Increased runoff of sediment, nutrients, and agrichemical contaminants (run-off) from the land has lowered coastal water quality and marine ecosystem health.

²⁴⁷ UNDP. (2019). USP-IAS. Fiji R2R 1.1.1.3 Freshwater Assessment Report. United Nations Development Programme. Retrieved from info.undp.org/docs/pdc/Documents/FJI/USP-IAS.Fiji%20R2R%201.1.1.3%20Freshwater%20Assessment%20Report.4%20Dec%202019.TFedit%205%20Dec%202019.pdf

²⁴⁸ SPREP. (2021). Climate-Proof Landfill Now Operational in Fiji. Secretariat of the Pacific Regional Environment Programme. Retrieved from [Climate-proof Landfill now Operational in Fiji | Pacific Environment](https://www.sprep.org/Climate-proof-Landfill-now-Operational-in-Fiji-|-Pacific-Environment)

²⁴⁹ The Guardian. (2023). Fiji's Mangrove Destruction: The Price of Paradise. The Guardian. Retrieved from <https://www.theguardian.com/world/2023/dec/13/fiji-mangrove-destruction-why-tourism-restoration-plan-importance-the-price-of-paradise>

Ba is an agricultural centre, and sugar cane has long been the mainstay of the local economy. The town exists largely due to its prolific sugar cane industry. The Rarawai Sugar Mill, which opened in 1886, was the first constructed during British governance in Fiji, making it an iconic symbol of colonial Indian settlement in the region. This mill is still running to this day.

Pollution from microplastics is an issue in Ba province. A study conducted in Fiji investigated the presence of microplastics in edible freshwater mussels (*Batissa violacea*) harvested from five Fijian rivers, including the Ba and Ra rivers²⁵⁰. Microplastics were found in all the mussels sampled from these rivers, with an average concentration varying from 2.78 ± 0.40 to 6.84 ± 0.89 microplastics per gram of dry weight²⁵¹. These mussels are an important source of protein and income for many people. Fragments of plastic less than 5mm in length, are a significant pollutant in the world's oceans, where they have built up over decades. Marine life may also mistake plastic for food (e.g., sea turtles and plastic bags for jellyfish²⁵²), leading to ingestion and choking as plastic interferes with many activities. This bioaccumulation can also have detrimental effects on marine ecosystems and can also impact human health, as these contaminants can enter our food chain through the consumption of seafood.

These changes add to the impacts of unsustainable fishing ('overfishing') is another significant challenge facing the Ba coastal region. The unsustainable exploitation of fish stocks can lead to the collapse of fish populations, threatening the livelihoods of local fishing communities and businesses while disrupting the balance of the marine ecosystem.

Several concerning issues related to fisheries and coastal management were highlighted during the stakeholder consultations as well. It was noted by the NTC representative that overfishing is rampant due to a lack of monitoring and enforcement, compounded by jurisdictional complexities. Furthermore, fishermen's practices have evolved, with nets now being used around reefs despite regulations on their size. The indiscriminate disposal of nets and plastic waste by fishing companies further contributes to marine pollution.

Pine and mahogany plantations in Fiji present several challenges (in Ba). Economically, the cost of operations through to shipment is significant. Ecologically, these plantations risk deterioration due to natural ageing and decay, genetic defects from inbreeding, and threats from natural disasters, pests, and diseases. Land availability and security, lease term and suitability, fire and disease risk, technical issues, ongoing funding and management, and social issues are key risks and constraints. The plantations naturally bounded in the form of creeks and rivers, generally comprised more than a hundred hectares of land, potentially impacting the watershed of rivers in Fiji²⁵³.

Community representatives, including headmen of villages, from Marou, Naiyaca, Lewa, and Waikubukubu villages voiced concerns regarding reforestation and plantation-related issues in the region. They highlighted how the proliferation of pine trees, exacerbated by climate change, has resulted in decreased water quality and extensive land clearing, displacing native forests. The expansion of pine plantations has also contributed to increased landslides, particularly near rivers exacerbating the decline of freshwater fish species, native hardwood trees, and wild fruits. Additionally, the planting of Mahogany trees has exacerbated environmental degradation, causing water to become brackish and deterring other plant growth. Forest fires, often sparked in a controlled but unmonitored manner by pine industry practices, have escalated in recent years.

There are, however, potential solutions to these challenges. The government has taken the leading role in ensuring the boundary of mahogany plantations is clearly defined and is surveyed for the legal acquisition of land parcels and the issuance of land titles to avoid misunderstanding in the future. The Fiji Forestry Emission Reductions (ER) Program, which began in 2009, is now in the implementation phase 2. This program rewards the efforts of those who choose to participate in reducing carbon emissions from deforestation and forest degradation²⁵⁴. The policies and strategies for the sector aim to sustainably manage and develop Fiji's forest resources with policies to strengthen sustainable forest management by encouraging private sector participation in plantation development and the development of more timber products. There are also initiatives to restore degraded forests, which can help in mitigating the impacts of plantations on the ecology and watershed. Thus, while pine and mahogany plantations pose significant challenges to

²⁵⁰ Barrientos, E.E. et al. 2022. Presence and abundance of microplastics in edible freshwater mussel (*Batissa violacea*) on Fiji's main island of Viti Levu. *Marine and Freshwater Research* 73(4). Retrieved from <https://repository.usp.ac.fj/13478/>

²⁵¹ World Wildlife Fund. (2020). What Do Sea Turtles Eat? Unfortunately, Plastic Bags. World Wildlife Fund. Retrieved from <https://www.worldwildlife.org/stories/what-do-sea-turtles-eat-unfortunately-plastic-bags>

²⁵² Watson, R., & Patel, M. (2020). The Effects of Ocean Acidification on Marine Biodiversity in Fiji. *SAGE Open*, 10(3), 2158244014530610.

²⁵³ Fiji Times. (2020). Fiji Government Approves US\$5.6M Climate Change Adaptation Project. *Fiji Times*.

²⁵⁴ IUCN. (2020). Climate Change Adaptation Report for Fiji. International Union for Conservation of Nature.

Fiji and its ecology, there are ongoing efforts and potential solutions to mitigate these impacts and ensure sustainable forest management.

Across the 8 villages, including Marou, Naiyaca, Lewa, and Waikubukubu, collective action for reforestation and farming, supported by the Ministry of Agriculture, is underway. The village heads mentioned that Communities are employing sustainable practices like "Solesole vaki," a traditional collaborative approach involving local youth groups in tree replanting efforts. They seek assistance in reintroducing native species and removing invasive ones to rewild their lands. Additionally, the villagers called for additional government intervention to restore native species and manage pests, with current pesticide bans lacking alternative solutions.

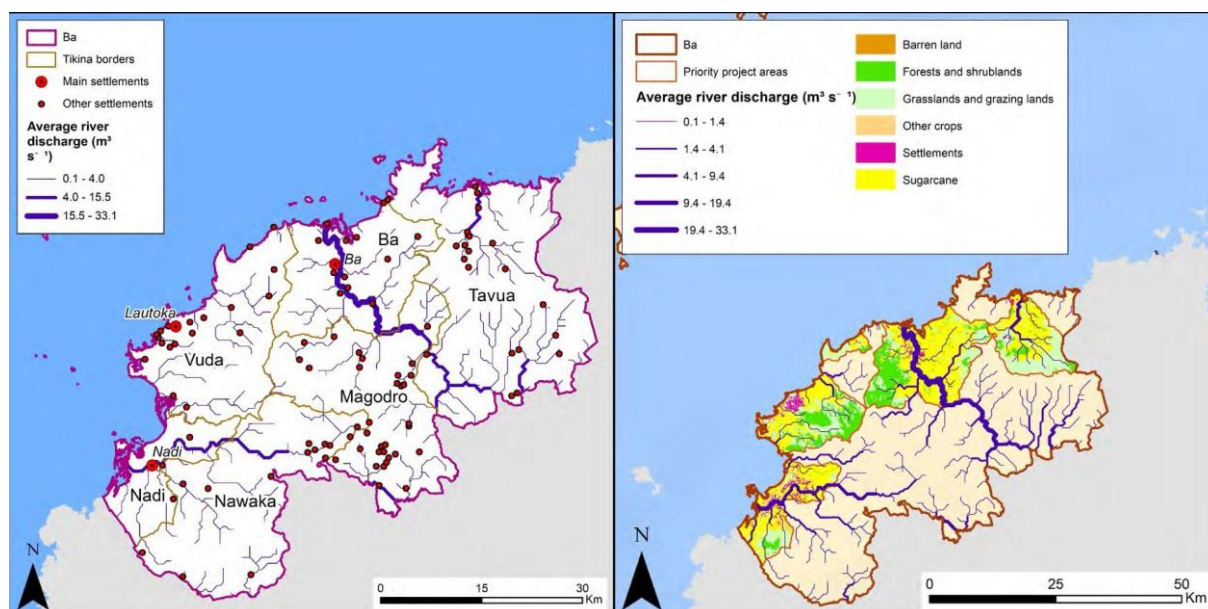


Figure 4-13 Populated areas in the Ba province from the National census in Fiji in 2017 (left). Priority project areas in the Ba Province. The main land use in the priority project areas of the Ba province is sugarcane cultivation (50% of the total area), followed by grasslands and grazing lands (28%), forests and shrublands (17%), and settlements (3%) (right)

4.2. Ra Province

Ra Province is located on the north-eastern coast of Viti Levu and has a rich socio-economic context. It comprises 93 iTaukei villages and 20 districts, or Tikina, and is administrated by the Ra Provincial Council. The province is divided into four main tribal boundaries: Vanua Rakiraki, Saivou, Nakorotubu, and Nailawa. The socio-economic baseline of Ra Province is influenced by its physical environment and the livelihoods of its residents. Ra also has diverse land use covering nearly 1,300 km². Ra's population is >30,000 people (2017 census), with the main urban centre being Vaileka. Ra is mostly comprised of open land/grassland (44.4%) and forest (40.5%), followed by sugar cane (14%), settlement (0.3%) and water (0.2%). Ra has a history of strong agricultural production. It boasts the largest complex of agricultural terraces ever constructed in Fiji along the northern planks of the Nakauvadra Mountains²⁵⁵. The extensive set of gardens and canals were once irrigated by diverting mountain streams, directing and drawing runoff from springs and seeps, but are no longer functioning²⁵⁶.

Ra's dependence on natural resources and the relatively low diversity of income sources at the household level can increase the vulnerability of local communities (Kim et al. 2017²⁵⁷). However, despite its rich natural resources and potential for income-generating activities, Ra is considered the poorest province in Fiji.^{258 259}

Climate change also poses significant challenges to the province. A case study of Nawairuku, an interior village in Ra, revealed that household adaptability to climate change depends on access to livelihood assets²⁶⁰.

²⁵⁵ Green, M. (2020). Assessing Climate Change and Vulnerability in Fiji. *Journal of Climate Change*, 12(3), 245–265.

²⁵⁶ SPC. (2016). Better farming and ranching practices: Ra. Secretariat of the Pacific Community. Retrieved from [Better-farming-ranching-practices-Ra.pdf](https://www.spc.int/publications/better-farming-ranching-practices-Ra.pdf)

²⁵⁷ University of Western Australia. (2019). Socioeconomic Factors in Fiji's Rural Development. UWA Research Repository.

²⁵⁸ Fiji Times. (2022). Fiji's Poorest Province. Retrieved from <https://www.fijitimes.com.fj/fijis-poorest-province/>

²⁵⁹ Anonymous. (n.d.). A Case Study of Nawairuku, Ra, Fiji. Retrieved from <https://docslib.org/doc/2664409/a-case-study-of-nawairuku-ra-fiji>

²⁶⁰ Anonymous. (n.d.). A Case Study of Nawairuku, Ra, Fiji. Retrieved from <https://docslib.org/doc/2664409/a-case-study-of-nawairuku-ra-fiji>

Households with access to tangible assets such as land and the resources to utilise it, along with intangible assets like motivation, labour, and knowledge, are better positioned to adapt their agricultural practices to changing climatic conditions²⁶¹ compared to households with limited access to such assets.

There is great potential in Ra province to restore degraded grasslands and abandoned sugar cane fields in remote upland areas and establish sustainable timber production that is profitable for investors and environmentally and socially beneficial to local communities, through ecosystem services and carbon markets. The district has a marine protected area along the coast of Namuaimada and trees are being replanted by the Ministry of Forestry and iTaukei Land Trust Board along the hills of Navolau²⁶²)

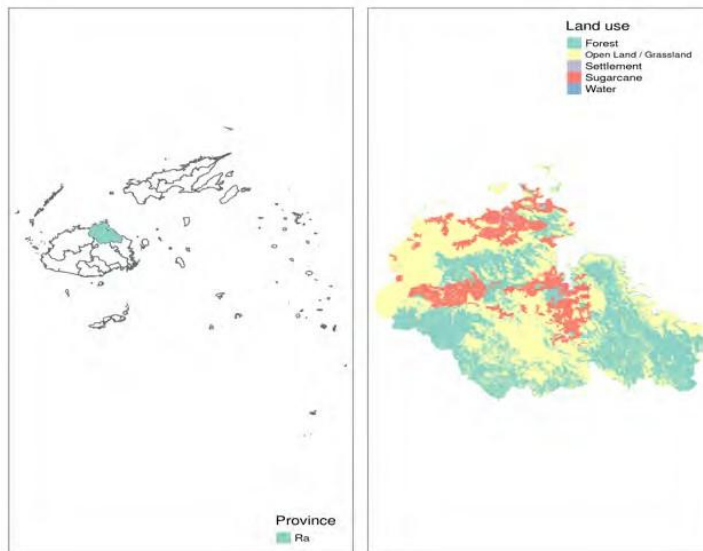


Figure 4-14 Ra province: the left-hand figure is the outline of provinces; the right-hand key land use was created for this report using GIS.

Ra contains a productive coastline with several government and community-led initiatives aimed at protecting these valuable resources. For example, The Ra Integrated Coastal Zone Management plan, which was developed in 2016, listed eight major threats to Ra’s coastal assets including black sand mining, gravel extraction, burning, unsustainable farming, destructive fishing, waste management, Vatu-i-Ra seascape, and poaching²⁶³. Ra also contains several aquaculture production areas- particularly for Mabe pearl production, which was valued at close to \$15,000 in 2020.

Ra does not currently have any wastewater treatment plants. Most human wastewater nitrogen is treated using septic tanks (~59 tonnes) and the rest with pit latrines (28 tonnes) (Kuempel et al. 2024). However, further surveying and assessments are needed to better account for WASH infrastructure and maintenance in this area. Coordinating and collaboration across sectors - particularly the health sector - could lead to benefits for both human and ecosystem health from improved wastewater treatment, infrastructure and management. Ra was significantly impacted by Cyclone Winston in 2016 leading to substantial riverine flooding.

Ra province also faces a significant threat from agricultural runoff (i.e., excess nutrients, pesticides, herbicides, and sediments)²⁶⁴. The region’s agricultural activities can lead to the runoff of nutrients, pesticides, and herbicides into coastal waters^{265 266}. This runoff can trigger eutrophication, a process where water bodies receive excess nutrients that stimulate excessive plant growth such as algal blooms. These algal blooms can create “dead zones” in the water where

²⁶¹ Anonymous. (n.d.). Initial Diagnosis of the Ra Province Pilot Site, Fiji. Retrieved from <https://docslib.org/doc/4403446/initial-diagnosis-of-the-ra-province-pilot-site-fiji>

²⁶² Fiji REDD+ (2022). Ra to Gain More from Trees. Retrieved from <http://fijireddplus.org/ra-to-gain-more-from-trees/>

²⁶³ Fiji REDD+ (2022). Ra to Gain More from Trees. Retrieved from <http://fijireddplus.org/ra-to-gain-more-from-trees/>

²⁶⁴ SPREP. (2022). Fiji’s Climate Change Adaptation Strategy Report. Secretariat of the Pacific Regional Environment Programme.

²⁶⁵ The Daily Star. (2020). Can Fiji Lead Pacific Climate Action?. The Daily Star. Retrieved from <https://www.thedailystar.net/opinion/news/can-fiji-lead-pacific-climate-action-1869035>

²⁶⁶ Kumar, R., & Singh, P. (2018). Impacts of Climate Change on Fiji’s Coastal Areas. ResearchGate.

oxygen levels are so low that most marine life cannot survive. The loss of marine life can disrupt the food chain and impact the biodiversity of these ecosystems²⁶⁷.

Another major threat is the declining water quality. Industries located in and around the Ra province can release toxic chemicals and heavy metals into the coastal waters²⁶⁸. These pollutants can accumulate in marine organisms, leading to long-term health effects. As these toxins move up the food chain, they can pose health risks to larger marine species and humans who consume seafood. This bioaccumulation of toxins can lead to a decrease in marine biodiversity and impact the health of local communities.

Overfishing is a significant concern for the coastal ecosystems of the Ra province²⁶⁹. Overfishing can disrupt the balance of marine ecosystems, leading to the decline of certain species and allowing others to overpopulate. This imbalance can have cascading effects on the ecosystem, impacting species diversity and abundance²⁷⁰.

Overfishing can also impact the local economy, as many communities in the Ra province rely on fishing for their livelihoods. The freshwater mussel, *Batissa violacea*, also known as “kai” in Fiji, is a significant source of protein and income for communities residing along and near the major rivers and their associated tributaries in the two major islands of Viti Levu and Vanua Levu.

Fisheries management faces significant challenges, as highlighted by stakeholders during consultations. The Ministry of Maritime Affairs provincial representative noted that fish wardens lack sufficient resources to effectively manage and monitor extensive fishing grounds, contributing to overfishing. Additionally, data from the Ministry of Fisheries is outdated, and licensed fishermen often fail to provide the required data to the ministry. To address these issues, there are ongoing fisheries management projects focusing on fishing techniques and identifying suitable areas for fishing. Furthermore, a trust has been established to manage marine areas and coral reefs; however, illegal fishing remains a concern. While a national strategy exists, there is a lack of a provincial-level strategy to address fisheries management comprehensively.

In the context of Ra Province, unsustainable coastal development for residential, commercial, or industrial use poses a significant threat to critical habitats such as mangroves, seagrass beds, and coral reefs²⁷¹. These habitats play a crucial role in maintaining biodiversity by providing breeding grounds and nurseries for a variety of marine species that are integral to the community and their livelihoods. Furthermore, the loss of these habitats can have socio-economic implications for the local communities that rely on these ecosystems for their livelihood, through activities such as fishing and tourism. Therefore, it is imperative to promote sustainable development practices that balance economic growth with the preservation of these critical habitats for the benefit of future generations.

²⁶⁷ Patil, A., & Kumar, S. (2021). Impact of Temperature Rise on Coral Reefs in Fiji. *Environmental Science Journal*, 44(3), 215-223. https://www.researchgate.net/publication/348703615_Impact_of_Temperature_Rise_on_Coral_Reefs_in_Fiji

²⁶⁸ United Nations. (2020). *Sustainable Development Goals: Oceans and Seas*. United Nations. Retrieved from <https://www.un.org/sustainabledevelopment/oceans/>

²⁶⁹ UNDP. (2020). *Sustainable Development in Fiji: The Road Ahead*. United Nations Development Programme. Retrieved from <https://www.undp.org/fiji>

²⁷⁰ The Guardian. (2022). *Sea Level Rise Accelerating in Pacific Islands: The Case of Fiji's Capital Suva*. The Guardian.

²⁷¹ ABC News. (2023). *Sea Level Rise Accelerating in Pacific Ocean: Impacts on Suva's Coastal Communities*. ABC News.

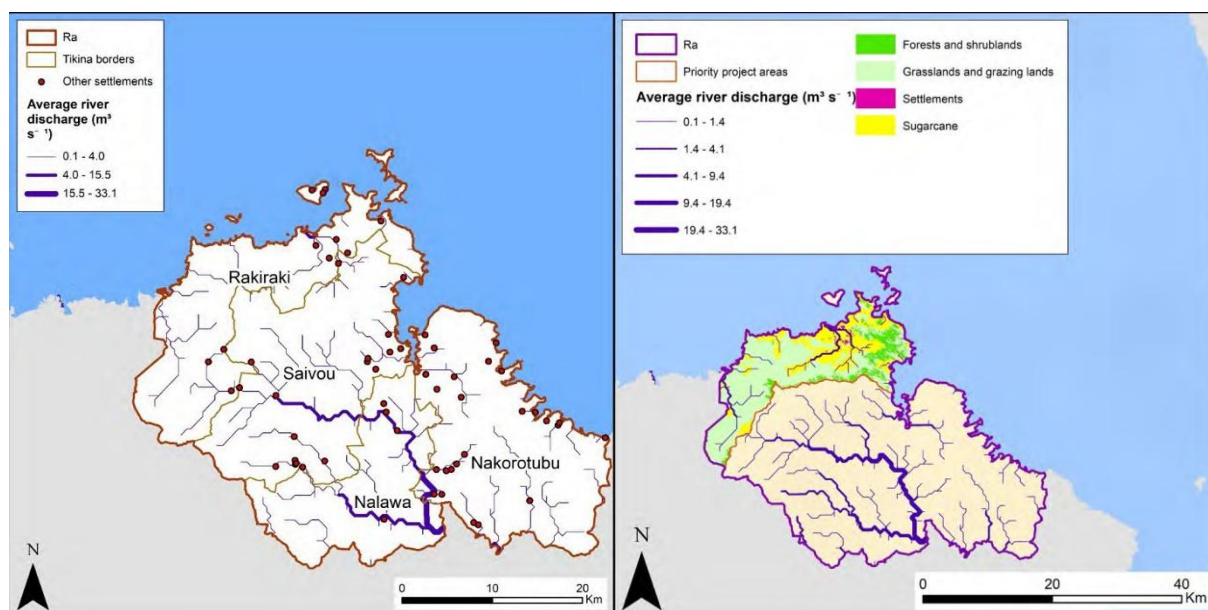


Figure 4-15 Populated areas in the Ra province from the National census in Fiji in 2017 (left). Priority project areas in the Ra Province. The main land use within the priority project areas in the Ra province was grasslands and grazing land (63% of the total area), followed by sugarcane cultivation (26%), and forests and shrublands (10%) (right)

4.3. Bua Province

Bua Province with a land area of 1,379 square kilometres is in the west of the northern island of Vanua Levu. It is one of three northern provinces within the three central districts of Bua, Vuya, and Wainunu. As per the 2017 census, Bua's population was 15,466, making it the fifth least-populous province. Bua also serves as one of the ports of entry into Vanua Levu, with the port located in Nabouwalu, which has recently been declared Nabouwalu a township, potentially boosting the local economy²⁷². Bua's major land uses are forests (64%), open land/grassland (32%), coconut plantation (15%), and rice (5%), followed by cultivated land, water, shrubs, mixed crops, settlement, wetland, and scattered forests (all <4%). Bua reportedly harvested 4,454.0 tonnes of coconut in the Fiji 2020 Agricultural Survey, followed by Dalo (3,997.4 tonnes) and Cassava (3,223.5 tonnes)²⁷³.

The socio-economic context of Bua Province is influenced by its geographical location, population, and economic activities. The province's economy mainly depends on natural resources, with many households relying on a single economic activity²⁷⁴. This dependence on natural resources and the relatively low diversity of income sources at the household level highlight the vulnerability of local communities. Despite these challenges, the potential development of Nabouwalu into a township could provide new economic opportunities and diversify income sources for the residents of Bua Province. However, the impacts of these developments on the local communities and the environment would need to be carefully managed to ensure sustainable growth.

Bua contains the Kilaka Forest Conservation Area (KFCA), which is in the Kubulau District. It is ~402 ha of pristine Fijian rainforest, 98% of which is completely undisturbed. It is one of the few last undisturbed rainforest stands in the country and has been recognised by the National Protected Areas Committee as an area of national biodiversity significance²⁷⁵. In 2005, the Wildlife Conservation Society (WCS) conducted a study on Kilaka Forest, revealing a rich biodiversity comprising 319 flora species from 99 families and 223 genera.

Approximately 40% of the plant species identified are unique to Fiji, with 5% exclusive to Vanua Levu Island - including endangered and previously undiscovered tree species²⁷⁶. The KFCA falls within land registered to the *mataqali*

²⁷²Ministry of Agriculture. (2020). 2020 Key Statistics. Government of Fiji. Retrieved from www.agriculture.gov.fj/documents/stats/2020KEYSTATISTICS.pdf

²⁷³ Ministry of Agriculture. (2020). 2020 Key Statistics. Government of Fiji. Retrieved from www.agriculture.gov.fj/documents/stats/2020KEYSTATISTICS.pdf

²⁷⁴ University of Western Australia. (2019). Socioeconomic Factors in Fiji's Rural Development. UWA Research Repository.

²⁷⁵ Wildlife Conservation Society. (n.d.). Kilaka Forest Conservation Area. Retrieved from <https://fiji.wcs.org/Initiatives/Protected-Areas/Kilaka-Forest-Conservation-Area.aspx>

²⁷⁶ Wildlife Conservation Society. (n.d.). Kilaka Forest Conservation Area. Retrieved from <https://fiji.wcs.org/Initiatives/Protected-Areas/Kilaka-Forest-Conservation-Area.aspx>

Nadicake. The residents depend on the forest for fish and freshwater, and it also holds cultural importance. Conservation concerns in this area include illegal logging, agriculture, mining, natural disasters, and climate change.

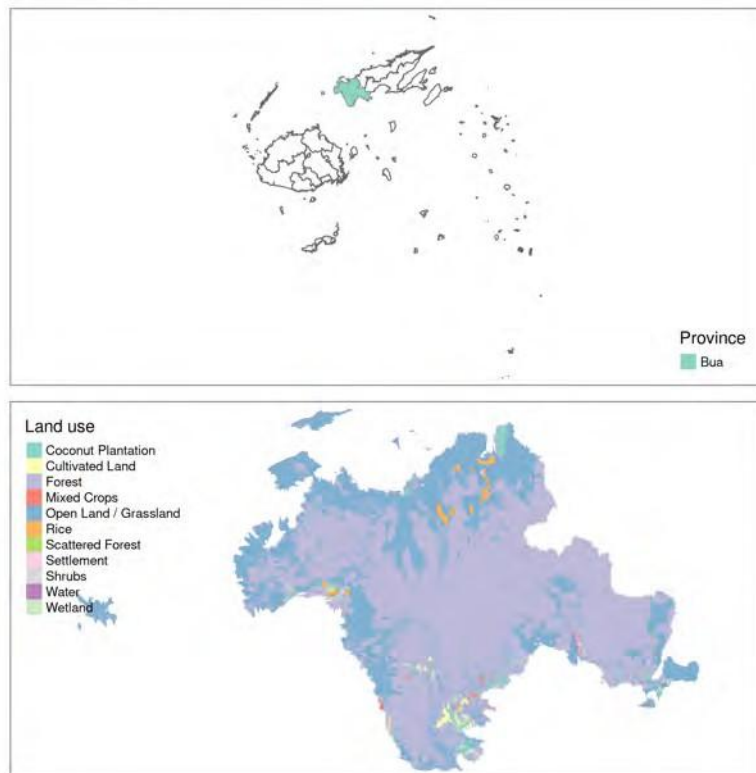


Figure 4-16 Land use across the Bua province: The left-hand figure is the outline of provinces; the right-hand key land use. Created for this report using GIS.

One of the significant threats to the coastal ecosystems of the Bua province is agricultural runoff²⁷⁷. Agricultural activities in the region can lead to a discharge of nutrients, pesticides, and herbicides into rivers and eventually coastal waters. This runoff can cause eutrophication, where water bodies receive excessive nutrients that stimulate excessive plant growth (e.g., microalgal blooms) which can trigger Crown-of-Thorns Starfish (COTS) outbreaks. In Fiji, COTS are known locally as “Bula” and are recognized for their impact on the reef ecosystems²⁷⁸. In Bua, as in other priority provinces (Ba, Ra or Bua), specific data on the presence of freshwater clams (*B. violacea*) is not available from the search results. However, considering that Bua is located on the island of Vanua Levu, it is likely that these mussels are present in the area, as they are found in the major rivers of this island. Industrial pollution is indeed a major threat to priority sites in Bua.

Overfishing is also a significant concern for the coastal ecosystems of the Bua province. Overfishing can disrupt the balance of marine ecosystems, leading to the decline of certain species and allowing others to overpopulate. This imbalance can have cascading effects on the ecosystem, impacting species diversity and abundance throughout a coastal region²⁷⁹. Overfishing can also affect the local economy, as many communities in the Bua province rely on fishing for their food and livelihoods. The communities of five districts in Bua Province have launched natural resource management plans to address the effects of overfishing and other unsustainable practices. These plans will help communities address threats such as overfishing, poaching of tabu areas (seasonal fishing closures), unsustainable logging, and poor farming practices. Therefore, sustainable practices are crucial to prevent the depletion of these valuable resources and to maintain the health of the ecosystems.

Representatives from the Ministry of Infrastructure and Metrology Services (MoIMS), the Ministry of Fishery (MoF), the provincial council, and the conservation office highlighted several critical issues: 1) Poaching in the Bua coastal waters is an ongoing problem, with enforcement teams conducting land patrols and monitoring activities around

²⁷⁷ IUCN. (2020). *Oceania Regional Focus: Climate Adaptation Strategies in Pacific Island Nations*. International Union for Conservation of Nature. Retrieved from <https://www.iucn.org/regions/oceania>

²⁷⁸ Ramsar Convention. (2021). *Fiji's Sustainability Priorities for Coastal Conservation*. Ramsar Convention. Retrieved from [Fiji | The Convention on Wetlands, The Convention on Wetlands](#)

²⁷⁹ Fiji Times. (2021). *Research Says Climate Change is the Biggest Threat to Fiji Agriculture and Forests*. Fiji Times.

Yadua Island. Coastal poaching, particularly the illegal sale of sea cucumbers, persists despite regulations. The Fishery Act of 1942 needs to be reviewed for increased effectiveness. Additionally, there are concerns about the use of chemicals, such as chlorine, to catch prawns in large quantities, which has been noted and confronted in some villages.

Industrial pollution is another major threat to priority provinces in Bua. Industries in and around the Bua province may inadvertently release toxic chemicals and heavy metals into the coastal waters. These pollutants can accumulate in marine organisms, leading to long-term health effects. As these toxins move up the food chain, they can pose health risks to larger marine species and humans who consume seafood. This bioaccumulation of toxins can lead to a decrease in marine biodiversity and impact the health of local communities.

Deforestation in the Bua coastal region contributes to soil erosion and increased sedimentation in coastal waters. Removing vegetation reduces the land's ability to retain water and stabilize soil, resulting in increased runoff and sediment transport to the coast. This sedimentation can smother coral reefs and seagrass beds, degrading essential habitats for marine life and reducing the coastal ecosystem's resilience. To mitigate the impacts of deforestation, it is crucial to implement reforestation programs, enforce sustainable land-use practices, and promote the protection of existing forests. Coastal development for residential, commercial, or industrial use can lead to the destruction of critical habitats and ecosystems such as mangroves, seagrass beds, and coral reefs²⁹¹. These habitats are essential for maintaining biodiversity, providing breeding grounds and nurseries for many marine species. The loss of these habitats can lead to a decline in marine species and impact the overall health of the coastal ecosystems. The introduction of non-native species can disrupt local ecosystems. Invasive species can outcompete native species for resources, leading to declines in native species populations. The introduction of these species can alter the structure of the ecosystem and lead to a loss of biodiversity. Managing these invasive species is crucial to maintaining the health and diversity of the coastal ecosystems in the Bua province.

The consultation participants also mentioned that mangrove destruction is a significant concern in Bua due to Fiji Pine 'chips' killing mangroves and the lack of legislation prohibiting mangrove destruction or cutting for firewood. Mangrove reforestation is seen as a necessary but short-term solution. Logging is common, and the lack of harsher penalties leads to continued exploitation of these resources.

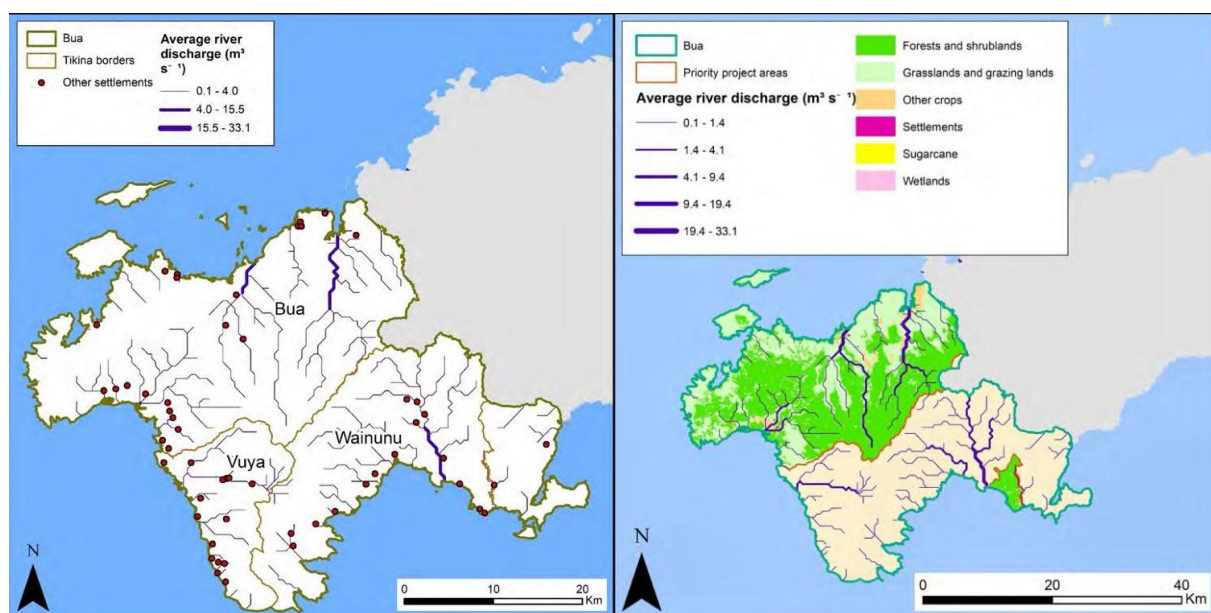


Figure 4-17 Populated areas in the Bua province from the National census in Fiji in 2017 (left). Priority project areas in the Bua Province. The main land use within the priority project areas in the Bua province was forests and shrublands (56% of the total area), followed by grasslands and grazing lands (41%), and other crops (3%) (right)

4.4. Macuata Province

Macuata is situated in the north of the second largest island, Vanua Levu. It occupies ~40% of the island with an area of ~2,000 km². The province has 114 villages spread over five districts (*tikinas*): Cikobia, Dogotuki, Labasa, Macuata, and Sasa. Macuata's population was ~65,983 (2017 census) making it the fourth largest of any Fijian province. Macuata is one of two predominantly Indo-Fijian provinces, the other being Ba province. The majority of the province's population (75%) lives in Labasa district, which contains the town of Labasa. There are two urban areas: Labasa and

Seaqqa. More than a quarter of Macuata's population (27,949 in 2007) lives in the town of Labasa²⁴⁴. The land use mostly consists of forest (47%), and open land/grassland (29%), and is dominated by sugarcane (19%) production, with some coconut plantations (2%). Much of Macuata's landscape is dominated by non-forested areas followed by lowland rainforests, and it is dotted with a few pine plantations, mostly in the district of Dreketi. According to Fiji's Agricultural Census (2020), Macuata's crop production was dominated by Cassava (8,752.8 tonnes) and Dalo (7,900.4 tonnes)²⁴⁵.

Macuata also has four major river systems that drain into the sea – Labasa, Qawa, Wailevu and Dreketi Rivers²⁴⁶. Notably, there are 30 catchments, or watersheds, that are wholly or partially in Macuata Province, requiring integrated management across provinces and sectors for successful outcomes. These rivers connect terrestrial, freshwater and marine systems and can transport run-off that impacts marine ecosystem health - such as sediments and nutrients in wastewater. For example, Macuata has one wastewater treatment plant - the Namara treatment plant, which treats ~10 tonnes of nitrogen annually (~5% of nitrogen excreted in human wastewater)²⁸⁰. Most of the population's wastewater is treated within septic systems (~129 tonnes) followed by pit latrines (47 tonnes; *ibid*). These nutrients can adversely impact coral reefs, promoting algal growth and driving disease in both corals and humans.

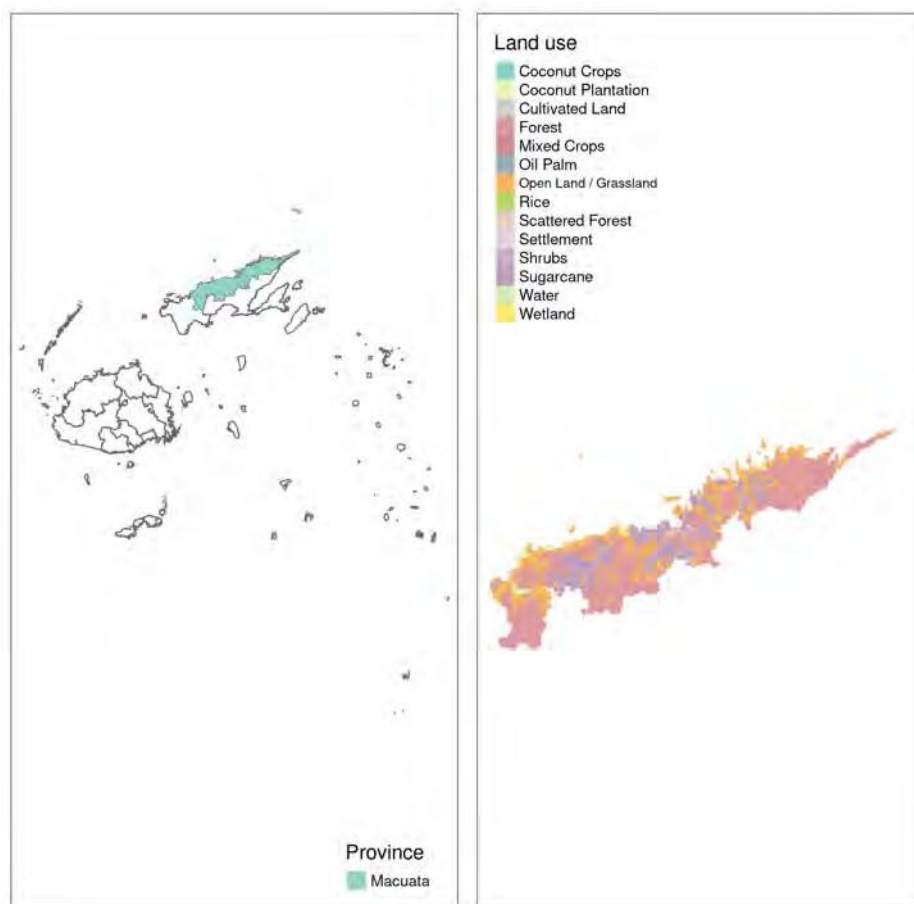


Figure 4-18 Land use across the Macuata province: the left-hand figure is the outline of provinces. Right-hand key land use); Created for this report using GIS.

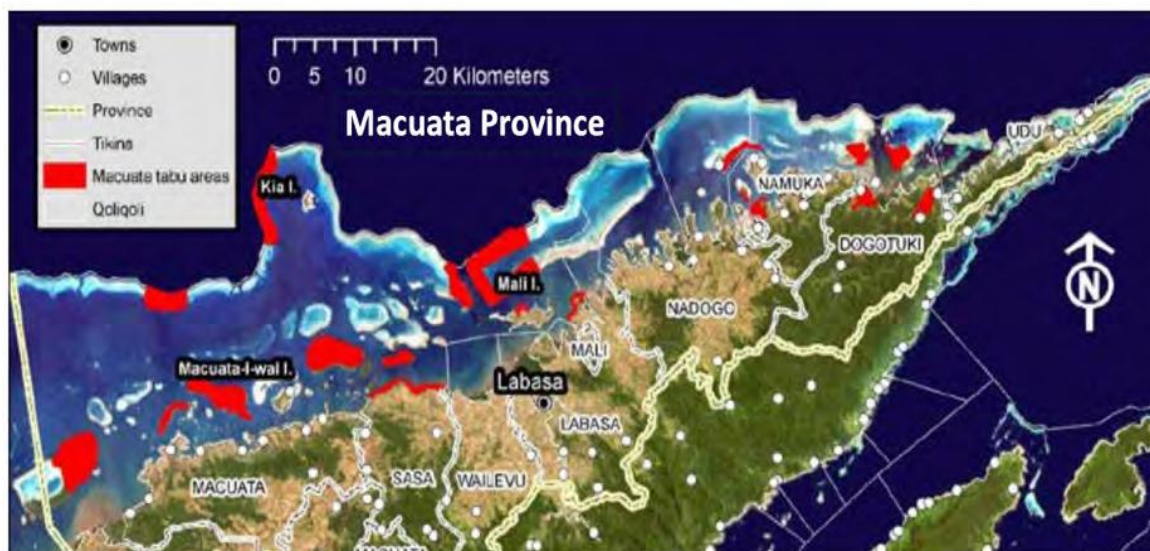
Macuata's primary agricultural crop is sugarcane, a cash crop generally used for income with no direct role in subsistence. The Labasa Sugar Mill, owned by the Fiji Sugar Corporation (FSC), processes all sugarcane harvested in Macuata, generally for export (FSC 2017). In 2017, the Labasa Sugar Mill crushed 653,000 tonnes of sugarcane, up from 544,000 in 2014. This resulted in 73,000 tonnes of sugar produced and 26,000 tonnes of molasses. Labasa is responsible for roughly 35% of national production, fluctuating year-to-year.

²⁸⁰ Smith, J., & Johnson, H. (2023). *Impact of Coastal Erosion in Fiji*. *Environmental Pollution*, 256, 123003.

As of 2012, approximately 4,000 sugarcane growers were reported in all of Vanua Levu²⁸¹. According to the ecosystem and socio-economic resilience analysis and mapping project in Macuata Province, the key threats from agriculture in the Macuata province include:

- Market forces for sugar production – export markets and efficiencies determine the demand for sugar production and land uses to favour farming.
- Coastal erosion affecting infrastructure – tramlines used to transport cane to the sugar mill are threatened by coastal erosion and sea-level rise.
- Lack of irrigation makes cane and other crops susceptible to drought.
- Intensive rainfall predicted by climate change can damage crops.
- Land tenure issues discourage conservation and long-term stewardship.
- Well-distributed food production system is needed to build resilience to localised storm damage and disaster response.
- Sediment load is proportional to catchment size and agricultural intensity.

Like Bua, the coastal waters extending from Macuata include some of the premier coastal fishing grounds in Fiji. In 2020, four fish aggregating devices were deployed in Macuata²⁸². Fish Aggregating Devices (FADs) are man-made structures deployed in the ocean to attract and aggregate schools of fish. FADS offer several benefits including increased catch efficiency, increased fishing opportunities, improved targeting of pelagic species, and resulting economic benefits. A community-based fish farm is developing in Macuatu focusing on mabe pearls²⁸³. The traditional fishing grounds (qoliqoli) provide for roughly 75,000 people in the province, many of whom are rural, indigenous and spread across 37 villages. The Macuata qoliqoli has been increasingly exposed to fishing pressures from both local subsistence and Labasa- and Suva-based commercial fisheries operators for export, largely to Suva. Fisheries management has received considerable support, including the establishment of permanent and temporary no-catch (tabu) areas, monitoring strategies, and marine protected areas (MPAs)²⁸⁴. However, Macuata's marine resources have experienced decreases in recent years due to this fishing pressure, in addition to terrestrial run-off from widespread deforestation and land conversion to agriculture, exposed and poorly designed road networks contributing sediment plumes, and constant small-scale and commercial fishing pressures, leading to declines in the coastal resource²⁸⁵.



²⁸¹ SPREP. (2020). *Ecosystem and Socio-economic Assessment of Macuata, Fiji*. Secretariat of the Pacific Regional Environment Programme. Retrieved from [Ecosystem-based adaptation options assessment - Macuata province Fiji](#)

²⁸² Ministry of Fisheries. (2023). *Ministry of Fisheries Annual Report 2020–2021*. Parliament of Fiji. Retrieved from [parliament.gov.fj/wp-content/uploads/2024/12/Ministry-of-Fisheries-Annual-Report-2022–2023.pdf](#)

²⁸³ Ministry of Fisheries. (2023). *Ministry of Fisheries Annual Report 2020–2021*. Parliament of Fiji. Retrieved from [parliament.gov.fj/wp-content/uploads/2024/12/Ministry-of-Fisheries-Annual-Report-2022–2023.pdf](#)

²⁸⁴ Ministry of Fisheries. (2023). *Ministry of Fisheries Annual Report 2020–2021*. Parliament of Fiji. Retrieved from [parliament.gov.fj/wp-content/uploads/2024/12/Ministry-of-Fisheries-Annual-Report-2022–2023.pdf](#)

²⁸⁵ SPREP. (2020). *Ecosystem and Socio-economic Assessment of Macuata, Fiji*. Secretariat of the Pacific Regional Environment Programme. Retrieved from [Ecosystem-based adaptation options assessment - Macuata province Fiji](#)

Figure 4-19 Macuata's tabu marine areas.²⁸⁶

Over recent years, there have been increasing social and economic demands on the local natural resources of Macuata Province. This pressure can be attributed, in part, to the Government's 'Look North Policy' for major infrastructural developments and increased economic investments that allow for a streamlined development process involving landowners. This has led to an increasing trend of investments in projects such as mining, logging, tourism, agriculture and fisheries across the province. Concurrent with, and perhaps in response to, the boom of activity has been a rise in interest from donor-funded implementing organisations (NGOs, intergovernmental organisations, etc.) that have had a natural resource adaptation focus, largely aimed at the topics of sustainability, conservation, capacity building, and implementing of pilot projects over a range of themes: fisheries, coastal management, forestry, forest carbon, climate change resilience, adaptation, land management, agriculture, and living shorelines²⁸⁷.

Most households in Macuata Province are subsistence-based. They depend heavily on ecosystem services for water and food provisions, shelter, income generation and overall health and well-being. The area and its people are vulnerable to climate change because many traditional Fijian villages are located along riparian areas within watersheds or distributed along the low-lying coastal zone. The effects of natural disasters in Fiji are far-reaching and negatively impact agriculture, housing, transport infrastructure, tourism and primary industries, among other sectors. Increased intensity and duration of climate extremes have greatly affected the urban areas and local economies and have largely resulted in 'reactive' rather than 'proactive' management responses to mitigate the effects²⁸⁸.

Macuata has several policies and regulations aimed at increasing natural resource management. Previous natural resource management strategies (expired in 2018) have focused on biodiversity, capacity building, sustainable finance, and leadership and governance²⁸⁹.

A recent Ecosystem-based adaptation assessment focused on two main priority actions in the area: review and update of the Macuata Province Natural Resource Management Strategy and support large-scale resource conservation of marine resources by supporting the Great Sea Reef management, including a Ramsar designation and development of appropriate management plans.

Macuata Province is facing challenges from local issues, particularly in the coastal areas. This occurs across the province and involves the migration of people to find agricultural solutions elsewhere²⁹⁰. This has led to the formation of informal settlements, often located along major transport routes, including rivers and roadways. These informal arrangements are expanding into native forests, mangroves, and critical riparian areas. These settlements often lack basic services, including access to clean water. In this regard, the integrity of the Dreketi river is a major concern for the communities of Macuata Province. Economic activities such as logging and unsustainable farming practices have placed pressure on both the land and river systems²⁹¹. Community representatives have been trained as river care monitors to carry out simple bio-monitoring surveys to assess the water quality of their respective streams which feed into the Dreketi river.

The rapid development in Macuata Province has led to the commencement of a Natural Resource Management Strategy for the sustainable use and protection of natural resources. This strategy will be incorporated into the Macuata Provincial Council's annual corporate plan to ensure that developments taking place within the province are sustainable and safe²⁹². The growth of urban areas, conversion to agriculture, and road networks that limit tidal and land-based water movement in Macuata Province have led to the loss of mangroves and coastal marshes. This loss greatly reduces the capacity to mitigate land-based pollution to the marine environment and causes substantial reductions in breeding and rearing grounds for fish and invertebrates²⁹³. The coastal communities of Macuata Province

²⁸⁶ SPREP. (2020). Ecosystem and Socio-economic Assessment of Macuata, Fiji. Secretariat of the Pacific Regional Environment Programme. Retrieved from [Ecosystem-based adaptation options assessment - Macuata province Fiji](#)

²⁸⁷ SPREP. (2020). Ecosystem-Based Adaptation in Macuata, Fiji. Secretariat of the Pacific Regional Environment Programme. Retrieved from <https://library.sprep.org/sites/default/files/EBA-Macuata-Fiji.pdf>

²⁸⁸ Ramsar Convention. (2016). Management of Wetlands in Fiji: Site FJ2331. Ramsar Information Service. [Fiji | The Convention on Wetlands, The Convention on Wetlands](#)

²⁸⁹ Reserve Bank of Fiji. (2020). Revised Growth Projections for Fijian Economy. Reserve Bank of Fiji. Retrieved from <https://www.rbf.gov.fj/press-release-no-29-revised-growth-projections-for-fijian-economy/>

²⁹⁰ Fiji Climate Change. (2020). Fiji's Climate Change Strategy: Roadmap to 2050. Fiji Climate Change Portal. Retrieved from <https://www.climatechange.fiji.org/>

²⁹¹ Climate Action Tracker. (2021). Fiji's Climate Action Progress. Climate Action Tracker.

²⁹² ABC News. (2023). Developing Climate-Resilient Crops and Agriculture in Fiji. ABC News.

²⁹³ ABC News. (2023). Fiji's Crop Resilience and Drought Adaptation Strategies for Climate Change. ABC News

have also been working towards finalizing a Fisheries Management Plan. The high attendance from district representatives to the forum is an indication of the coastal fisheries community's support towards managing their fisheries sustainably.

Coastal development for residential, commercial, or industrial use has led to the displacement of mangrove and coastal wetland areas, lowering the capacity for flood and storm water mitigation, and attenuating land-derived pollutants to the marine environment. The Macuata Natural Resource Management Strategy requires updating and climate resilience components²⁹⁴. While there is no direct reference to mining in Macuata Province, the Natural Resource Management Strategy mentioned earlier would likely cover the sustainable management of mineral resources²⁹⁵.

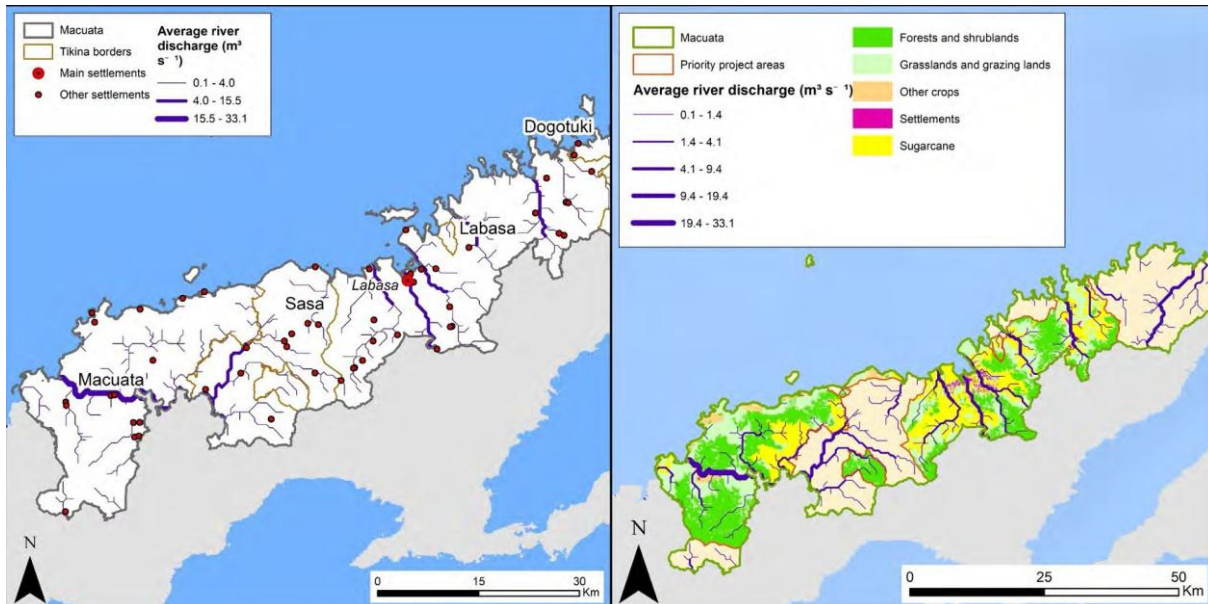


Figure 4-20 Populated areas in the Macuata province, from the National census in Fiji in 2017 (left). Priority project areas in the Macuata Province. The main land use in the priority project areas of the Macuata province are forests and shrublands (36% of the total area), followed by grasslands and grazing lands (34%), sugarcane cultivation (26%), and other crops (3%) (right)

²⁹⁴ Reserve Bank of Fiji. (2022). *Economic Impact of Climate Change in Fiji*. Reserve Bank of Fiji.

²⁹⁵ SPREP. (2021). *Pacific Island Climate Change Socio-Economic Study Report*. Secretariat of the Pacific Regional Environment Programme. Retrieved from [Pacific Islands Climate Change Monitor 2021](#)



Figure 4-21 Geography and land use close to Labasa, Macuata, Fiji; (OHG, Feb 2024).

5. Climate changes and Interactions

The GSR is a dominant feature of Fiji's major coral system and is surrounded by a diversity of habitats that interact with each other creating high levels of biodiversity and productivity. Four priority locations were selected across the northern coast of the two largest islands of Fiji, Viti Levu and Vanua Levu. A vast amount of literature and consultation with expert and community leaders to understand how recent challenges could be understood and managed. Drivers and threats affecting the Great Sea Reef were investigated based on expert literature, academic reviews, government information, local site visits, and data from governments, communities, research institutes, and non-government organisations. Local threats spanned both the land and sea, making it essential to consider human-caused threats to climate adaptation provided by the reef and its resources within a ridge-to-reef framework. The climate vulnerability and overall state of the GSR and local and global threats across the priority provinces of this Feasibility Study lay the groundwork for exploring the cumulative stresses and vulnerability in the major types of tropical marine ecosystems.

5.1. Driving factors and system interactions

Observations from multiple perspectives are critically important to deeply understand the important changes occurring through such a vast ecosystem. Networks and data provide critical insights into climate change's effects on tropical marine ecosystems. They also empower informed decision-making, adaptation, and conservation efforts to safeguard these vital ecosystems for future generations²⁹⁶.

²⁹⁶ SPC. (2021). *Fiji's Sea-Level Rise and Coastal Vulnerability: Implications for Future Development*. Secretariat of the Pacific Community.

5.1.1. Coral cover

Coral reefs in Fiji were surveyed for basic coral cover and fish abundance, not shown here but carefully documented via a comprehensive ecological survey of the GSR was completed²⁹⁷. Visiting 74 sites across the entire Great Sea Reef, Andradi-Brown and colleagues collected information on fish and coral populations from the Mamanuca Islands in the southwest to Udu point in the northeast. Of the sites surveyed, 48 had historic survey data available, allowing trends in coral reef health to be calculated. Survey results are reported for the GSR by province and by individual qoliqoli. The results of this major assessment were analysed and published by WWF²⁹⁸. Given recent global impacts on GSR ecosystems (principally corals and fish), a second study was done, which is being analysed for release in early 2025.

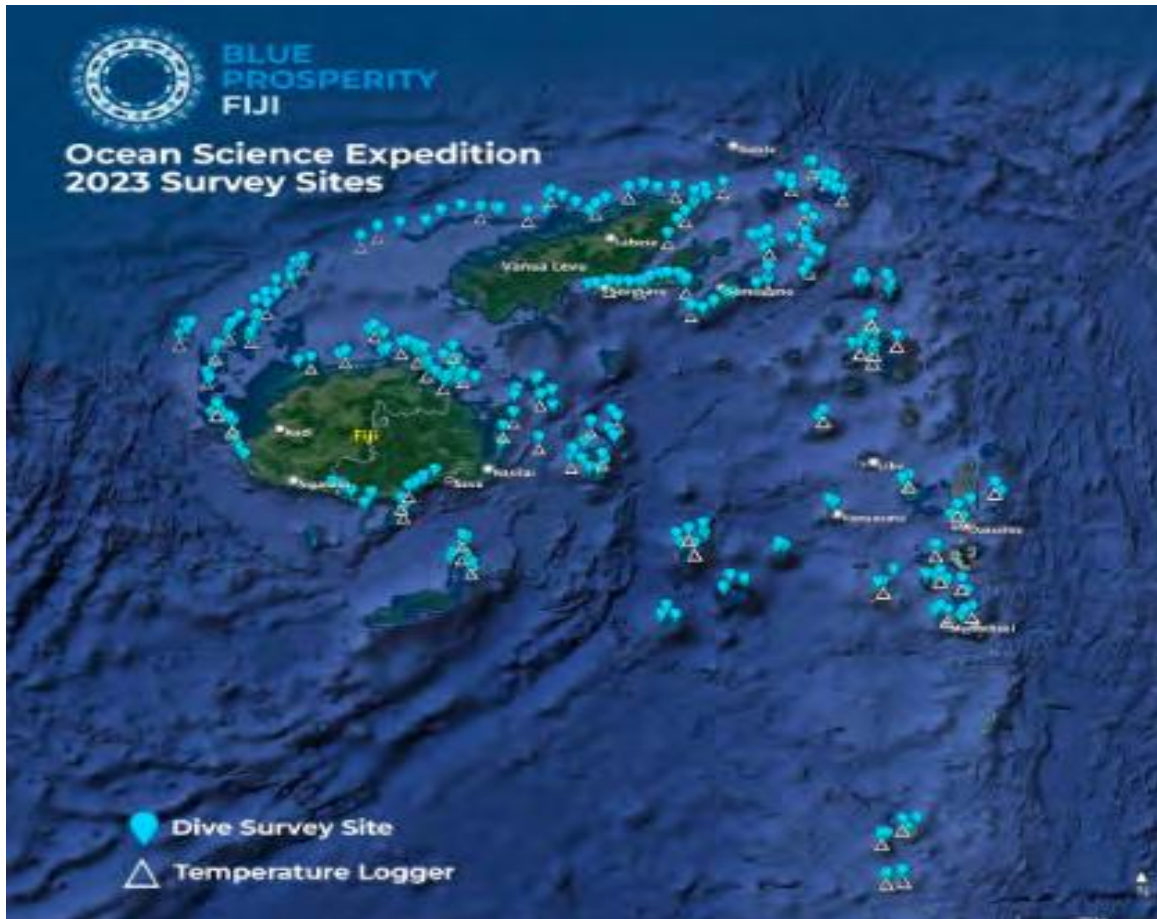


Figure 5-1 Great Sea Reef Survey sites in 2023 (under analysis and to be published soon with Waitt Foundation).

Coral cover across the GSR was generally high (34%), with the highest found in the northern GSR. For example, Bua province had exceptionally high coral cover at 45%, followed by 36% in Macuata province. Reefs in the south of the GSR had the lowest coral cover: 26% in Ba province and 23% in Nadroga-Navosa province, although this is still high relative to many reefs in the global context. Analysis of survey results suggests that coral cover has changed since the early 2000s across much of the GCR reefs, with past surveys indicating a historic GSR regional coral cover of 31%. Algae cover was low across the GSR, though it was extremely likely there was a small increase – from 4% in historical surveys to 5% in 2019. However, there was evidence of recent disturbance to some reefs, with it virtually certain that rubble increased on reefs across the GSR (from 5% to 17%). These results suggest that while coral reef benthic communities remain generally healthy, there have been some recent disturbances to reefs. The diversity of the GSR is indeed remarkable. The team provides scientific support for research and monitoring work in the Great Sea Reef, Fiji. It establishes a critical baseline for the GSR and contributes significantly to our understanding of this vital ecosystem²⁹⁹.

The goal was to document the condition of the three ecosystems: coral reefs, seagrass and mangroves health, and to understand whether the resilience of these key components is changing. This is then used to work out how to set

²⁹⁷ World Food Programme. (2020). *Fiji's Response to Climate Change and Food Security Challenges*. World Food Programme.

²⁹⁸ United Nations. (2020). *UN Secretary-General's Statement on Climate Action in Fiji*. United Nations.

²⁹⁹ Fiji Times. (2021). *Fiji's Climate Action Pledge for 2021-2022: Strategies and Goals*. Fiji Times.

thresholds and drive decisions at a landscape level using Nature-based Solutions (NbS) involving living shorelines and Ecosystem-based Adaptation (EbA).

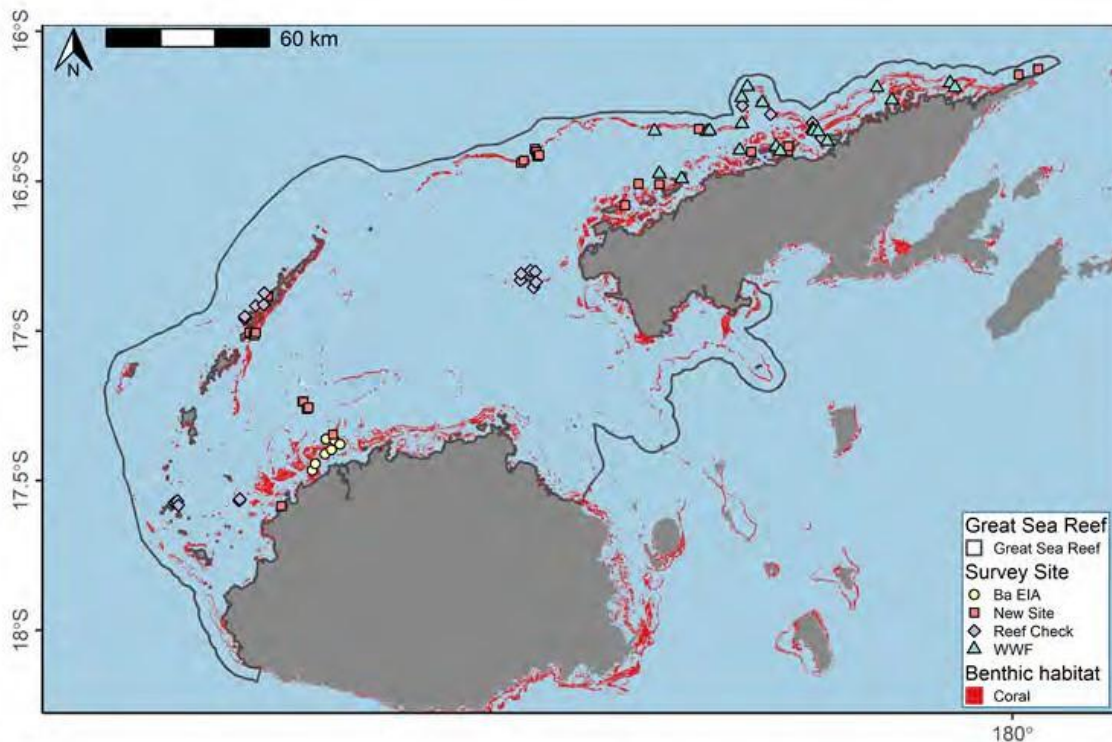


Figure 5-2 Great Sea Reef sites sampled by Andradi-Brown et al. in 2019.

5.1.2. Unsustainable fishing

In the 2019 survey described above, transects were also used to estimate the abundance and biomass of fish species across the Great Sea Reef. Historical data were also collated where available, based on surveys conducted by WWF and other groups³⁰⁰, covering the years 2001, 2003, 2004, 2006, 2007, 2010, and 2011. The fish abundance from the 2019 survey was subtracted from the historical fish abundance at each survey site. From this calculation, fish abundance was interpolated between sites based on ordinary kriging³⁰¹ and normalised to values ranging from 0 to 10. The datasets included a total of 428 unique fish taxon, which were assumed to all be impacted by fishing given the extremely high level of fishing pressure in the Great Sea Reef and non-discriminate fishing practices. While some changes in fish abundance are due to natural variation or environmental factors, this represents the best information on changes in fish abundance through time given the lack of fish monitoring available across Fiji.

Key fisheries species (such as Sweetlips, Snapper, Goatfish, Parrotfish, and Grouper) have declined by 33% across the Great Sea Reef, GSR, since the 2000s. However, reef fish abundance and biomass were declining and low compared to global reference values needed to maintain key ecological functions. The report suggests increased species-specific conservation strategies, and economic incentives to support sustainability and conservation in the GSR. The GSR plays a crucial role in Fiji's biodiversity and local economy, making its conservation efforts vital for the future.

³⁰⁰ World Bank. (2020). *Fiji Climate Change and Economic Development Report*. World Bank Group.

³⁰¹ OECD. (2021). *Climate Change Impacts and Policy Options for Fiji: An Analysis*. OECD Publishing.



Figure 5-3 Sustainable fishing near Labasa (Nov 7, 2023, OHG photo).

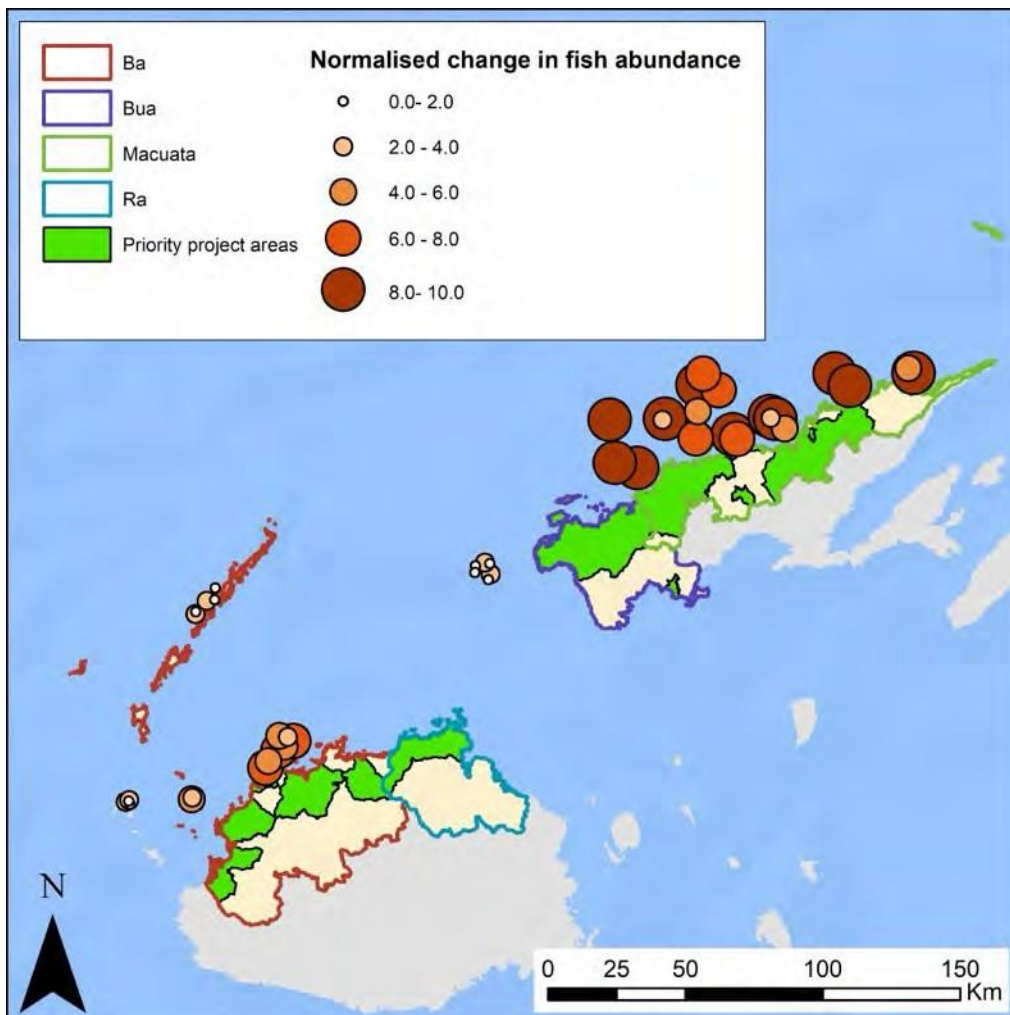


Figure 5-4 Normalised change in fish abundance based on surveys developed in 2019 and historical data (years 2001, 2003, 2004, 2006, 2007, 2010, and 2011). Higher values (from 0 to 10) show larger decreases in fish abundance. NB: the latest surveys (Ocean Science Expedition 2023 Survey Sites) are still being analysed and will be very useful in terms of understanding the long-term data trends.

5.1.3. Soil and sediment erosion

To model soil erosion, newly available high-resolution data and models adapted to Fiji³⁰² were used as in Suarez-Castro et al. (2021)³⁰³. The global potential soil erosion model developed by Borrelli et al. (2017)³⁰⁴ based on the revised universal soil loss equation (RUSLE; Renard et al., 1997³⁰⁵) was used to estimate soil erosion in each watershed. To quantify total sediment exported at watershed scales, the InVEST sediment delivery model, which implements a soil loss algorithm linked to the sediment connectivity algorithm proposed by Borrelli et al. (2008)³⁰⁶ was used. This approach is suitable for the present study as it aims to capture the major differences between watersheds that can help to identify hotspots of higher sediment export where priority actions should focus. In this sense, estimates were generated that optimally captured relative differences and opportunities among watersheds, rather than describing fine-scale processes within watersheds.



Figure 5-5 Near Labasa (Macuata Province): Nov 7, 2023 (OHG photo) (left). Soil erosion along banks of the Ba River (17 Feb 2024, OHG) (right).

³⁰² SPC. (2020). *Community Resilience Assessment in Fiji: Impacts of Climate Change on Vulnerable Communities*. Secretariat of the Pacific Community.

³⁰³ Wildlife Conservation Society. (2020). *Fiji Wildlife Conservation Plan: Strategies for Protecting Biodiversity*. WCS Newsroom. Retrieved from [wildlife-conservation-annual-report-fiji.pdf](https://www.wildlife-conservation-annual-report-fiji.pdf)

³⁰⁴ World Food Programme. (2021). *Fiji's Climate Change Adaptation Strategy: Moving Forward with Resilience*. World Food Programme.

³⁰⁵ WWF Pacific. (2021). *Macuata Province Leads Conservation Efforts in Fiji*. WWF Pacific. Retrieved from <https://www.wwfpacific.org/?205003/Macuata-Province-leads-conservation-efforts>

³⁰⁶ SPC. (2020). *Macuata Province: A Case Study of Climate Adaptation Success*. Pacific Climate Change Centre. Retrieved from <https://www.spcc.org/documents/Macuata-Fiji-Climate-Adaptation-Success>

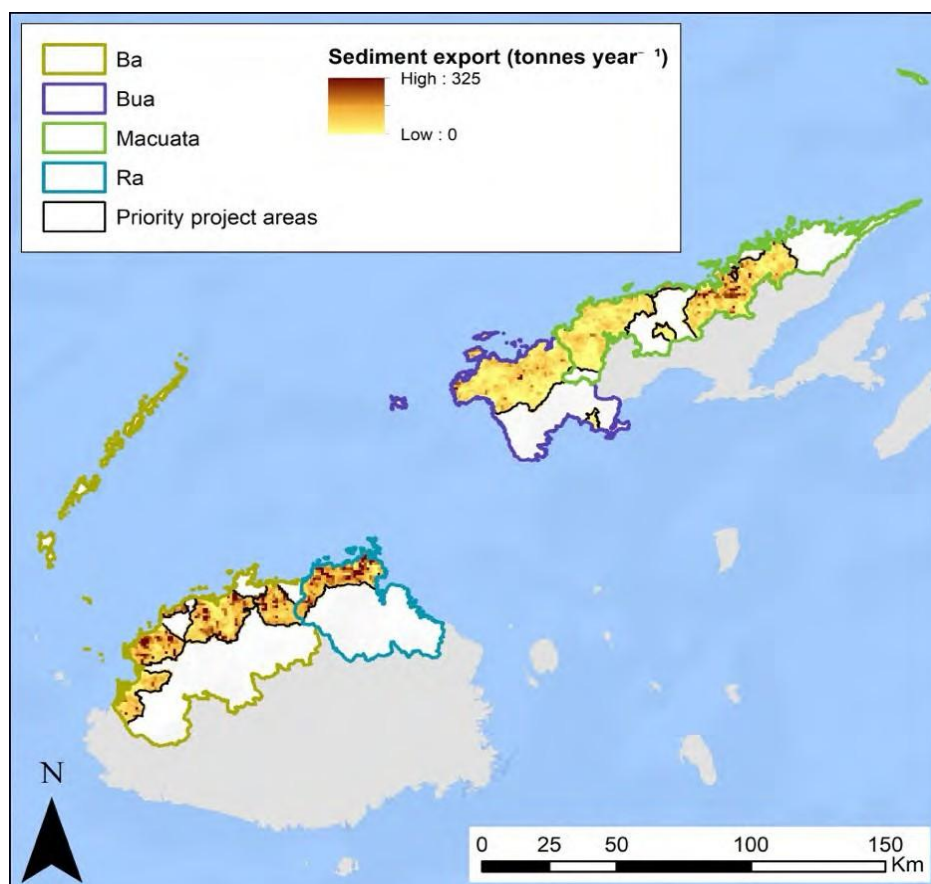


Figure 5-6 Spatial distribution of sediment export across selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Newly available high-resolution data and models adapted to Fiji from Suárez-Castro et al (in prep) were used³⁰⁷.

Based on observational information gathered during the site visit in February 2022 that confirmed relative differences in model estimates. Significant soil erosion was seen, particularly in coastal watersheds in the Ba and Ra provinces, and in proximity to Labasa in the Macuata province. A combination of sea level rise, storms and erosion have led to exposed root structures of mangroves.



³⁰⁷ SPC. (2018). Mid-term Diagnosis of RESCCUE: Kavadu Province and Ra Province, Fiji. Secretariat of the Pacific Community. Retrieved from <https://www.spc.int/sites/default/files/wordpresscontent/wp-content/uploads/2018/01/Mid-term-diagnosis-of-RESCUE-Kavadu-province-and-Ra-province.pdf>



Figure 5-7 Soil erosion seen in the Ba province. Top figure shows erosion along the Ba River exposing tree roots. Bottom figure shows a local person from a fishing village explaining how sediment used to be up the red line on the light pole but has decreased to current levels.

Increased numbers of landslides can contribute to increasing amounts of sediments reaching marine environments was obtained by direct communication with the Ministry of Lands and Mineral Resources in Fiji (2024). Recorded landslide events ranging from 1985 to 2024 were summed within each basin-Tikina intersection.

Forestry operations affect water quality (through filtration) and can impact marine ecosystems, mainly through increased sediment runoff. Forestry harvesting areas were obtained from 1991 to 2023 by direct communication with the Ministry of Forestry in Fiji (2024). Within this time frame, forestry harvesting areas particularly occurred within the southwestern portion of Vanua Levu Island within the Bua and Macuata provinces.

Deforestation increases sediment runoff and thus can negatively impact marine ecosystems. Historic deforestation was assessed by examining the change in pixels (forest to no forest) between 2005 and 2021, based on data obtained from direct communication with the Ministry of Forestry in Fiji (2024). Data shows that within this time frame, deforestation was widespread, particularly within the Bua province.

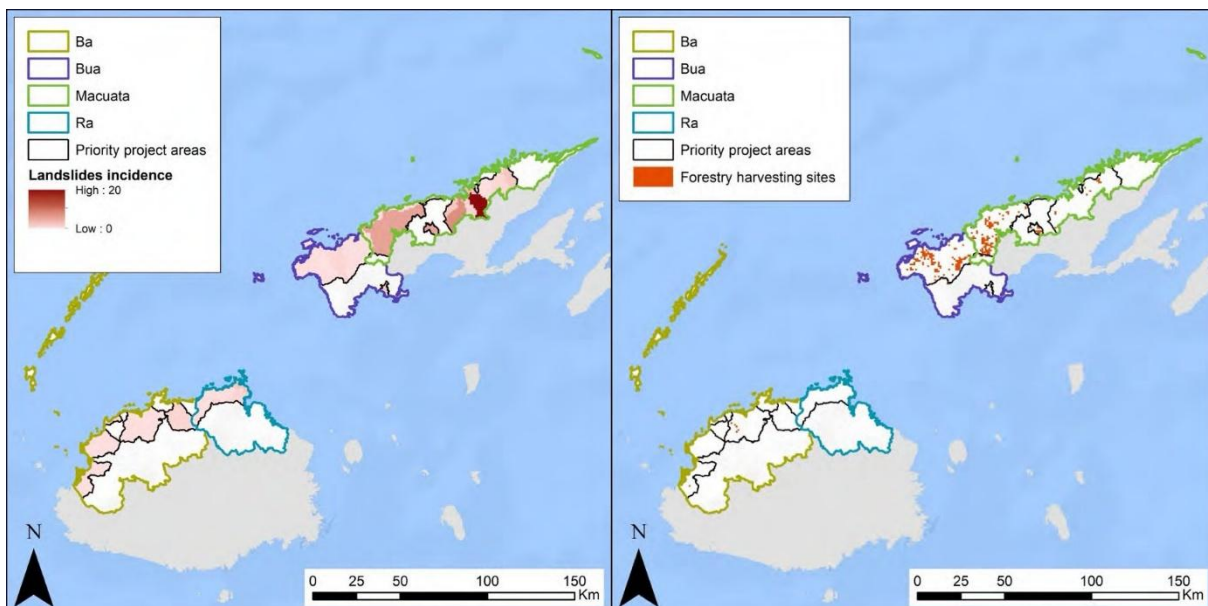


Figure 5-8 Sum of landslide events across basin-Tikina intersections. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Ministry of Lands and Mineral Resources in Fiji (2024) (left). Spatial distribution of forestry harvesting sites across selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Ministry of Forestry in Fiji (2024) (right)

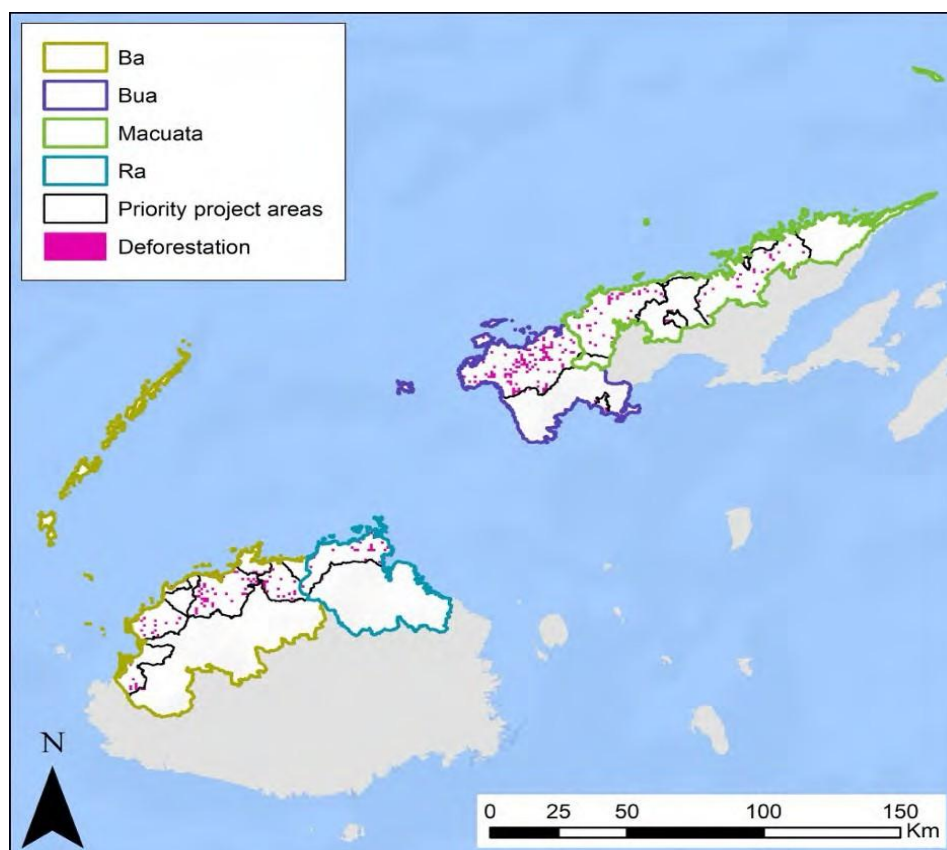
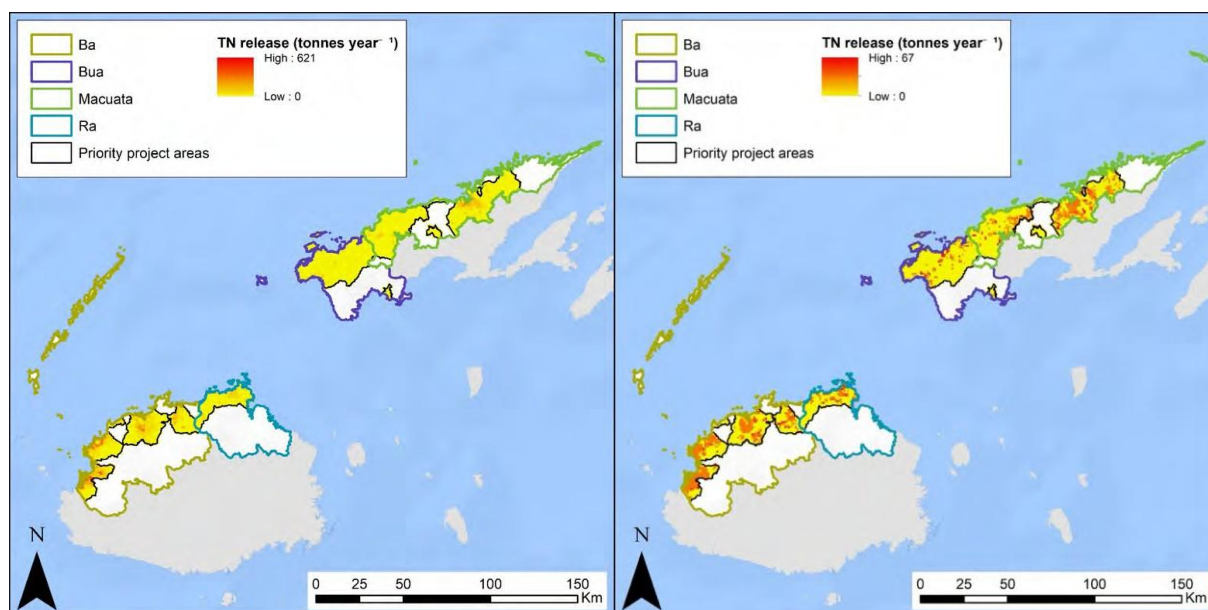


Figure 5-9 Spatial distribution of deforestation across selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Ministry of Forestry in Fiji (2024).

5.1.4. Nutrient pollution

To assess the impact of water, sanitation and hygiene on coral reef nutrient exposure and inform strategic sanitation improvements for coral reef health, a modelling approach developed by Kuempel et al. 2024³⁰⁸ was used. The model considers three types of sanitation categories: wastewater treatment plants, septic systems, and pit latrines. It uses estimates of population using each sanitation category, coupled with nutrient removal rates and dispersion models to assess nutrients reaching coral reefs.



³⁰⁸ WWF. (2020). *Fiji Marine Conservation Update: Strategies and Achievements*. World Wildlife Fund. Retrieved from [Fiji | WWF](#)

Figure 5-10 Spatial distribution of human wastewater as nitrogen pollution from septic tanks across selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from Keumpel et al. (2024) (left)³⁰⁹. Spatial distribution of human wastewater as nitrogen pollution from pit latrines across selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from Keumpel et al. (2024). (right)

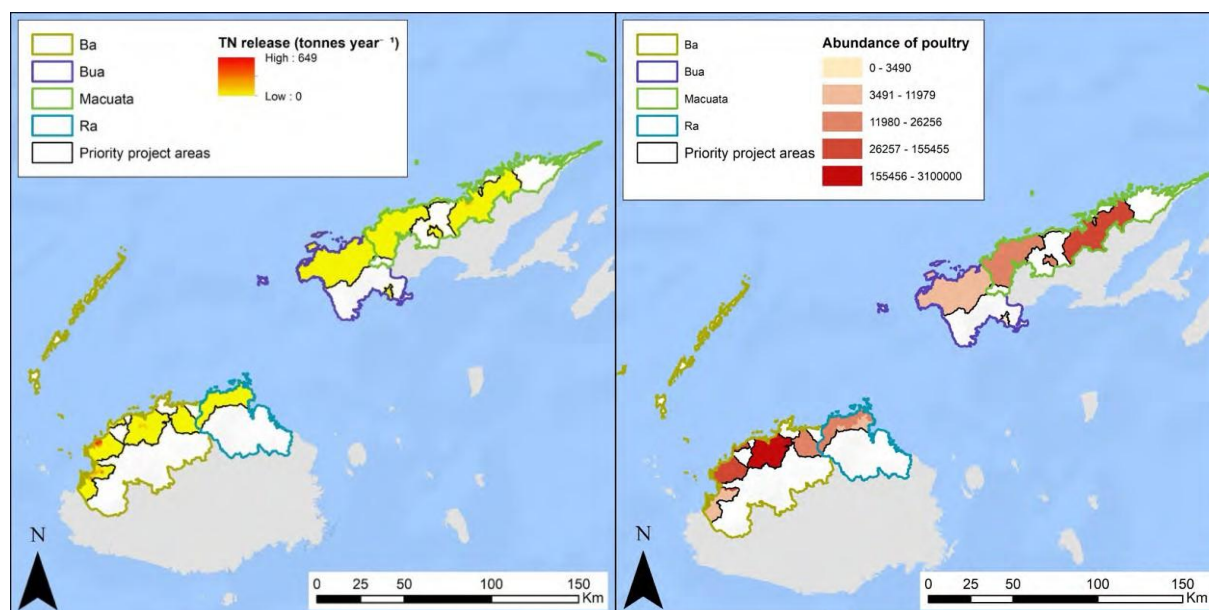


Figure 5-11 Spatial distribution of human wastewater nitrogen pollution from wastewater treatment plants across selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from Keumpel et al. (2024) (left)³¹⁰. The sum of the abundance of poultry across Tikinas. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Fiji Agricultural Census (2020) (right)³¹¹.

Data on the treatment catchment areas and the amount of nutrient discharge for sewage treatment plant discharge was obtained from Water Authority Fiji to inform the models. Septic and pit latrines were based on population estimates and observational information from a study conducted in Fiji that measured the travel distance of nutrient pollution from these sanitation back-ends.

No data on the nutrient discharge due to livestock is currently available in Fiji. We used livestock abundance as a proxy for nutrients from livestock. We obtained data from the Ministry of Agriculture and Waterways that surveyed livestock abundances of poultry, goats, cattle, pigs, sheep, and horses across Tikinas in 2020³¹². We summed these values across areas under the assumption that a higher abundance of livestock correlates with higher levels of manure and nutrient pollution reaching the environment, surface waters, and coastal areas.

³⁰⁹ Fiji REDD+. (2021). Fiji Forest Conservation and REDD+ Program: Achievements and Challenges. Fiji REDD+ Project. Retrieved from [Home - REDD+ Fiji](#)

³¹⁰ Climate Action Tracker. (2021). Fiji Climate Policy and Emissions Progress. Climate Action Tracker.

³¹¹ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR Fiji 2020 F 22022022.pdf](#)

³¹² FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR Fiji 2020 F 22022022.pdf](#)

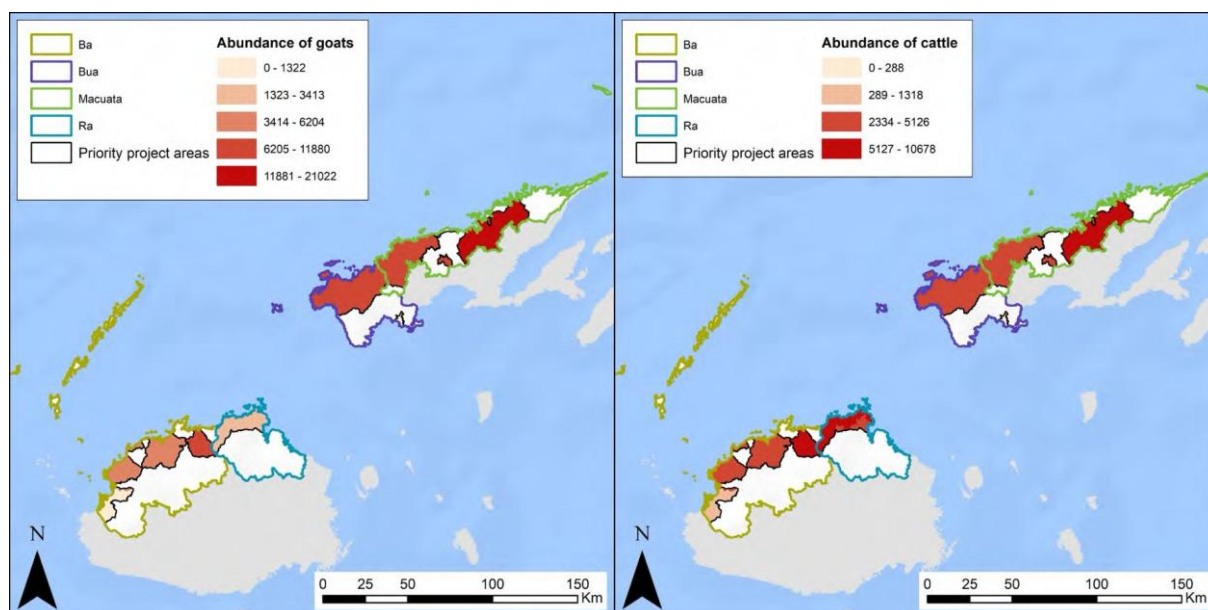


Figure 5-12 Summary of the abundance of goats across Tikinas. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Fiji Agricultural Census (2020) (left)³¹³. The sum of the abundance of cattle across Tikinas. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Fiji Agricultural Census (2020) (right)³¹⁴.

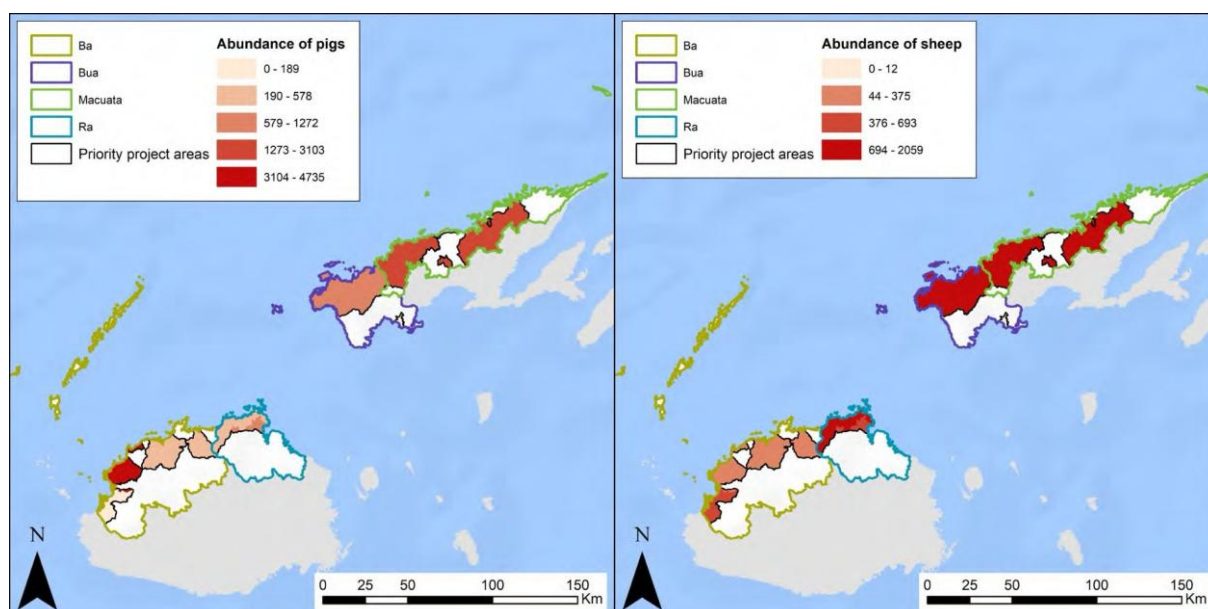


Figure 5-13 Sum of the abundance of pigs across Tikinas. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Fiji Agricultural Census (2020) (left)³¹⁵. The sum of the abundance of sheep across Tikinas. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Fiji Agricultural Census (2020) (right)³¹⁶.

³¹³ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR_Fiji_2020_F_22022022.pdf](#)

³¹⁴ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR_Fiji_2020_F_22022022.pdf](#)

³¹⁵ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR_Fiji_2020_F_22022022.pdf](#)

³¹⁶ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR_Fiji_2020_F_22022022.pdf](#)

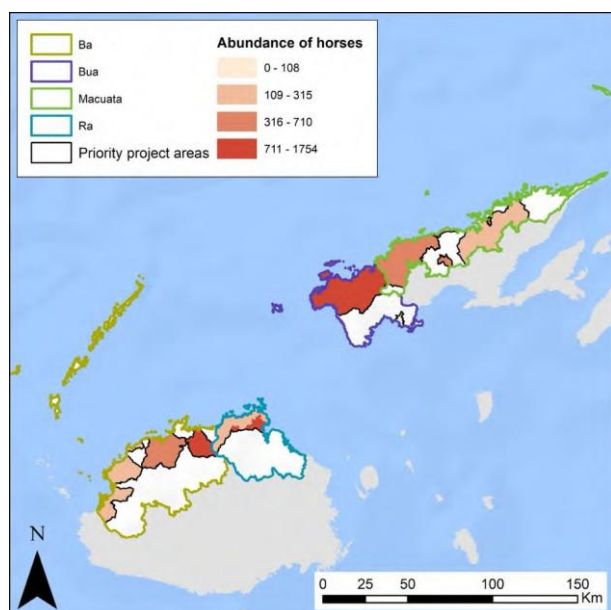
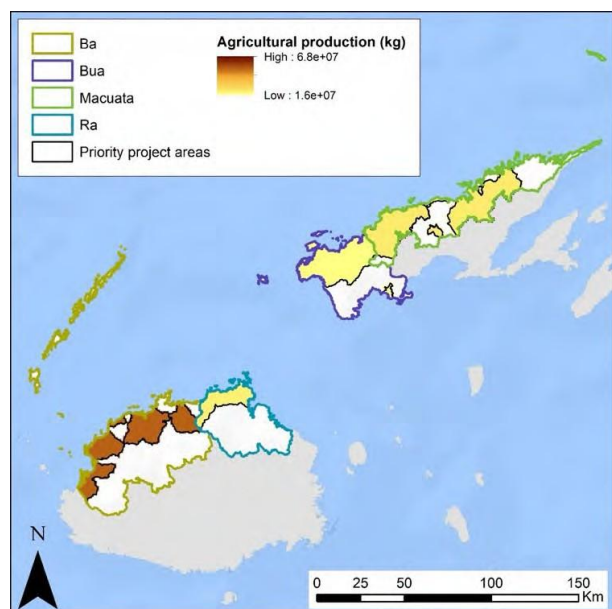


Figure 5-14 Sum of the abundance of horses across Tikinas. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Fiji Agricultural Census (2020)³¹⁷.

5.1.5. Agricultural run-off

Agricultural activities constitute a major source of pollution, as they generate excess nutrients, sediments, and pesticides that can reach marine ecosystems and thus coral reefs. The spatial distribution of agricultural land was obtained from the Pacific Risk Information System land-use classification³¹⁸ as a proxy for pollution sources affecting marine ecosystems. Agricultural land included grazing areas (open land/grassland and grazing lands), as well as crops (orchards, sugarcane, cassava, coconut plantations, rice, oil palm, and other types of cultivated land). As an additional proxy on pollution sources to marine ecosystems, the agricultural production volume was obtained at the province level from the Ministry of Agriculture and Waterways surveys in 2020³¹⁹. The volume of all types of agricultural products was then summed within each province.



³¹⁷ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR_Fiji_2020_F_22022022.pdf](#)

³¹⁸ SPC. (n.d.) Risk and resilience information for the Pacific.

³¹⁹ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR_Fiji_2020_F_22022022.pdf](#)

Figure 5-15 Sum of the agricultural production volume across provinces. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata). Data from the Fiji Agricultural Census (2020)³²⁰.

5.1.6. Mangrove loss and degradation

Mangroves play a critical role in intercepting pollutants such as inorganic nutrients and sediments, before they can reach coral reefs and the interconnected marine ecosystems. Additionally, mangroves serve as habitats for species reliant on coral reefs, mitigate coastal erosion, and serve as a local source of timber for communities. The decline and degradation of mangroves consequently diminish the resilience of coral reefs and their associated ecosystems.

5.1.7. Mining

Mining operations can constitute a source of pollutants reaching marine ecosystems, including sediments, nutrients, and toxic substances. Data on active mining leases was obtained from direct communication with the Ministry of Lands and Mineral Resources. The Bua and Macuata provinces in Vanua Levu Island contain the largest active mining leases within the priority provinces.

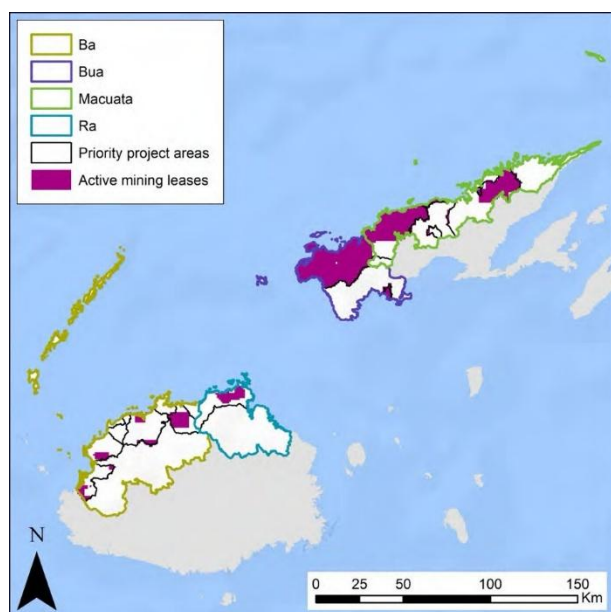


Figure 5-16 Spatial distribution of active mining leases across selected project sites, within priority provinces (Ba, Ra, Bua, Macuata).

5.1.8. Urban population

Urban population constitutes a source of pollutants in the form of sediments, nutrients, pathogens, organic compounds, and toxic substances, including heavy metals and micro and macro-plastics. The urban population was summed to obtain the proportion of the urban population within each Tikina, based on a dataset obtained by direct communication with the National Disaster Management Office in Fiji. The urban population is concentrated around Nadi (Bua province) and Labasa (Macuata province).

³²⁰ FAO. (2020) Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. Food and Agriculture Organization of the United Nations. Retrieved from [MR_Fiji_2020_F_22022022.pdf](#)

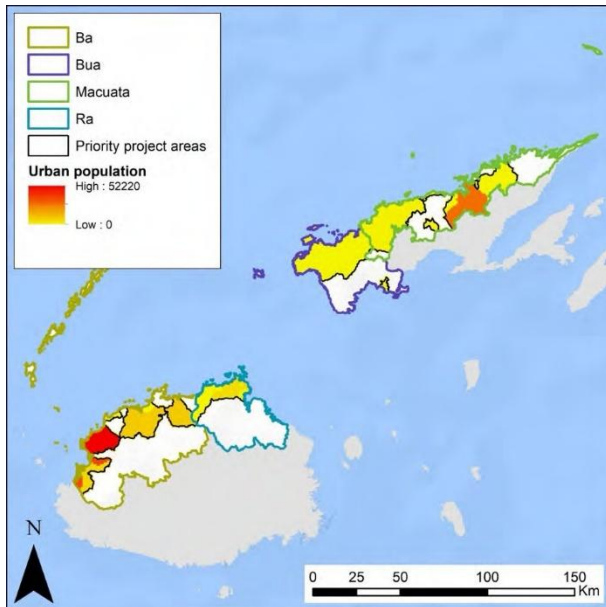


Figure 5-17 Sum of urban population across Tikinas. The map shows the selected project sites, within priority provinces (Ba, Ra, Bua, Macuata).

5.1.9. Coastal flooding

The Great Sea Reef system in Fiji acts as a barrier reef to the northern coastlines of the islands of Viti Levu and Vanua Levu in Fiji. Like the rest of Fiji's coastlines, these are typical of tropical island coastlines. The offshore bathymetry in this region is characterized by a steep continental shelf with large extents of atoll, patch, barrier and fringing coral reefs in the nearshore including some inhabited reef islands. The mainland coastline is highly undulating with several hydrodynamically isolated bays separated by headland features. The coastal topography is characterized by a steep nearshore profile, climbing rapidly from 0 m above Mean Sea Level to higher than 10 meters.

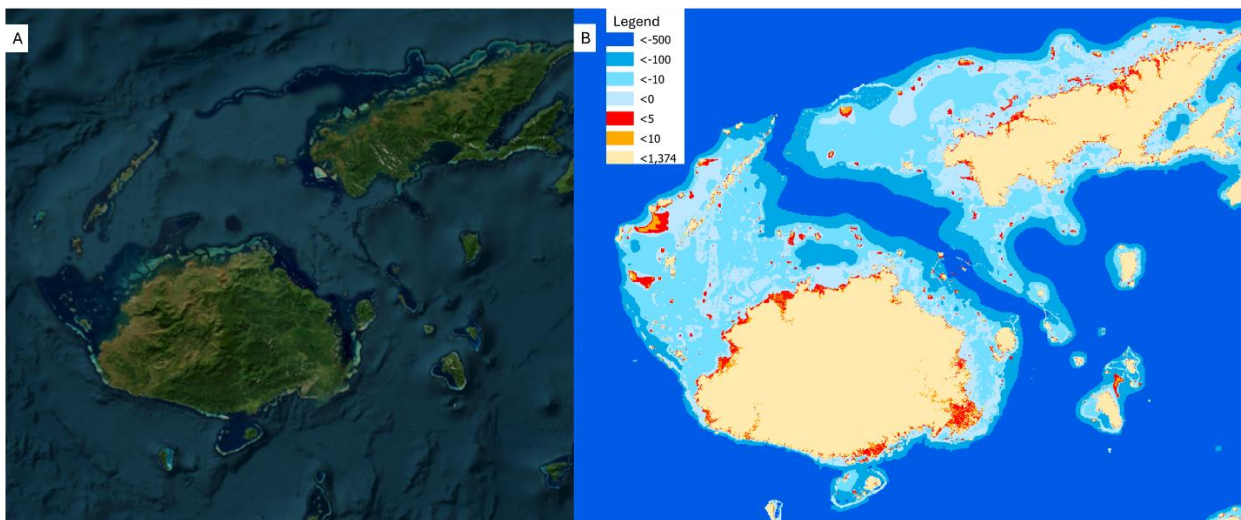


Figure 18: Left Panel (A): Satellite imagery of the coastlines of Viti Levu and Vanua Levu islands of Fiji. Right Panel (B): Stitched bathymetry and topography for Viti Levu and Vanua Levu (see Methods for details). World Imagery Basemap from ArcGIS.

Coastal Land-Use and Demographic Patterns

The northern coastlines of Viti Levu are mostly comprised of small, sparsely populated communities near the coastline except for the city of Nadi in the east which is densely populated and also contains Fiji's international airport. Most of the rest of the Viti Levu coastline consists of small coastal communities surrounded by grassland, agricultural fields and plantations.³²¹ Mangrove forests are widely present on the coastline of both islands. The coastline of Vanua Levu is very sparsely populated relative to Viti Levu, with mangroves, grassland and cropland dominating the coastal

³²¹ Zanaga, D., et al., ESA WorldCover 10 m 2021 v200. 2022. <https://zenodo.org/records/7254221>

floodplain. The densest networks of roads and most of the population in this region lie within the 10 m elevation contour, with about 40% of the population residing below the 5 m elevation contour.

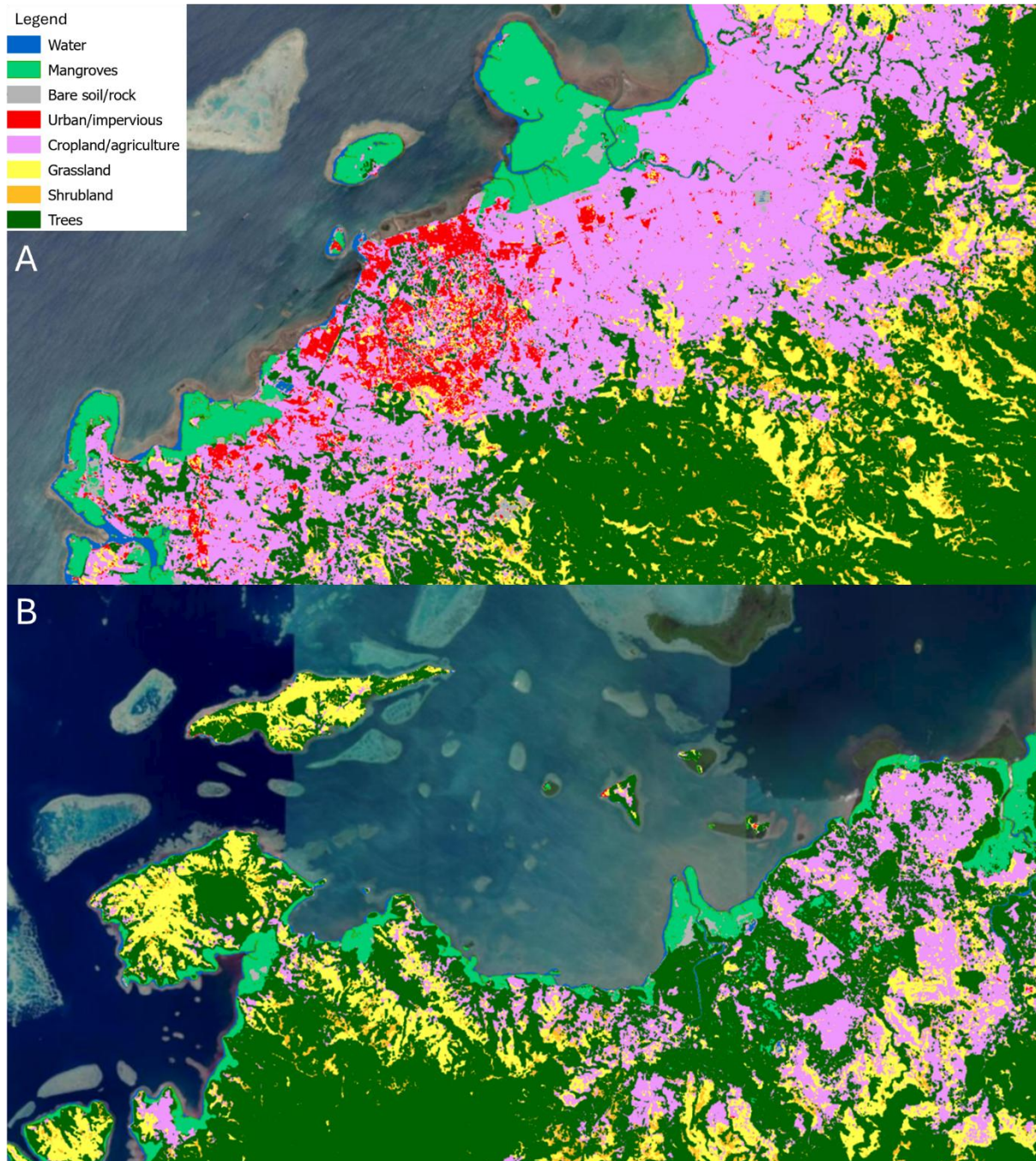


Figure 19: Land use patterns in Top (A): North-eastern Viti Levu, Fiji and Bottom (B): north-eastern Vanua Levu. World Imagery Basemap from ArcGIS.

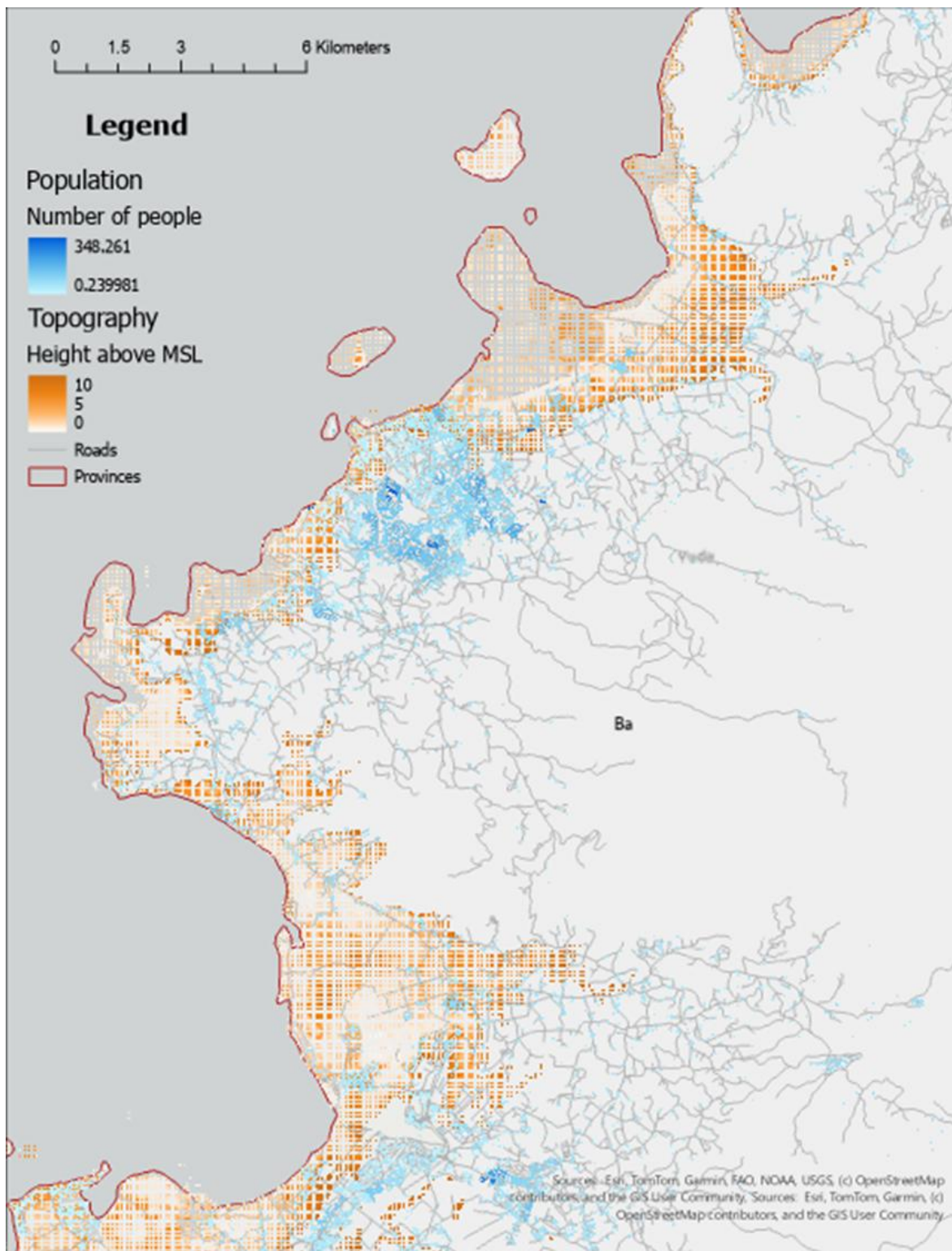


Figure 20: Distribution of bathymetry (orange shades), population (blue shades) and roads (grey lines) in Ba Province, Viti Levu. Light Gray Canvas Basemap from ArcGIS.

Tropical Cyclones and Flooding from Storm Surges

Flooding from tropical cyclones occurs due to a combination of storm surges, rainfall, and increased river discharges. For communities on the coast, storm surges are typically the most destructive source of flooding during a tropical cyclone.³²² The extent of storm surge flooding that occurs during a storm depends on a number of factors such as the size, track and forward speed of the storm, the slope of the continental shelf, the shape of the coastline, the presence

³²² Rahmstorf, S., *Rising hazard of storm-surge flooding*. Proceedings of the National Academy of Sciences, 2017. 114(45): p. 11806-11808.

of features such as coral reefs in the nearshore region, and topographic elevations behind the coastline which determine the extent of the floodplain inundated by the oncoming storm surge. As sea-levels rise around the Fijian coastline, the extent of inundation from storm surges, and non-linear interactions between sea-levels and storm surge levels can worsen future impacts from storm surges.³²³

On the northern coastlines of Viti Levu and Vanua Levu in Fiji, flooding from storm surges will be influenced by the interaction of several factors, from the steeply sloping continental shelf to the presence of several emergent and submerged near-shore reefs, the highly inundated shoreline itself, and the topography of the coastal floodplain. The complex and highly fragmented nature of these coastlines can result in very different storm surge inundation extents across coastal floodplains that are not very distant from one another. Storm surge flood extents may also be influenced by upstream river discharges during the tropical cyclone.

Here, we describe coastal storm surge flooding analyses conducted for a historical and a future timeline. For the historical timeline, we consider the time-period 1990 – 2014, and use, as the baseline for our storm surge model, the 2014 Mean Sea Level value for Fiji. For the future timeline, we consider the time-period, 2014 – 2040, and use as our baseline, the 2040 projected Mean Sea Level for Fiji, based on a Shared Socio-Economic Pathway (SSP) 2 – 4.5 scenario of global greenhouse gas emissions.³²⁴

5.1.10. Climate vulnerability and disaster risk

The climate disaster risk index measured here is based on the INFORM Risk Index. The INFORM Risk Index is a global, open-source risk assessment for humanitarian crises and disasters developed by the European Commission. It can support decisions about prevention, preparedness and response. Recently, a sub-national INFORM index was developed through the CommonSensing project for Fiji. CommonSensing is an international project, funded by the UK Space Agency’s International Partnership Programme (IPP) through the BEIS Global Challenge Research Fund (GCRF) that supports Fiji, Vanuatu and the Solomon Islands to achieve climate resilience and sustainable development using innovative solutions.

The index combines aspects of hazard, exposure, vulnerability, and lack of coping capacity to determine the overall disaster risk of an area. The general equation to achieve this is:

$$\text{Risk} = \text{Hazard} \times \text{Exposure}^{1/3} \times \text{Vulnerability}^{1/3} \times \text{Lack of coping capacity}^{1/3}$$

Detailed information on the various components of each aspect of the index and relevant methodologies can be found below. The colours of the backdrop shading represent different dimensions listed under the first column.

Table 5-1 Datasets and methodology: For each indicator in the disaster risk composite index.

Dimensions	Categories	Component	Indicators	Methodology
Hazard & Exposure	Natural Hazard	Physical exposure to Riverine Flood	Physical exposure to flood - number of populations inside an area of potential flood around seasonal water (inhabitants)	The indicator is based on the estimated number of people exposed to potential floods on top of seasonal rainfall. It results from the combination of potential flood zones using a relatively simplistic Digital Elevation Model (DEM) with the Height Above Nearest Drainage (HAND) technique and the number of populations living in the spatial unit. It thus indicates the number of expected people exposed in the hazard zone.
		Physical exposure to Coastal Inundation	Physical exposure to coastal flood - number of population	The indicator is based on the estimated number of people exposed to coastal floods. It results from the combination of the low-lying areas using simplistic relative DEMs (less than 10 meters) and the total

³²³ Zhang, K., et al., *Comparison of three methods for estimating the sea level rise effect on storm surge flooding*. Climatic Change, 2013. **118**(2): p. 487-500.

³²⁴ Lee, H., et al., *IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]*. IPCC, Geneva, Switzerland. 2023.

			exposed to low-lying areas (< 10m) (inhabitants)	population living in the spatial unit. It thus indicates the number of expected people exposed in the hazard zone.
		Physical exposure to Earthquake	Population exposes to MMI scale VI or greater, horizontal peak ground acceleration 500MRP	Assumption Fiji rural areas are mostly sub-standard housing. At MMI-VII considerable damage in poorly built or badly designed structures occurs. Overlay earthquake shaking with 10% probability of exceedance in 50 years, corresponding to a return period of 500 years from pacgeo with FB population
		Physical exposure to Cyclone	Population exposed to tropical cyclone greater than category I 100MRP	Assumption Fiji rural areas are mostly sub-standard housing. At Category I considerable damage in poorly built or badly designed structures occurs. Overaly Windpeed zones > 110mph (Saffir–Simpson scale) for 100MRP, with FB population
		Physical exposure to Erosion	Population near high intensity of water increase from 1985-2018 from JRC surface water map	Increasing water trend refers to erosion that may be from the sea or river. Higher intensity refers to greater erosion from 1985-2018. Creating a buffer of 50m will represent an area of potential threat, which can be overlayed with FB population.
Vulnerability	Socio-Economic Vulnerability	Economic Growth	Gridded GDP	Source: Zonal aggregation of gridded stock
		Poverty	Poverty headcount	World Bank 2011
		Unemployment Ratio	Unemployment Ratio	Unemployment Ratio - Proportion of No - Census 2017
	Vulnerable Groups	Children	Age less than 5 yrs old.	Age less than 5 yrs old - Proportion of No - Census 2017
		Disability	No. of disabled person	Disability Person - Proportion of No - Census 2017
		Elderly	Age more than 65	Age more than 65 - Proportion of No - Census 2017
Lack of Coping Capacity	Infrastructure	Communication	Access to electricity	HH without electricity - Proportion of No - 2017 Census Determinant in coping capacity. Reference: https://archive.ipcc.ch/ipccreports/tar/wg2/index.php?idp=651 .
			Internet Access	HH without internet - Proportion of No - 2017 Census
			Mobile Access	HH without a mobile phone - Proportion of No - 2017 Census
		Physical Infrastructure	Road Density	Total Road length (km)/ Population - Open Street Map
			Access to water	HH without access to improved water source - Proportion of No- 2017 Census
			Access to sanitation	HH without access to improved sanitation facilities - Proportion of No - 2017 Census
			Improved building materials	HH without improved building materials - Proportion of No - 2017 Census.
		Access to health service infrastructure	Hospital density per 1000 people	Ministry of Lands & Mineral Resources (MLMR)

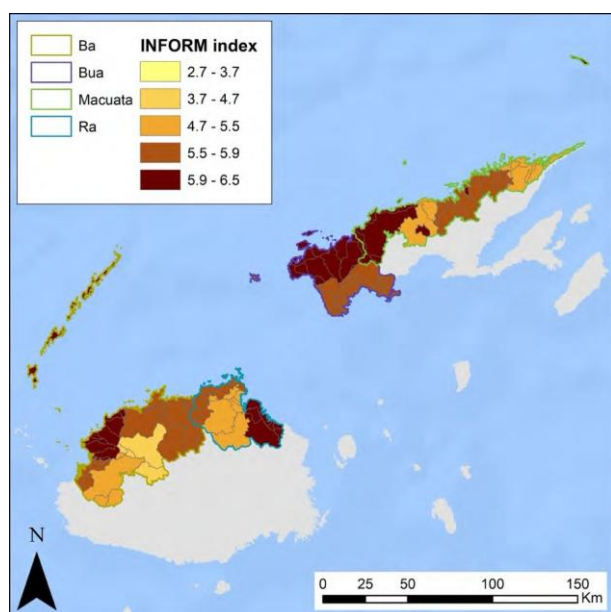


Figure 5-21 Climate vulnerability and disaster risk across intersections basins-tikinas in Fiji.

The local threat indicators were combined into a single index to identify priority project areas where local threats impacting the Great Sea Reef were the highest. The climate vulnerability indicators were also combined into a single index to identify populations with the greatest risk for disaster and climate vulnerability.

To create the composite indices, each indicator was first re-scaled so that all indicators have an identical range of 0-10, with higher values corresponding to higher local threats or higher climate risk. Once normalised, the indicators are “unitless” and can be summed across categories to produce the final composite index. Notably, the disaster risk index was provided at the division (i.e., Tikina) level. Values were the same across watersheds within divisions.

The resulting high-threat and vulnerability areas were selected as key project areas. The local threats in these areas were then assessed in further detail to identify key management interventions that would have the greatest chance to reduce these local threats, thus preserving and increasing the climate adaptation benefits provided by the Great Sea Reef.

5.2. Current climate

Fiji is an archipelago in the South Pacific Ocean with a tropical marine climate characterized by minimal temperature variations between seasons and moderate average yearly temperatures which remain relatively constant throughout the year³²⁵. Fiji has distinct wet and dry seasons, with the wet season occurring from November to April and the dry season from May to October³²⁶. However, Fiji's climate is not uniform across the islands. Several factors influence its variability, including topography, ocean currents, land cover, the El Niño-Southern Oscillation (ENSO), the Indian Ocean Dipole (IOD), and other climate drivers.

The topography of the islands significantly influences Fiji's climate by creating distinct wet and dry zones. The windward (southeastern) sides of the mountains experience higher rainfall due to orographic precipitation, where moist air is forced to rise and cool, leading to condensation and rainfall. Conversely, the leeward (northwestern) sides of the mountains lie in the rain shadow and are therefore drier. This orographic effect results in pronounced variations in rainfall patterns across the islands.³²⁷

Ocean currents play a crucial role in shaping Fiji's climate. The South Pacific Convergence Zone (SPCZ), a band of heavy rainfall caused by converging winds and rising air over warm waters, is the main rainfall-producing system for the

³²⁵ Best Time to Visit Fiji | Climate Guide | Audley Travel US, accessed January 15, 2025, <https://www.audleytravel.com/us/fiji/best-time-to-visit>

³²⁶ climateknowledgeportal.worldbank.org, accessed January 15, 2025, [Fiji - Trends & Variability \(ERA5\) | Climate Change Knowledge Portal](https://climateknowledgeportal.worldbank.org/fiji-trends-variability-eras5-climate-change-knowledge-portal)

³²⁷ Physical Geography - Fiji, accessed January 15, 2025, <http://uclafijidryforest.weebly.com/physical-geography.html>

region³²⁸. The SPCZ is closest to Fiji during the wet season, bringing increased rainfall and thunderstorm activity³²⁹. Changes in Pacific Ocean temperature gradients also influence rainfall patterns and the development of cyclones³³⁰. These gradients drive atmospheric responses that affect weather systems and contribute to Fiji's climate variability.

Land cover, particularly changes in vegetation, can also affect local climate conditions³³¹. Deforestation, for example, can lead to changes in temperature and rainfall patterns. Forests play a vital role in regulating local climate by influencing evapotranspiration, soil moisture, and surface albedo. Changes in land cover can disrupt these processes and contribute to localized climate change.³³²

The El Niño-Southern Oscillation (ENSO) is a major driver of year-to-year climate variability in Fiji. ENSO has a strong influence on the position and strength of the SPCZ, which in turn affects rainfall patterns. During El Niño events, the SPCZ typically shifts north eastward, away from Fiji, resulting in reduced rainfall and potentially drier conditions³³³. Conversely, La Niña events tend to bring wetter conditions as the SPCZ moves closer to Fiji³³⁴.

The Indian Ocean Dipole (IOD) is another climate driver that influences weather patterns in the Asia Pacific region, including Fiji³³⁵. The IOD interacts with ENSO to modulate rainfall and temperature variability. While positive IOD events generally lead to drier conditions in Australia and wetter conditions in East Africa, and negative IOD events have the opposite effect, it's important to note that negative IOD events tend to be weaker and have less severe impacts³³⁶.

Fiji is highly exposed to tropical cyclones, which usually occur during the November-April wet season. These cyclones can cause significant damage to infrastructure and communities, hindering economic growth and posing a risk to human life³³⁷. Understanding the factors that influence cyclone development and intensity is crucial for disaster preparedness and risk reduction in Fiji.

In addition to ENSO and the IOD, other climate drivers contribute to Fiji's climate variability. These include the monsoonal trough, which brings increased rainfall during the wet season, and trade winds, which influence temperature and humidity. These drivers interact with each other to create the complex and dynamic climate system of Fiji.

ENSO influence on Fiji

The ENSO cycle is the dominant driver of year-to-year climate variability, significantly influencing rainfall patterns, temperatures, extreme weather, and marine conditions in Fiji. Current and projected climate change is expected to interact with ENSO, partly amplifying both risks and uncertainties for Fiji.³³⁸

- El Niño events generally bring below-average rainfall and cooler conditions, and correlate with droughts, especially during Fiji's Cool/Dry Season (May–October)³³⁹, but also increased tropical cyclone activity. El Niño also plays a role in the genesis and track of tropical cyclones affecting Fiji, with some cyclones more likely to

³²⁸ Current and future climate of the Fiji Islands - 350, accessed January 15, 2025, https://350pacific.org/files/2014/01/1_PCCSP_Fiji_8pp.pdf

³²⁹ PACCSAP Current and future climate of the Fiji Islands, accessed January 15, 2025, <https://www.pacificclimatechange.net/document/current-and-future-climate-fiji-islands>

³³⁰ Fiji: Ocean temperature record unlocked from coral - Oceanographic Magazine, accessed January 15, 2025, <https://oceanographicmagazine.com/news/ocean-temperature-record-unlocked-from-coral-in-fiji/>

³³¹ Detecting Flooding in Fiji's Croplands - Climate Change AI, accessed January 15, 2025, <https://www.climatechange.ai/blog/2022-09-06-grants-fiji-flood>

³³² Land Use Change and Prediction for Valuating Carbon Sequestration in Viti Levu Island, Fiji, accessed January 15, 2025, <https://www.mdpi.com/2073-445X/11/8/1274>

³³³ Climate Change in the Pacific | Volume 2: Country Reports | Chapter 5: Fiji Islands, accessed January 15, 2025, <https://www.pacificclimatechange.net/document/climate-change-pacific-scientific-assessment-and-new-research-volume-2-country-reports>

³³⁴ FIJI CLIMATE OUTLOOK - Wamis, accessed January 15, 2025, <https://wamis.org/wamis/wp-content/uploads/2023/06/fiji20233.pdf>

³³⁵ Understanding Climate Phenomena in the Asia Pacific: El Niño-Southern Oscillation and the Indian Ocean Dipole - Aon, accessed January 15, 2025, <https://www.aon.com/apac/insights/blog/understanding-climate-phenomena-in-the-asia-pacific>

³³⁶ Why climate change will cause more 'strong' Indian Ocean Dipole events, accessed January 15, 2025, <https://www.carbonbrief.org/guest-post-why-climate-change-will-cause-more-strong-indian-ocean-dipole-events/>

³³⁷ Fiji - Vulnerability | Climate Change Knowledge Portal, accessed January 15, 2025, <https://climateknowledgeportal.worldbank.org/country/fiji/vulnerability>

³³⁸ International Monetary Fund (2025) 'Climate Change and Sea Level Rise: Fiji', *Selected Issues Papers*, 2025(085), Available at: <https://www.elibrary.imf.org/view/journals/018/2025/085/article-A001-en.xml>

³³⁹ Fiji Meteorological Service. (2023) 'Annual Climate Summary 2023'. Available at: https://www.met.gov.fj/media/climate_product_files/2023annualSum2024.12.24_13.44.17_HAbEPnk.pdf

form or strengthen during the positive phase. However, cyclone characteristics also depend on local and seasonal factors.³⁴⁰

- La Niña brings wetter and warmer phases and is typically associated with more rainfall and higher risk of flooding, particularly during the warm and wet Season (November–April).³⁴¹
- During ENSO-neutral phases, rainfall and temperatures are usually close to average but influences due to IOD may be significant.³⁴²

These significant events are a major driver behind severe events that directly affect agriculture, water resources, infrastructure, and health.³⁴³

There have been long-term trends in the ENSO cycle, though many of these trends are not statistically significant. From 1960 to 1980, ENSO anomalies averaged -0.2282 , indicating a tendency toward La Niña-like conditions. This favoured wetter conditions, frequent flooding, and stronger water availability in Fiji. Since 1980, the average ENSO state has shifted closer to neutral, with anomalies of -0.0163 between 1980 and 2000 and -0.0243 between 2000 and 2020. This transition reduced the dominance of La Niña-driven wet conditions and introduced greater variability in rainfall and cyclone exposure.

Although not statistically significant, there is a weak upward trend of 0.0381 per decade in ENSO values from 1960 to 2025, equivalent to 16.7% per decade. This indicates a gradual drift toward El Niño-like conditions. For Fiji, such a trend increases the likelihood of drought episodes, reduced river flows, and heightened cyclone risk linked to eastward shifts in cyclone genesis.

The variability between ENSO phases has also increased, which means Fiji is now more frequently exposed to alternating periods of drought and flooding. The lowest annual ENSO values show a small positive trend, suggesting that extreme La Niña events are becoming less intense, while the highest annual ENSO values show a stronger positive trend, pointing to more intense El Niño episodes. These patterns indicate that drought and cyclone-related risks are intensifying more quickly than flood risks are weakening.

The number of extreme and strong La Niña months has declined, while weak and moderate La Niña months have increased. This shift suggests that Fiji faces fewer catastrophic wet years but more frequent moderate rainfall surpluses, which can still drive damaging floods and soil saturation. At the same time, weak and moderate El Niño months have declined, while strong and extreme El Niño months have increased. This means that El Niño events, when they occur, are increasingly severe. For Fiji, this points to a higher probability of severe drought, reduced agricultural productivity, and elevated cyclone exposure during these strong El Niño years.

Proportion of months in each ENSO phase from 1960-2025

	La Niña (negative) phase					El Niño (positive) phase				
	Extr-eme	Stro-ng	Mod-erate	Weak	Near normal	Near normal	Weak	Mod-erate	Stro-ng	Extr-eme
1960	0%	0%	3%	13%	40%	21%	14%	6%	3%	0%
1970	3%	8%	13%	20%	17%	21%	12%	4%	3%	1%
1980	3%	3%	10%	15%	30%	12%	6%	14%	3%	4%
1990	0%	4%	5%	11%	18%	34%	8%	9%	6%	6%
2000	0%	6%	5%	15%	28%	24%	14%	4%	3%	0%
2010	0%	4%	6%	14%	26%	22%	13%	7%	3%	5%
2020	0%	0%	15%	25%	25%	16%	1%	6%	9%	1%

The net effect is a more variable and less predictable climate in which Fiji faces heightened risks of both severe drought and damaging floods, with stronger El Niño events likely emerging as a critical driver of future climate hazards.

³⁴⁰ Kuleshov, Y., McGowan, H., Jones, D., & Qi, L. (2014). Extreme Weather and Climate Events and Their Impacts on Island Countries in the Western Pacific: Cyclones, Floods and Droughts. *Open Journal of Marine Science*, 4(3), 99-115. doi:10.4236/ojms.2014.43010

³⁴¹ Australian Bureau of Meteorology & CSIRO (2011). *Climate Change in the Pacific: Scientific Assessment and New Research. Volume 2: Country Reports. Chapter 5: Fiji Islands. Pacific Climate Change Science Program*, Australian Government, Canberra. Available at: <https://www.pacificclimatechangescience.org/wp-content/uploads/2013/09/Fiji.pdf>

³⁴² Fiji Meteorological Service. (2023) 'Annual Climate Summary 2023'. Available at: https://www.met.gov.fj/media/climate_product_files/2023annualSum2024.12.24_13.44.17_HABEPnk.pdf

³⁴³ Kapoor, A., Alcayna, T., de Boer, T., Gleason, K., Bhandari, B., & Heinrich, D. (2021) 'Climate Change Impacts on Health and Livelihoods: Fiji Assessment', Red Cross Red Crescent Climate Centre, April 2021. Available at: https://www.climatecentre.org/wp-content/uploads/Climate-change-impacts-on-health-and-livelihoods-FJI-assessment_April-2021_.pdf

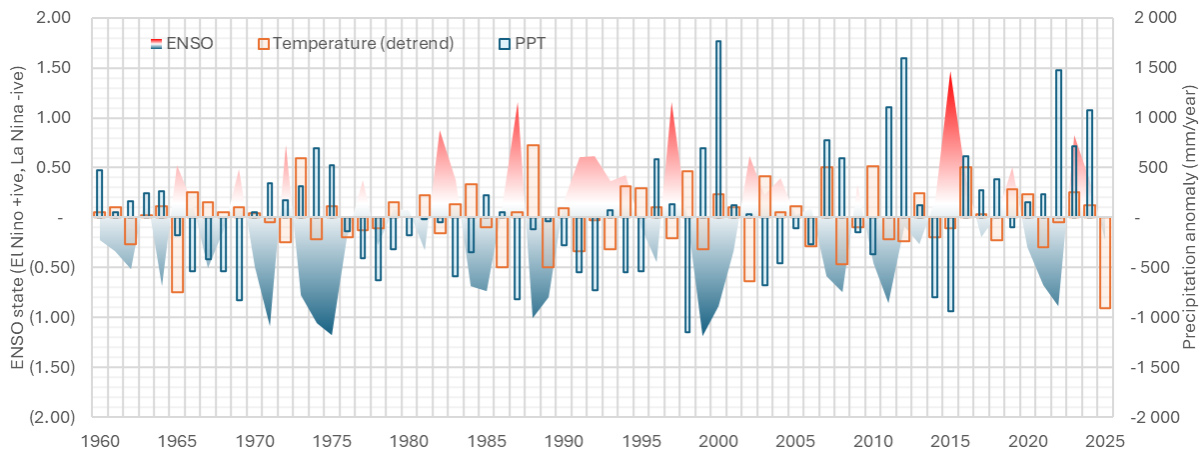


Figure 22. ENSO phase changes relative to rainfall and temperature anomalies. ENSO phase (area graph), Fiji temperature anomaly (orange bars), Fiji rainfall anomaly (blue bars)

The current ENSO cycles have significant impacts on the local ecosystems of Fiji.

- More frequent and intense El Niño events raise sea surface temperatures and increase the risk of coral bleaching. Past bleaching events in Fiji (e.g. 2000, 2016) were closely tied to strong El Niño phases. El Niño-driven droughts reduce freshwater in land flow towards coastal areas, increasing salinity stress on reefs. Conversely, wetter La Niña periods cause high sediment and nutrient runoff, which can smother corals and promote algal blooms. The overall trend of stronger El Niño events suggests bleaching risk will increase, while continuing La Niña variability maintains chronic sedimentation pressures.
- Strong El Niño droughts can reduce freshwater inputs and raise salinity in mangrove estuaries, stressing seedling survival and growth. Additionally, the more intense cyclones associated with El Niño increase physical damage to mangrove stands. During wetter La Niña phases, excessive runoff and sedimentation can alter tidal dynamics and degrade mangrove habitats. Over time, the dual impacts of ENSO variability raise the likelihood of mangrove loss, which reduces coastal protection for communities.
- Droughts associated with El Niño reduce soil moisture, lower river flows, and stress terrestrial vegetation. This increases wildfire risk in drier zones. Conversely, flooding, particularly during La Niña episodes, leads to erosion, land degradation, and biodiversity loss in low-lying inland ecosystems. The trend toward stronger El Niño means inland ecosystems are more likely to face recurrent drought stress, while flood damage remains an intermittent but significant hazard.

Beyond the ecosystems, there are significant impacts on the livelihoods, populations and infrastructure of Fiji.

- Noted droughts during strong El Niño years threaten freshwater supply, reduce groundwater recharge, and lower crop yields. Staple crops like cassava, taro, and sugarcane are particularly vulnerable. Wet La Niña phases cause flooding of farmlands, destroying crops and contaminating water supplies with sediment and pathogens. Increased ENSO variability means households must cope with frequent swings between drought and flood, creating chronic food insecurity.
- El Niño droughts increase heat stress, dehydration risk, and vector-borne diseases as water storage promotes mosquito breeding. While La Niña floods promote outbreaks of waterborne diseases such as leptospirosis and diarrhoea. These greater extremes amplify health system stress.
- Impacts on infrastructure and disaster risk are noted through droughts, reducing hydropower reliability (accounting for 52–60% of supply³⁴⁴) and putting stress on urban water systems. Strong El Niño years heighten cyclone exposure, bringing destructive winds, storm surges, and heavy rain that damage housing, transport networks, and utilities. La Niña floods destroy roads, bridges, and low-lying infrastructure, isolating communities. The observed shift toward more frequent strong El Niño events suggests Fiji's disaster profile is tilting toward cyclone- and drought-related damages, though flood risks from moderate La Niña remain persistent.

Fiji's ecosystems, population, and infrastructure are increasingly exposed to a dual hazard profile: intensified drought and cyclone risks during El Niño years and persistent flood risks during La Niña years. Stronger El Niño phases threaten coral reefs with bleaching, weaken mangroves through salinity stress and cyclone damage, and increase agricultural and water insecurity. At the same time, increased variability means communities and ecosystems have little time to recover between alternating extremes. This elevates disaster risk for infrastructure and human populations, undermines food and water security, and weakens the natural ecosystems that provide vital coastal protection and livelihoods.

³⁴⁴ International Trade Administration. (2024) 'Fiji - Renewable Energy'. Available at: <https://www.trade.gov/country-commercial-guides/fiji-renewable-energy>

Historical ENSO phases and associated impacts^{345 346 347 348}

Years(s)	ENSO Type	Documented Impact in Fiji
1965	Moderate El Niño	Severe drought, reduced rainfall, water shortages, and crop stress.
1972–73	Strong El Niño	Widespread drought, water rationing, stress on sugar production and rural livelihoods.
1982–83	Strong El Niño	Intense dry period, severe agricultural and water supply impacts, and wildfires.
1987	Moderate El Niño	Severe drought, crop failures, water shortages, and economic losses.
1992–93	Moderate El Niño	Drought conditions, reduced rainfall affected the rural economy.
1997–98	Very Strong El Niño	Extreme drought, severe water shortage, widespread food insecurity, and coral bleaching.
2003	Weak El Niño	Drought, stress on agriculture, and water supply challenges.
2015–16	Strong El Niño	Drought, crop losses, wildfires, increased coral bleaching risk, and major water stress.
1974–75	Moderate La Niña	Higher rainfall, flooding, and disruption of rural transport and infrastructure.
1998–99	Strong La Niña	Heavy rains, flooding, landslides, risk of cyclones increased.
2010–11	Strong La Niña	Severely increased rainfall, widespread floods, landslides, and damage to infrastructure.
2020	Moderate La Niña	More rainfall, flooding in multiple provinces, landslides, and agricultural losses.
2023–24	Moderate El Niño	Regional dry spells; in some areas, abnormal rain and flooding, variable impacts across islands.

Climate change influence on ENSO

The influences of current and projected climate changes on the trends of ENSO phases have a significant uncertainty in climate analysis. Observational records since 1900 do not show a clear long-term significant trend in the overall frequency of El Niño or La Niña events. However, analyses suggest an increase in strong El Niño frequency since the late 20th century (e.g. 1982–83, 1997–98, 2015–16), but this remains uncertain due to the relatively short and noisy dataset.

Climate models in CMIP5 and CMIP6 generally project that ENSO variability will continue through the 21st century, but the magnitude of changes varied by model, with some models suggesting stronger SST anomalies in the eastern equatorial Pacific during El Niño events. However, studies^{349 350} project that extreme El Niño events will occur more often, increasing from about once every 20 years historically to once every 10 years by 2100 under high-emission scenarios. Similarly, extreme La Niña events are projected to increase in frequency, often following strong El Niño events due to rapid ocean–atmosphere feedback. However, there is a tendency for increased frequency of El Niño to see increases in extreme events over La Niña, but both phases are likely to become more impactful.

The consensus (IPCC AR6) suggests there is no clear evidence that climate change has altered the mean frequency of ENSO cycles so far. But there is emerging evidence that climate change is likely to increase the frequency and intensity of extreme ENSO events, particularly El Niño. Additionally, there is high confidence that ENSO impacts on rainfall and temperature extremes will be stronger in a warmer world, regardless of whether ENSO itself becomes more frequent.

For Fiji, this will likely result in potentially stronger wet and dry seasons, with extreme rainfall events and droughts becoming more common and intense. The impacts from ENSO phase extremes will be a compounding stress in addition to higher background temperatures, higher sea levels, and shifting rainfall baselines.³⁵¹ ENSO will remain the main driver of Fiji's climate variability, but its impacts may be magnified in key sectors (agriculture, fisheries, water) due to climate change.³⁵²

³⁴⁵ UNDP. (2009) 'Pacific Adaptation to Climate Change: Fiji – Report of In-country Consultations'. Available at: https://www.adaptation-undp.org/sites/default/files/resources/pacc_report_of_in-country_consultations_in_fiji_-_june_2009.pdf

³⁴⁶ Fiji Meteorological Service and Pacific Climate Change Science Program. (2011) 'Current and future climate of the Fiji Islands'. Available at: https://350pacific.org/files/2014/01/1_PCCSP_Fiji_8pp.pdf

³⁴⁷ Australian Bureau of Meteorology & CSIRO (2011). *Climate Change in the Pacific: Scientific Assessment and New Research. Volume 2: Country Reports. Chapter 5: Fiji Islands.* Pacific Climate Change Science Program, Australian Government, Canberra. Available at: <https://www.pacificclimatechangescience.org/wp-content/uploads/2013/09/Fiji.pdf>

³⁴⁸ Fiji Meteorological Service. (2020). *Annual Climate Summary 2020*. Available at: https://www.met.gov.fj/media/climate_product_files/2020annualSum2024.11.29_12.10.21.pdf

³⁴⁹ Cai, W., Borlace, S., Lengaigne, M., Raftery, E. A., Collins, M., Vecchi, G., Timmermann, A., Grothe, P., Guillemin, A., Luo, J., & Wang, G. (2014). Increasing frequency of extreme El Niño events due to greenhouse warming. *Nature Climate Change*, 4(2), 111–116

³⁵⁰ Cai, W., Santos, A., Collins, M., et al. (2021) 'Changing El Niño–Southern Oscillation in a warming climate', *Nature Reviews Earth & Environment*, 2, pp. 628–644. doi:10.1038/s43017-021-00199-z.

³⁵¹ Kapoor, A., Alcayna, T., de Boer, T., Gleason, K., Bhandari, B., & Heinrich, D. (2021) 'Climate Change Impacts on Health and Livelihoods: Fiji Assessment', Red Cross Red Crescent Climate Centre, April 2021. Available at: https://www.climatecentre.org/wp-content/uploads/Climate-change-impacts-on-health-and-livelihoods-FJI-assessment_April-2021_.pdf

³⁵² McGregor, A. & Taylor, M. (2022). *Introduction to the impact of climate change on agriculture in Fiji and the Pacific Islands: Climatically, Environmentally and Economically Smart Farming Practices*. Available at: https://pacificfarmers.com/wp-content/uploads/2022/09/Module-1-Intro-to-the-impact-of-climate-change-on-agric-in-Fiji-and-the-Pacific_250822.pdf

Current changes

The scientific consensus leaves little room for doubt: human-driven climate change is undeniably underway, and its effects are being felt almost everywhere. The primary driver (elevated temperature) is energised by escalating levels of greenhouse gases such as carbon dioxide, methane, and hydrofluorocarbons which are accumulating in the Earth's atmosphere at unprecedented rates. Consequently, the planet's temperature is increasing rapidly (100-1000 times greater than it takes to transition out of an ice age). Added to this, the sea level is increasing rapidly due to the melting of land-based ice sheets and the thermal expansion of the oceans. One critical manifestation of this global shift is the alteration in sea level and circulation patterns.

As discussed below, many variables have seen changes in recent years as climate change and acidification intensified. Some of these changes have long -return times. Intense rainfall events, such as receiving months of rain in a single episode, are now commonplace. These events also overwhelm natural and human structures, triggering record flooding in coastal areas, transporting substantial sediment loads and nutrient-rich materials to coral habitats, and smothering otherwise thriving reefs.

Moreover, the ocean itself is undergoing rapid shifts. Sea surface temperatures, water column dynamics, and chemical composition—all influenced by climate change—are changing, mostly to the negative. The ocean's recovery from these alterations, even after CO₂ reduction, will span millennia. Beyond temperature, the narrative encompasses profound transformations affecting a wide array of oceanic species and ecosystems. Iconic organisms like kelp, reef-building corals, seagrass, and mangroves are experiencing shifts in distribution, underscoring the urgency of understanding and mitigating these changes.

Understanding the recent past is critically important to understanding the future. The analysis starts with a broad analysis of whether climate change is beginning to change key environmental conditions and systems of Fiji. The AR6 reports, which draw on the findings of hundreds of scientists, provide a detailed assessment of the physical science of climate change, its impacts, adaptation and vulnerability, and mitigation strategies. It details the devastating consequences of rising greenhouse gas emissions around the world, including the destruction of homes, loss of livelihoods, and fragmentation of communities. In the context of Fiji, the AR6 report and other climate studies can provide valuable insights into how climate change might impact the country's unique climate and ecosystems. These could include changes in rainfall patterns, sea-level rise, increased frequency and intensity of storms, and shifts in oceanic conditions, all of which could have profound implications for Fiji's communities and economy.

Climate change is a pressing global issue that manifests its effects most intensely at the local as well as global level. Fiji is a prime example. Confronted with a host of challenges such as rapidly rising sea levels, unpredictable weather patterns, and soil erosion, Fiji stands at the front line of the climate change challenge. As an early signatory to the UNFCCC and Paris Agreement (2015), Fiji has proactively addressed these challenges. Here, the primary causes and impacts of climate change in Fiji are explored, highlighting the resilience and adaptability of its populace and sectors in the face of these extraordinary challenges that have already occurred in Fiji and its associated regions.

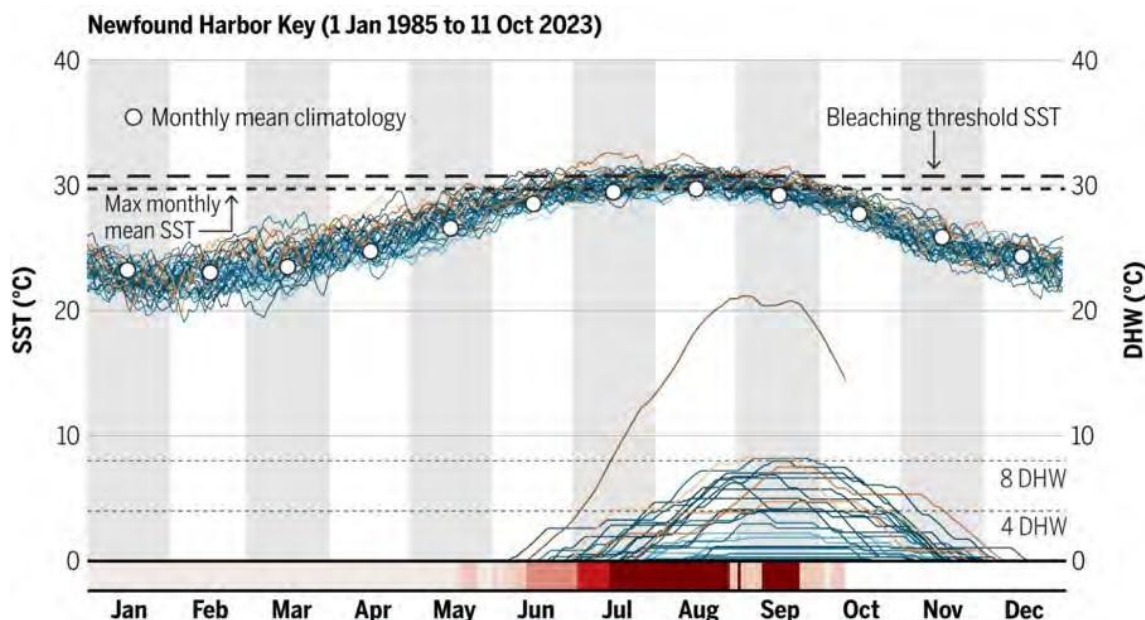


Figure 5-23 Daily Sea surface temperatures in the Caribbean Sea, which is continuing to set records, despite the extraordinary warmth seen in 2023. This Figure was collected from NOAA Satellite data Over the past 40 years. (Figure from Hoegh-Guldberg et al., 2024; Science,330). Similar trends are being seen across the Pacific Ocean.

The team conducted a field study in Fiji, focusing on coastal areas where the risk of living has significantly escalated due to the combined effects of sea-level rise, thermal expansion, and regional sea-level increases. This rise in sea level has led to an increased influx of sediment, causing local farmers to lose up to 50 tons of valuable soil per hectare annually. However, the impact of this phenomenon is not confined to land. It also threatens marine ecosystems, particularly the fragile coral reefs that are crucial for marine biodiversity. The sediment runoff, coupled with agricultural chemicals such as fertilizers and pesticides, poses a serious risk to these delicate underwater habitats.

5.2.1. Precipitation

Like other tropical climates, Fiji has two main precipitation zones. (1) The wet zone includes the southeastern parts of the main islands of Viti Levu, Vanua Levu, Taveuni, and Kadavu. These areas receive high yearly rainfall, with a warm and humid climate. (2) The dry zone includes the north-western parts of Viti Levu and the Yasawa and Mamanuca island groups. These areas receive less rainfall than the wet zone, and the climate is drier and warmer. Fiji experiences a distinct wet season from November to April and a dry season from May to October. The wet season is characterised by intense rainfall and high humidity levels. The average annual rainfall in Fiji ranges from 2,000 to 3,000 mm, with more mountainous areas receiving up to 6,000 mm annually. During the wet season, frequent heavy rain may lead to flooding and landslides in susceptible regions. By contrast, the dry season is generally less humid, with reduced rainfall and typically more pleasant conditions, featuring lower humidity and cooler temperatures. Nevertheless, certain areas, especially the western and northern regions, may encounter drought conditions during the dry season.

Fiji's rainfall patterns have exhibited notable trends and variations over the past decades. From 1980 to 2020, the country's annual precipitation averaged approximately 2380mm. While this period has shown a modest upward trend of 4.52% per decade, the increase is not statistically significant, and annual totals now typically range between 2389mm and 2707mm. Comparing more recent data (2000–2020) to the reference period of 1971–2000, Fiji experienced an average annual increase of about 109 mm.

The spatial distribution of rainfall highlights significant geographic variability. Inland and elevated areas receive the highest volumes, with annual totals exceeding 3000 mm, particularly on the southern side of the northern island. In contrast, the western coastal areas are comparatively drier, recording approximately 1600 mm annually.

Seasonal rainfall patterns indicate that the wettest months occur from January to April, with the largest average monthly increase (+72.76 mm) observed in April. Conversely, the drier season spans June to September, with decreases in rainfall also notable in February, March, August, September, October, and November.

Fiji has seen an increase in the frequency of wet days, rising from an average of 233.3 days annually in 1980 to 2020 with a statistically significant growth of 16.43 days per decade. Wet days now range between 244.51 and 270.02 annually. Rainfall intensity shows a mixed trend. The average annual rainfall intensity was 10.23 mm/day, but this has

seen a slight, statistically insignificant decline of -0.27 mm/day per decade, now ranging between 9.42 mm/day and 10.26 mm/day. Peak single-day rainfall events occur in elevated regions, with extreme daily totals reaching up to 150 mm, and the same regions also experience the highest 5-day rainfall accumulations.

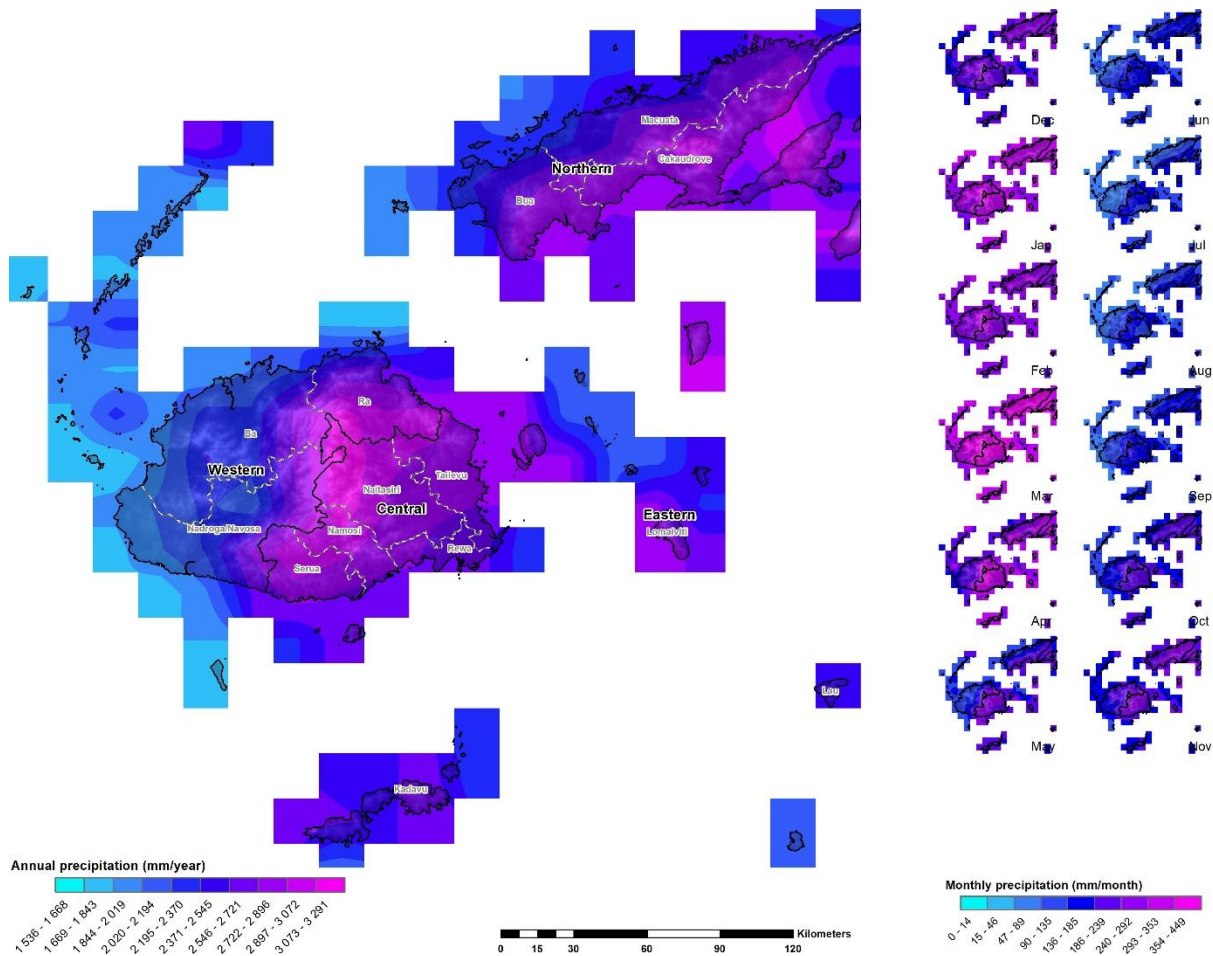


Figure 5-24: Current rainfall volume distribution. Annual (left) and monthly (right)

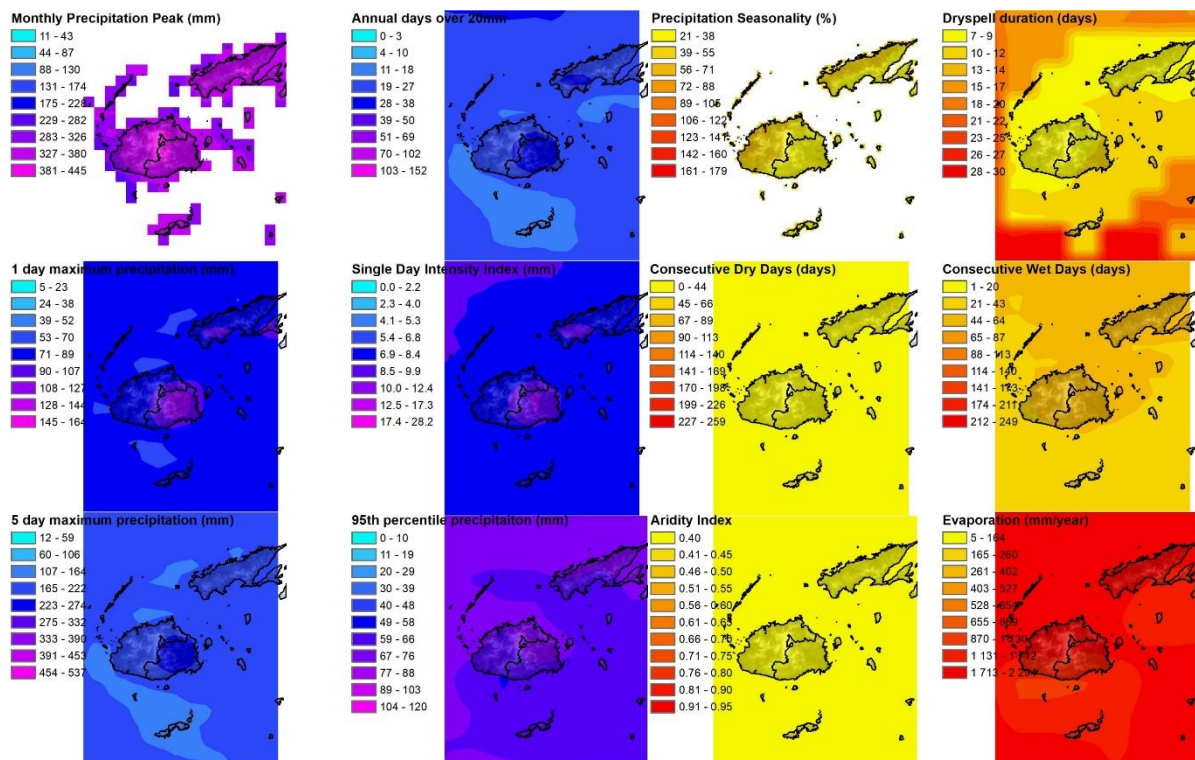


Figure 5-25: Current flooding and extreme rainfall characteristics. Extreme rainfall characteristics (left), Current Drought and drying rainfall characteristics (right)

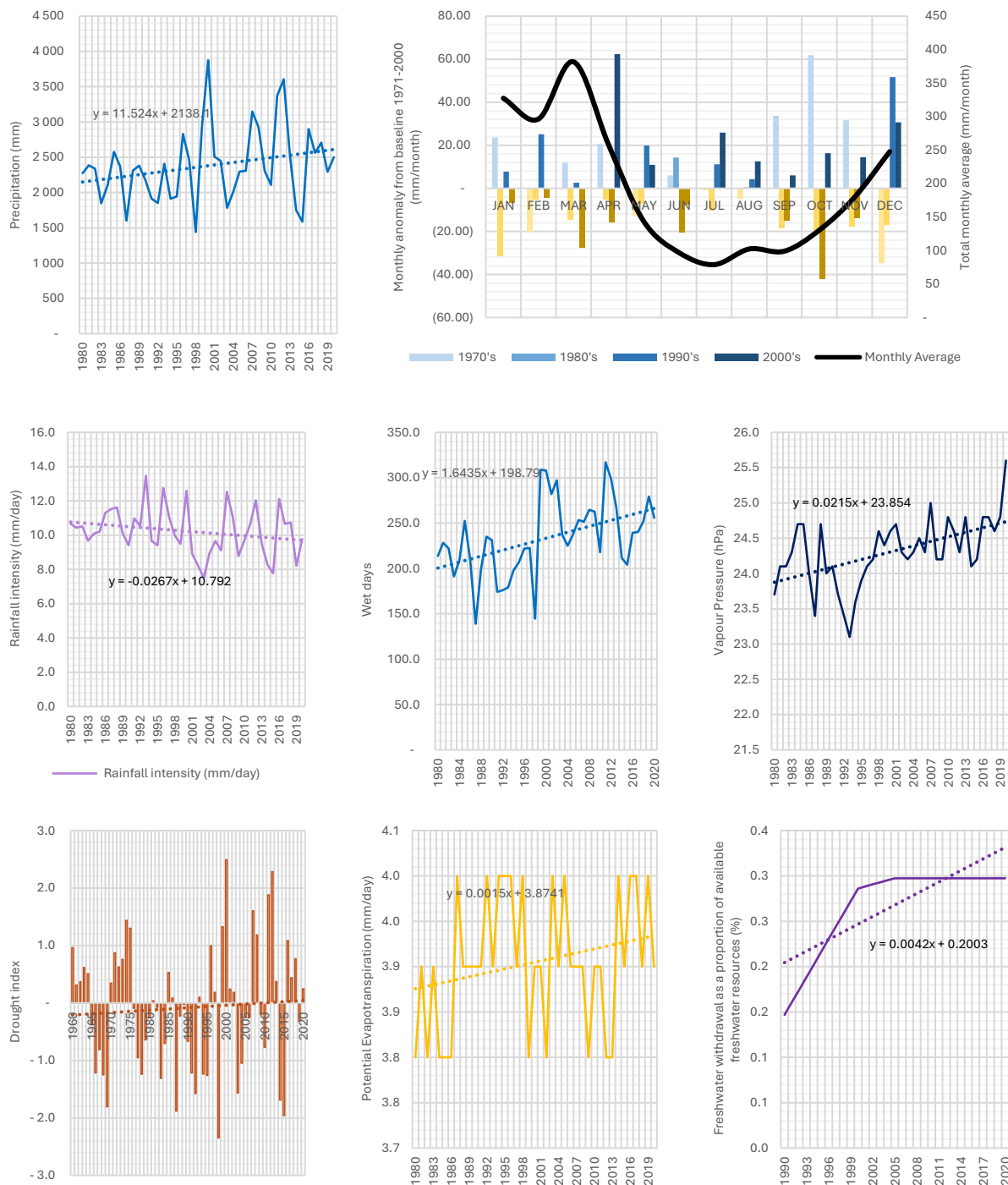


Figure 5-26. Longitudinal change in rainfall parameters from 1980-2020. Annual rainfall (top left), monthly changes (top right), average rainfall intensity (centre left), number of wet days (centre middle), vapour pressure (centre right), drought intensity (bottom left), potential evaporation (bottom middle), and water stress (bottom right)

Table 5-2. Change in rainfall from 1980-2020

	Precipitation (mm)	Wet days	Rainfall intensity (mm/day)	Vapour Pressure (hPa)	SPEI	Potential Evapo transpiration (mm/day)	Water stress
Mean 1980-2020	2 380.12	233.30	10.23	24.30	-0.08	3.90	0.27
95% confidence interval	2389.91 - 2707.58mm	244.51 - 270.02 days	9.42 - 10.26mm/day	24.41 - 24.7hPa	-0.06 - 0.51	3.89 - 3.93mm/day	0.28 - 0.31%
Statistical Trend	Not Significant	Significant	Not Significant	Significant	Not Significant	Not Significant	Significant

Trend (change per decade)	4.52%	16.43 days	-0.27mm/day	0.21hPa	0.04	0.01mm/day	0.04%
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Droughts are a consequence of natural processes in Fiji, with many being partly influenced by the El Nino Southern Oscillation (ENSO).³⁵³ A long-term dataset from various stations across Fiji revealed statistically significant downward trends in rainfall from 1949 to 2008. However, Drought conditions averaged -0.08 from 1980 to 2020. This index has shown a slight, statistically insignificant upward trend of 0.04 per decade, suggesting a reduction in drought severity and frequency over time. Year-on-year rainfall variability is low to moderate, with Fiji experiencing relatively consistent wet and dry day patterns across its regions.

The amplification and intensification of climate change threats is a significant and growing concern, especially for sites such as the dry side of Vita Levu. As the world experiences a steady increase in global temperatures, a rise in the occurrence and intensity of extreme weather events, including but not limited to storms, floods, and droughts. Drought and dryness can severely impact humans, particularly in terms of irrigation and drinking water. Droughts also influence public health outcomes and can affect the availability of drinking water, as well as the success of crops. Drinking or potable water (or groundwater) is a crucial resource for the rural communities in Fiji (around 220,000 people), who depend on creeks and rivers for their water supply (see muddy rivers in Labasa, pages 43 and 59). However, climate change poses several challenges to the availability and quality of drinking water. Rising sea levels, increased rainfall, and more frequent and intense cyclones can cause saltwater intrusion of aquifers, flooding, erosion, and contamination of freshwater/potable sources (see WISH project)³⁵⁴ On the other hand, drought reduces the water flow and increases the concentration of pollutants in the remaining water.³⁵⁵ These impacts can affect the health, livelihoods, water availability, and food security of the rural population, especially vulnerable groups such as women, children, and the elderly. To address these challenges, efforts are being made to improve water quality monitoring capacities, use portable water testing laboratories and kits, and implement nature-based and infrastructure-based solutions to protect and restore freshwater ecosystems.

The country's potential evapotranspiration averaged 3.9 mm/day during the 1980–2020 period, with no significant changes noted. However, annual evaporation totals of up to 2000 mm annually point to a high level of atmospheric moisture exchange. The warming trends observed over the same period have contributed to an increase in water vapour in the atmosphere, with specific humidity levels between 24.4 and 24.7 hPa (2000–2020), rising at a statistically significant rate of 0.21 hPa per decade. This increased moisture may also be contributing to a rise in severe storm events. Additionally, Fiji has seen a statistically significant rise in water stress levels. Freshwater withdrawal as a proportion of available resources increased from 0.28% to 0.31% between 1990 and 2020, with a 0.04% increase per decade. Despite this, Fiji remains relatively low in overall aridity due to its abundant rainfall and moderate seasonality.

Fiji is vulnerable to extreme weather events, including cyclones, floods, droughts, erosion, and landslides. These events are increasingly being attributed to human-driven climate change. In 2012, Fiji experienced severe flooding that caused widespread damage to infrastructure and agriculture. The flooding was caused by heavy rainfall and storm surges, which affected many low-lying areas³⁵⁶. Vunidogoloa, located on the shores of Vanua Levu, has the unfortunate distinction of being one of the first communities in the world to be relocated as part of a government-planned relocation due to climate change. The village is reportedly a 'ghost town', as former residents have been moved to a new village 2 km away (at a higher elevation). Vunidogoloa is one of six Fijian villages that have already been moved because of the impacts of climate change, and dozens more have been identified for future relocations despite the deep cultural ties of villages to their lands.

Due to the unique geography of the islands as well as the interconnected nature of extreme events, most areas are vulnerable to multiple threats. For example, local communities in the region noted the "squeeze" from storm surges near the coast and flooding from higher in the watershed, effectively impacting villages from both directions and causing significant damage to infrastructure, food, and livelihoods. Additionally, many villages recounted the lasting impacts of such events, with some reporting a lack of full recovery nearly eight years following Cyclone Winston.

³⁵³ Ministry of Health Fiji (2021) Drought and Health. Available at: <https://www.health.gov.fj/fact-sheet-drought-and-health/>.

³⁵⁴ Watershed interventions for system health. <https://wishfiji.sydney.edu.au/>

³⁵⁵ FAO. (2020). Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report. https://www.parliament.gov.fj/wp-content/uploads/2021/08/VOLUME-I_DESCRIPTIVE-ANALYSIS-AND-GENERAL-TABLE-REPORT.pdf

³⁵⁶ IPCC, 2021. Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Available at: <https://www.ipcc.ch/report/ar6/wg1/chapter/summary-for-policymakers/>.

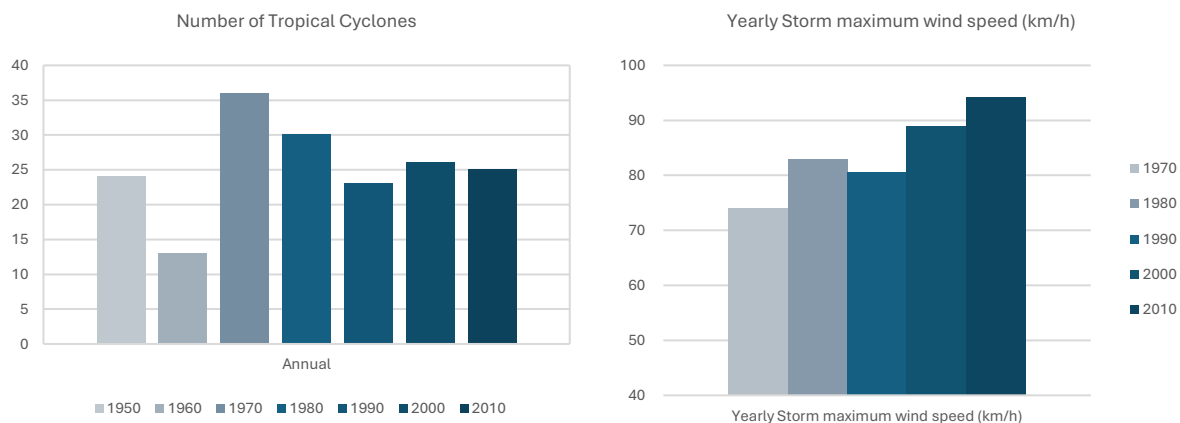
According to the Fiji Climate Vulnerability Assessment (Fiji CVA 2022) created by the World Bank, climate change is projected to grow with its impacts on Fiji's ecosystems, economy, livelihoods, poverty levels, health, food security, and key industries such as agriculture and tourism. This report also highlights the potential impacts of sea level rise on coastal areas and low-lying islands. The assessment projects a cost of \$4.5 billion to reduce Fiji's vulnerability to climate change. The report also identified the need for an investment of \$USD 9.3 billion by 2027 (nearly 100% of GDP) to strengthen Fiji's resilience to climate change.^{357 358}

Tropical cyclones usually affect Fiji between November and April, and occasionally in October. In the 42 years between the 1969 and 2010 seasons, 117 tropical cyclones developed within or passed through Fiji's Exclusive Economic Zone, an average of 28 per decade. The number of tropical cyclones varies widely yearly, with none in some seasons but up to six in others.

On average, two cyclones affect Fiji every season³⁵⁹. Tropical cyclones impacting the Fiji Islands increased during an El Niño phase and decreased during a La Niña phase³⁶⁰. The peak cyclone activity typically occurs from January to February, although they can form anytime during the November to April season³⁶¹. Historical data reveals the devastating impacts of cyclones on Fiji, with notable examples including Cyclones Bebe in 1972 and Kina in 1993. Cyclone Winston in 2016, one of the most powerful cyclones on record, caused significant damage and losses, affecting over half of Fiji's population and resulting in economic losses of approximately USD 1.4 billion³⁶².

The impact of cyclones varies depending on their category, which is determined by wind speed. Category 1 cyclones have sustained winds of 33-42 knots, while Category 5 cyclones have sustained winds of 137 knots or greater³⁶³. Higher-category cyclones generally cause more damage due to stronger winds, heavier rainfall, and increased storm surge (WMO, 2023). However, even lower-category cyclones can cause significant damage and life-threatening weather, particularly in vulnerable areas³⁶⁴.

The occurrence of tropical cyclones indicates that they are more prevalent on the norther side of the islands. Category 1 and tropical depressions are the most comment from 1975 to the present. However, there has been a noted decrease over time in the depressions within 200km. There has also been a recent increase in the number of severe category 5 events with the only 2 since before 1975 occurring since 2010. There has also been an increase in the annual storm maximum windspeeds since 1970 to the recent years with speeds increasing from ~74km/h to above 90km/h.



³⁵⁷ ABC News, 2023. In Fiji, the climate crisis is no longer off in the future – it's a daily reality. Available at: <https://www.abc.net.au/news/2023-04-06/fiji-climate-change-moving-villages-vunidogoloa/102186670>.

³⁵⁸ UN OCHA, 2023. Fiji Disaster Management Reference Handbook. Available at: <https://reliefweb.int/report/fiji/fiji-disaster-management-reference-handbook-march-2023>

³⁵⁹ Tropical Cyclone Outlook - Fiji Meteorological Service, accessed January 20, 2025, <https://www.met.gov.fj/index.php?page=tcoutlook>

³⁶⁰ Tropical Cyclone Activity in the Fiji Region: Spatial Patterns and ..., accessed January 20, 2025, <https://journals.ametsoc.org/view/journals/clim/22/14/2009jcli2880.1.xml>

³⁶¹ Tropical Cyclone Outlook - Fiji Meteorological Service, accessed January 20, 2025, <https://www.met.gov.fj/index.php?page=tcoutlook>

³⁶² Weathering Financial Shocks from Disasters in the Pacific Islands - GFDRR, accessed January 20, 2025, <https://www.gfdr.org/en/feature-story/weathering-financial-shocks-disasters-pacific-islands>

³⁶³ Tropical Cyclone Outlook - Fiji Meteorological Service, accessed January 20, 2025

³⁶⁴ Tropical Cyclone Outlook - Fiji Meteorological Service, accessed January 20, 2025

Figure 5-27. Change in tropical cyclone character within 200km of Fiji over time. Occurrence of tropical cyclones (top left), Maximum wind speed (top right), and change in tropical cyclone category occurrence

Tropical cyclone annual occurrence from 1980 to 2023

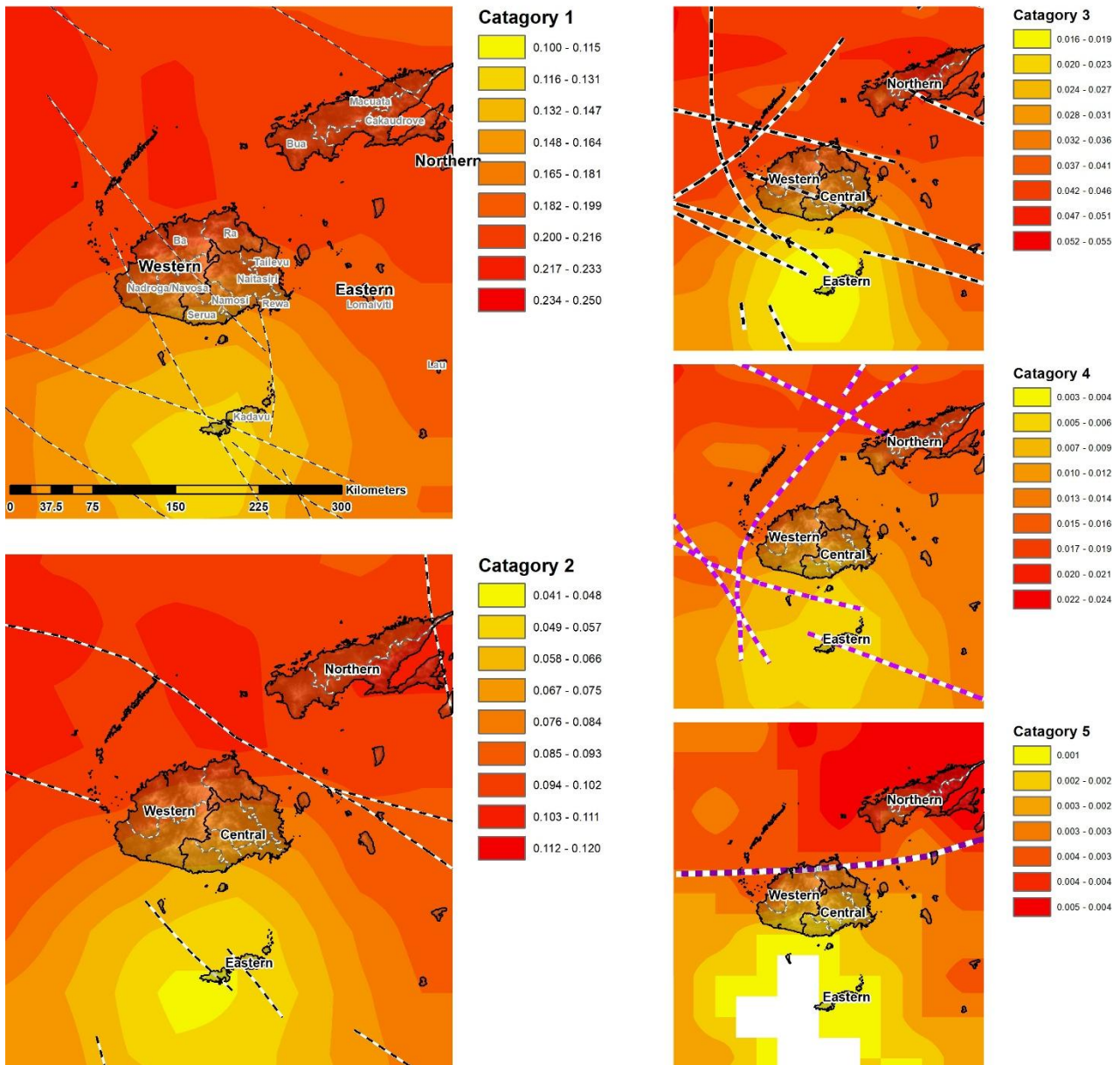


Figure 5-28: Current annual tropical cyclone occurrence per category. Category 1 and 2 (left), categories 3, 4, and 5 (right)

Cyclones are less frequent during the El Niño phase of the El Niño Southern Oscillation (ENSO)³⁶⁵ in some parts of the western Pacific. In recent years, Fiji has experienced several severe cyclones, including Cyclone Winston in 2016, one of the largest cyclones ever recorded in the Southern Hemisphere. Cyclone Winston caused significant damage to infrastructure and agriculture, resulting in 44 deaths and widespread power outages³⁶⁶. Others include Cyclone Harold (April 2020), and Cyclone Cody (January 2022). In the past, Fiji has been hit by several Category 4 or 5 cyclones, including Cyclone Yasa, which hit Fiji on December 17, 2020, with wind speeds reaching up to 177 mph (or 285 kph). Some of the most notable cyclones to have hit Fiji include Cyclone Bebe (in 1972), which caused widespread damage and resulted in the death of nine people, and Cyclone Evan in 2012, which caused extensive damage to Fiji's infrastructure and resulted in the death of two people, and Cyclone Winston in 2016, which rendered tens of thousands of people homeless and prompted an international humanitarian response. Cyclones damage infrastructure

³⁶⁵Wang, C. et . 2016.El Niño and Southern Oscillation (ENSO): A Review.

³⁶⁶ Wang, C. et . 2016.El Niño and Southern Oscillation (ENSO): A Review

and have lasting effects on food supply, resulting in the reduced availability of fish due to mangrove and coral loss, as well as significant agricultural damage and productivity declines following these extraordinary cyclone events.

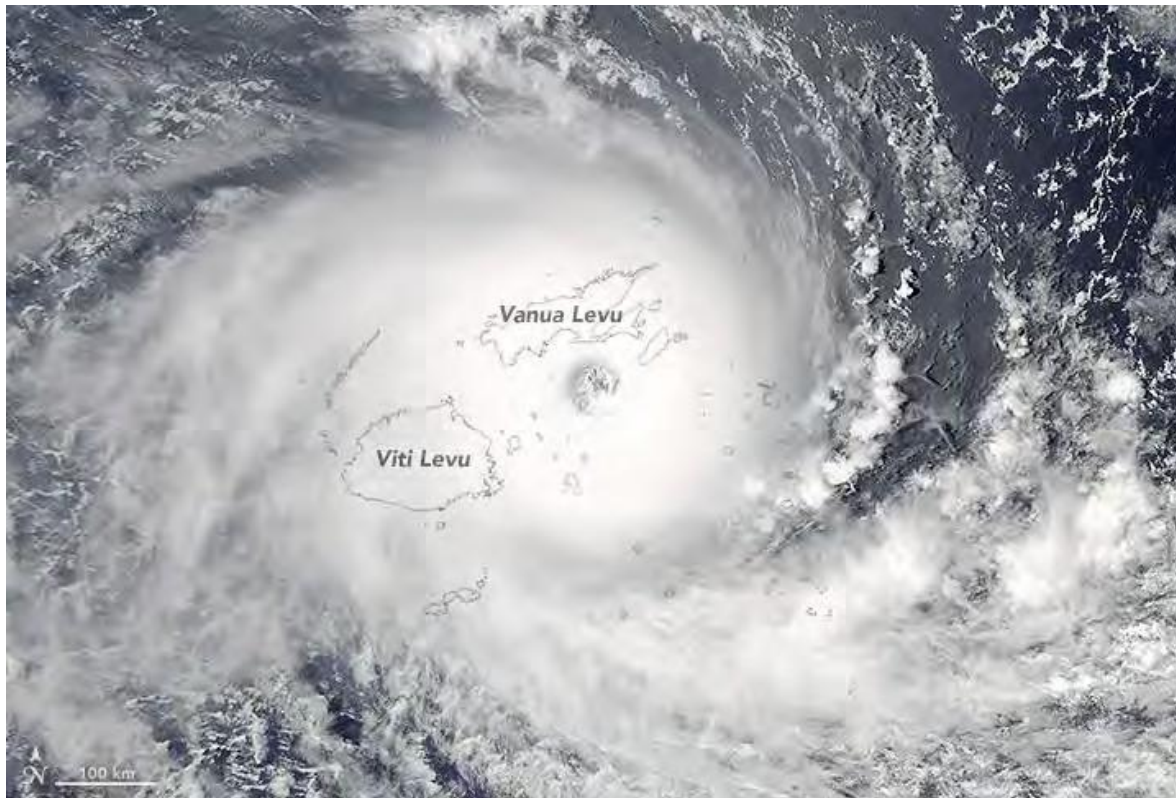


Figure 5-29 The most powerful cyclone (Cyclone Winston) in the southern hemisphere as viewed from a satellite in 2016.

The disruption caused by tropical cyclones can be huge. More than 10,000 people had to shelter in emergency evacuation centres due to torrential rain and strong winds causing severe flooding and widespread damage to buildings, crops, and public infrastructure because of cyclones Yasa (December 2020) and Ana (January 2021). Cyclone Yasa passed north-south over Macuata (near Bua) while Cyclone Ana passed along the east coast of Viti Levu. These extreme weather events highlight the increasing frequency of storms due to the warming of tropical oceans, posing significant challenges to Fiji's infrastructure and economy. They also underscore the urgent need for effective climate change mitigation and adaptation strategies. The frequency of extreme storms and flooding is projected to rise substantially due to the warming of tropical oceans. Path of Tropical Cyclone Winston (Feb 2016) travelled on the lower edge of the channel between the two main Fiji Islands in February 2016 and had a huge impact on people (44 deaths), infrastructure from cyclonic wave action and ecosystems (e.g. seagrass; McKenzie and Yoshida 2020³⁶⁷; showing category and area of wind strength. Long-term seagrass monitoring locations: CW = Cawaci, Ovalau; DN = Denarau; ND = Natadola; NN = Cuvu Harbour, Nadroga Navosa; SV = Nasese, Laucala Bay (Suva); TQ = Tagaqe, Coral Coast. Data on cyclone path, category and wind strength data from cycle Winston courtesy Fiji Meteorological Service and was related damage from sites cyclone conditions).

³⁶⁷ McKenzie, L.J. and Yoshida, R.L. (2020). Over a decade monitoring Fiji's seagrass condition demonstrates resilience to anthropogenic pressures and extreme climate events. Available at: <https://www.sciencedirect.com/science/article/pii/S0025326X20307542?via%3Dihub>.

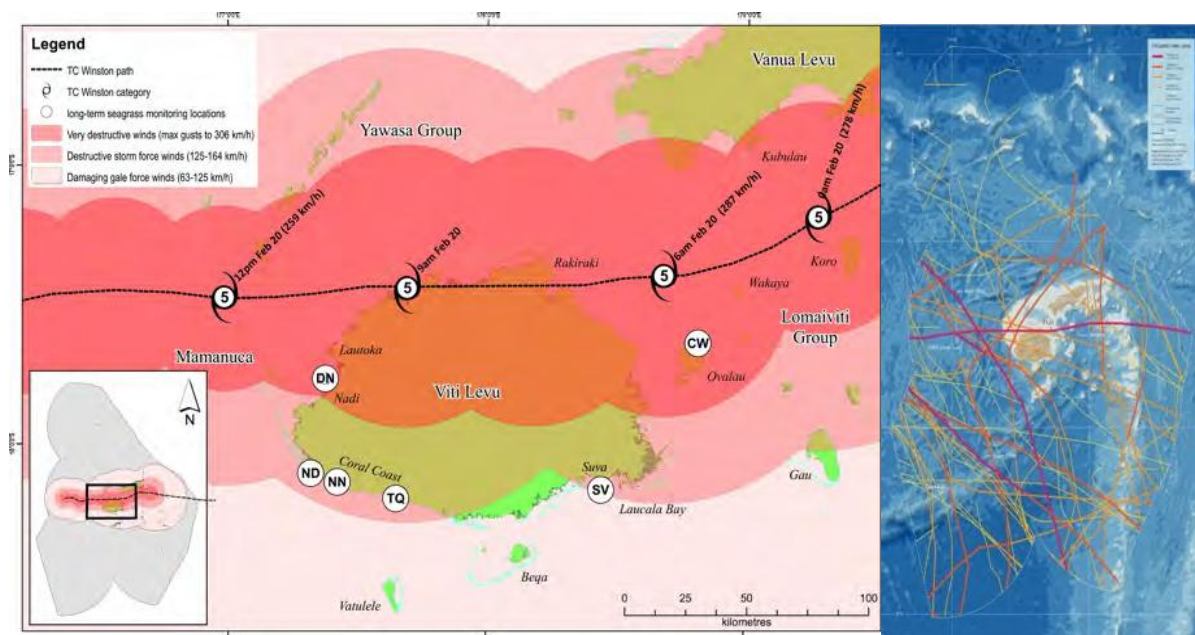


Figure 5-30 Path of Tropical cyclone Winston across the Fijian islands in February 2016 (left) and Pathways of recorded cyclones in Fiji, Western Pacific (right)

5.2.2. Temperature

Fiji has experienced significant warming trends in recent decades, with all key temperature indicators showing clear upward trajectories. Between 1980 and 2020, the national minimum temperature averaged approximately 21.29°C, increasing at a statistically significant rate of 0.19°C per decade. Similarly, the national mean temperature averaged 25.09°C, rising by 0.14°C per decade, while the maximum temperature, which averaged 28.91°C, increased at a slightly slower pace of 0.10°C per decade.

Geographically, the highest average maximum temperatures are observed along the western coastal areas, where values hover around 29°C. The northern areas of the northern island also experience elevated maximum temperatures, averaging approximately 28°C. In contrast, cooler conditions prevail in the higher-elevation regions of Fiji's main island and the eastern island.

The diurnal temperature range (DTR), which averaged 7.63°C during the 1980–2020 period, has shown a statistically significant decreasing trend of -0.09°C per decade. This narrowing of the temperature range is primarily due to nighttime temperatures increasing at a faster rate than daytime temperatures, reflecting a common characteristic of climate warming. The DTR now typically varies between 7.38°C and 7.57°C.

Extreme temperatures in Fiji exhibit a similar spatial pattern to average maximum temperatures. The peak monthly temperatures reach between 28°C and 33°C. This region records below 10 days annually where temperatures exceed 35°C and have seen single-day temperature extremes surpassing 31°C. Warm spell durations last up to 12 consecutive days.

Seasonal temperature variations are evident, with the warmer months spanning late November to early May, during which average high temperatures range from 31°C to 32°C. Cooler conditions are typical from June to October, with temperatures moderating to between 24°C and 27°C. These seasonal cycles are shaped by Fiji's tropical maritime climate and are influenced by both latitude and local geography.

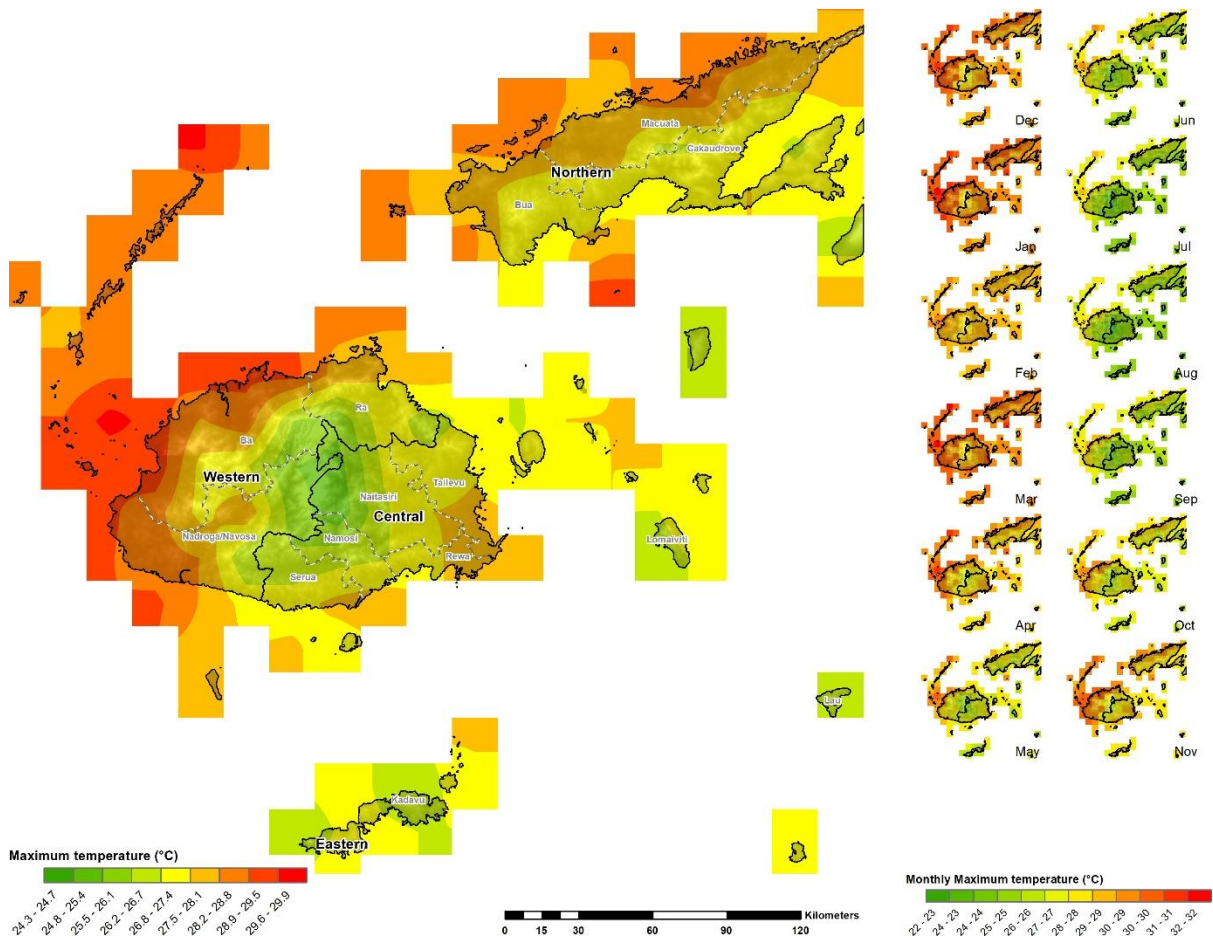


Figure 5-31: Current temperature distribution. Annual (left) and monthly (right)

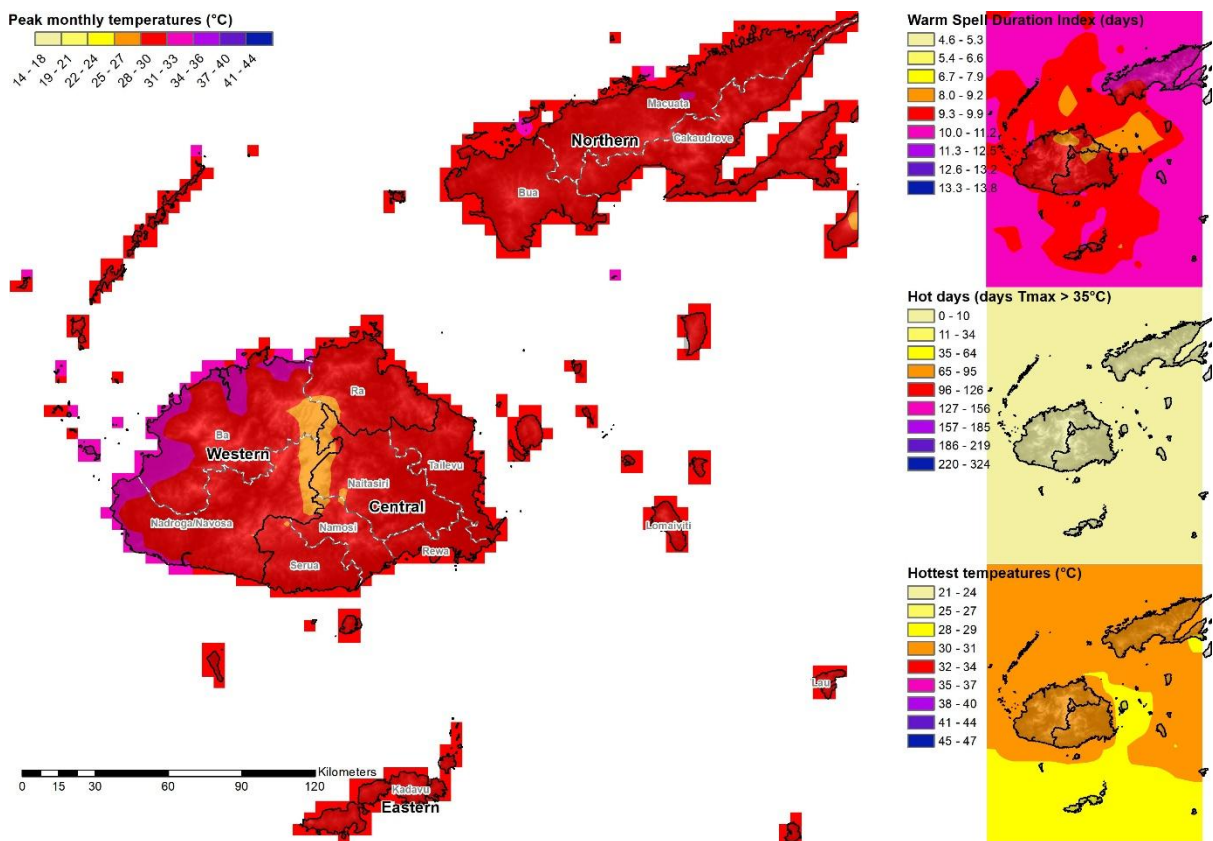


Figure 5-32: Current heatwave and extreme temperature characteristics. Peak monthly temperatures (left), extreme temperature characteristics (right)

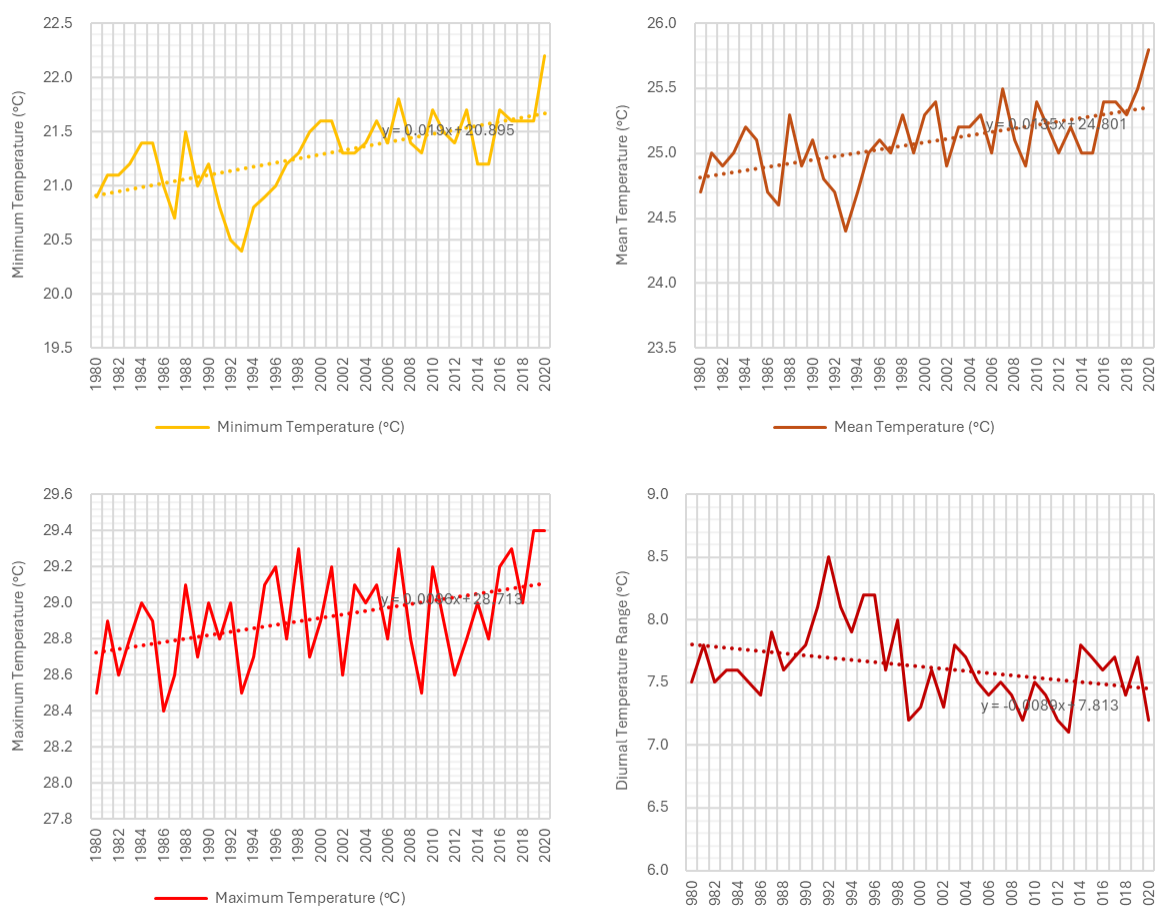


Figure 5-33. Longitudinal change in temperatures from 1980-2020. Minimum (top left), Mean (top right), Maximum (bottom left) temperatures, and changes in diurnal temperature (bottom right)

Table 5-3. Change in temperatures from 1980-2020

	Minimum Temperature (°C)	Mean Temperature (°C)	Maximum Temperature (°C)	Diurnal Temperature Range (°C)
Mean 1980-2020	21.29	25.09	28.91	7.63
95% confidence interval	21.42 - 21.64°C	25.15 - 25.32°C	28.91 - 29.08°C	7.38 - 7.57 days
Statistical Trend	Significant	Significant	Significant	Significant
Trend (change per decade)	0.19°C	0.14°C	0.1°C	-0.09°C

5.2.3. Ocean characteristics

Fiji, as a small island developing state, is highly susceptible to the impacts of rising sea surface temperatures, mean sea level rise, and storm surges³⁶⁸. These changes have significant implications for the island nation's environment, economy, and society. Recent research indicates that sea surface temperatures in Fiji are at their highest point in over 600 years, with 2022 being the warmest year since 1370³⁶⁹. This warming trend, largely attributed to anthropogenic activities, has far-reaching consequences, notably its influence on the El Niño-Southern Oscillation, a key driver of global climate variability. Mean sea level rise is another critical concern, with satellite data indicating an increase of about 6 mm per year since 1993, a rate that surpasses the global average and highlights Fiji's vulnerability to this phenomenon³⁷⁰. This rise is primarily driven by the thermal expansion of ocean water and the melting of glaciers and ice sheets. From 1993 to the present, sea level has risen by 29 cm³⁷¹. Projections indicate a potential sea level rise of 0.5-1.2 meters by 2100, with more pessimistic scenarios suggesting even higher levels³⁷². Furthermore, official reports

³⁶⁸ Small Islands - Intergovernmental Panel on Climate Change (IPCC), accessed January 20, 2025, https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap29_FINAL.pdf

³⁶⁹ Sea surface temperature record in the southwestern Pacific: Coral colony from Fiji reveals warmest temperatures in over 600 years, accessed January 20, 2025, <https://www.sciencedaily.com/releases/2024/09/240918135751.htm>

³⁷⁰ Current and future climate of the Fiji Islands - 350, accessed January 20, 2025, https://350pacific.org/files/2014/01/1_PCCSP_Fiji_8pp.pdf

³⁷¹ Sea Level Summary for Suva, Fiji, accessed January 20, 2025, https://sealevel.nasa.gov/internal_resources/535/Suva_Fiji_combined.pdf

³⁷² Sea Level Rise Projection Map - Fiji | Earth.Org, accessed January 20, 2025, https://earth.org/data_visualization/sea-level-rise-by-2100-fiji/

from the Fiji government indicate that sea level rise around the country, measured by satellite altimeters from 1992 to 2023, was between 4-5mm/yr³⁷³. A sea level monitoring station at the Lautoka Wharf recorded a relative sea level trend of 4.3mm/year between 1993 to 2023³⁷⁴. Storm surges, exacerbated by rising sea levels and potentially increasing cyclone intensity, also pose a significant threat to Fiji. While the frequency of tropical cyclones affecting Fiji may decrease in the future, their intensity, and consequently the risk of storm surges, may increase³⁷⁵. In Vunidogola village on the island of Vanua Levu, over 160 villagers have already relocated 2km inland to avoid constant exposure to storm surges, highlighting the potential for increased internal displacement and community relocation due to the combined effects of sea level rise and storm surges. These changes have led to coastal erosion, flooding, and damage to infrastructure, with some communities already experiencing displacement and loss of livelihoods³⁷⁶. The long-term impacts of these climate-related changes are far-reaching, with potential consequences for freshwater resources, marine ecosystems, and the overall socio-economic well-being of Fiji.

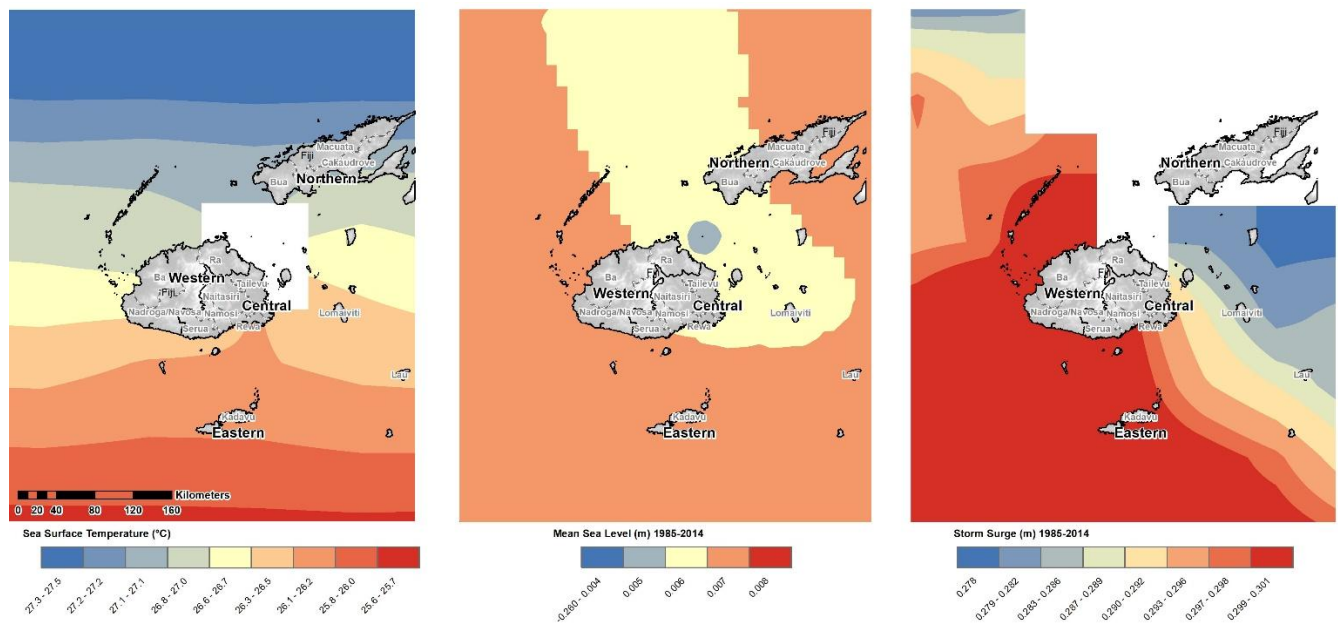


Figure 5-34: Current Ocean characteristics. Sea surface temperatures (left), mean sea level (centre), and average storm surge (right)

Mean Annual Sea Surface temperatures go back to 1901, with the trend accelerating in recent decades. The warmest sea temperatures (1983-2023) increased at a slower rate ($\sim 1^{\circ}\text{C}$) compared to that of the coolest annual temperature records (1.2°C), confirming other studies where winter is warming at a faster rate than summer. Temperature is a strong driver of change and is critical for life. The complexity and structure of reefs provided by warm-water reef-building corals help explain the large number of species (biodiversity) associated with this coral reef.

³⁷³ Fiji Meteorological Service. 2023 Annual Climate Summary.

https://www.met.gov.fj/media/climate_product_files/2023annualSum2024.12.24_13.44.17_HAbEPnk.pdf

³⁷⁴ Sea level rise real - The Fiji Times, accessed January 20, 2025, <https://www.fijitimes.com.fj/sea-level-rise-real/>

³⁷⁵ CLIMATE RISK COUNTRY PROFILE, accessed January 20, 2025, https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/15854-WB_Fiji%20Country%20Profile-WEB.pdf

³⁷⁶ The Grim Reality of Loss and Damage in Fiji - ReliefWeb, accessed January 20, 2025, <https://reliefweb.int/report/fiji/grim-reality-loss-and-damage-fiji>

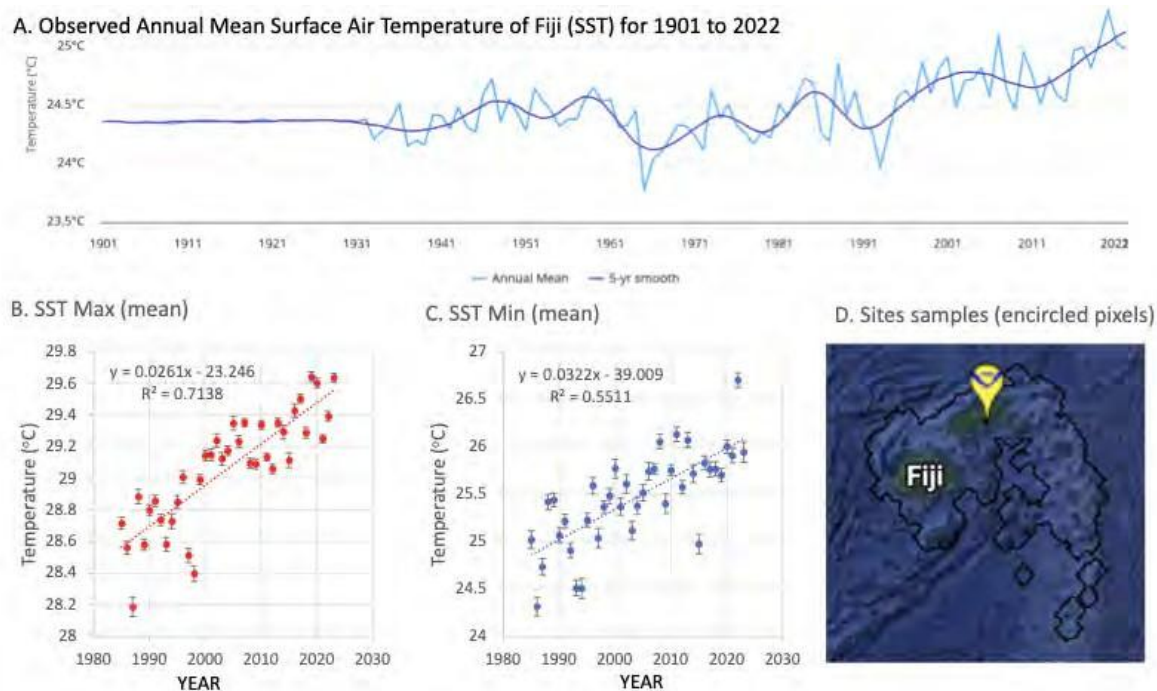


Figure 5-35. Observed Mean Annual Surface Air Temperature over 120 years, B. Sea Surface Temperature (SST, annual max) and C. Sea Surface Temperature (SST, annual min) for D. is a map of the virtual climate station maintained by NOAA Coral Reef Watch (from 1985). Data sources: Figure A. NOAA uses the Extended Reconstructed Sea Surface Temperature (ERSST v5) analysis for its Sea Surface Temperature (SST) products dating back to 1901³³¹; B. NOAA uses the CoralTemp data product for its Sea Surface Temperature (SST) Coral Reef Watch products dating back to 1985 to present³³². These satellite data products are derived from two related reanalysis SST products and a near real-time SST product. The CoralTemp SST data product is one of the most internally consistent daily global 5km SST products available.

Fiji's ocean temperatures have shown a clear and concerning trend of warming over recent decades. From 1980 to 2020, the observed average sea surface temperature was approximately 27.58°C. However, this period also exhibited a statistically significant warming trend of 0.36°C per decade, underlining the impact of global climate change on the region's marine environment.

In recent years, the average annual sea surface temperature has risen to 28.61°C, reflecting this long-term warming trend. When examining monthly averages, the data reveals that the lowest and highest monthly temperatures have also increased over time. During the 1980-1990 period, the lowest average monthly temperature was 24.83°C, and the maximum was 29.19°C. By 2010-2020, these values had risen to 25.19°C and 29.85°C, respectively.

This upward trend in sea surface temperatures has significant implications for Fiji, particularly for its marine ecosystems, weather patterns, and coastal communities. Warmer seas contribute to coral bleaching, which threatens vital reef systems, while also increasing the intensity of extreme weather events such as cyclones.

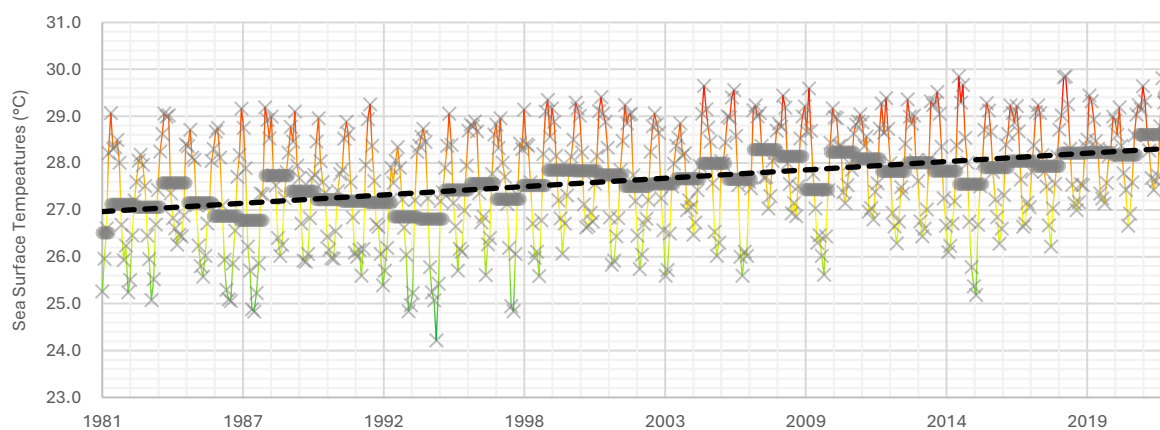


Figure 5-36. Longitudinal historical change in Sea surface temperatures. West of Fiji (Longitude: 176.1E, Latitude: 17.1S)

According to the National Oceanographic and Atmospheric Administration (NOAA, Washington DC) in 2022³⁷⁷, the global average sea level was over 101.2 mm/per year above 1993 levels, making it the highest annual average increase in the satellite record (1993-present). This is mainly due to the melting of land-based ice sheets and glaciers and the thermal expansion of seawater as it warms. Global sea level rise is also accelerating it has more than doubled from 1.4 mm/per year throughout most of the twentieth century to 3.6 millimetres per year from 2006–2015 and is about 4.6 mm/per year for Fiji. Sea level rise is a global problem that has consequences, including increased intensity of storm surges, flooding, and damage to coastal areas. The rate of local sea level rise can be greater than the global average due to land processes like erosion, local oceanography, oil and groundwater pumping, and subsidence³⁷⁸.

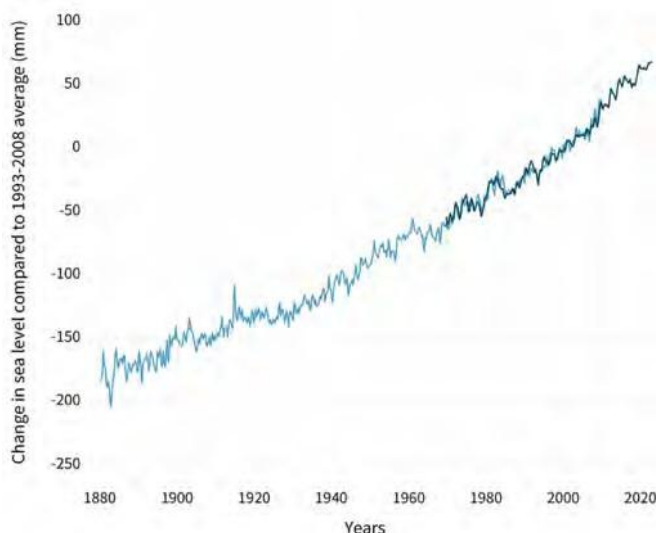


Figure 5-37 Change in sea level over more than a century. Seasonal (3-month) sea level measurements University of Hawaii data (dark blue). The values are shown as changes in sea level in mm/yr compared to the 1993-2008 average. The satellite referred to in the context of sea level measurements is most likely the TOPEX/Poseidon satellite, which was later succeeded by the Jason series of satellites (USA/French).

In many cases, this is where large population centres are located, in addition to fragile habitats, ecosystems and resources³⁷⁹. Sea level increases due to three factors: (1) Expansion of the ocean due to its expansion due to warming, (2) melting of glaciers that are currently above the waterline, and (3) local scale variability due to oceanographic and other factors³⁸⁰. According to a study by the University of the South Pacific, the rate of sea level rise for the Great Sea Reef (Cakaulevu Reef) is about 4.6 mm/per year, which is higher than the global average of 3.3 mm/per year³⁸¹, due to local factors influencing sea level. Rising sea levels are already affecting many villages in Fiji, with predictions that as many as 600 communities may have to be relocated in the coming years.³⁸²

The impacts of even small amounts of sea level rise are transforming in terms of low-lying ecological systems and delta systems that are typical of Fiji. They are not only transformative in terms of what can live there but also in terms of exacting a massive impact on food production. With almost no exception, food production will have to be transferred up the mountain slopes (i.e., R2R) which will put pressure on other ecosystems and subsequently create a domino effect of change. Representative examples from 0.5 to 2m are shown from the coastlines of the four priority provinces here although this needs to be carefully examined in terms of its implications and impacts.

From 1980 to 2020, Fiji experienced a steady increase in sea levels, with an observed rise of approximately 0.025 meters per decade. On average, this amounted to a sea-level increase of 0.016 meters over the entire historical period. The highest annual average sea level recorded during this time was 0.07 meters, underscoring a relatively modest but consistent upward trend.

³⁷⁷ NOAA Coral Reef Watch. (2025). Daily Global 5km Satellite Sea Surface Temperature (a.k.a. CoralTemp). Retrieved from https://coralreefwatch.noaa.gov/product/5km/index_5km_sst.php

³⁷⁸ Mackenzie, L.N et al. (2020). Over a decade monitoring Fiji's seagrass condition demonstrates resilience to anthropogenic pressures and extreme climate events Retrieved from <https://www.sciencedirect.com/science/article/pii/S0025326X20307542?via%3Dihub>

³⁷⁹ Ministry of Health, Fiji. (2020). Fact Sheet: Drought and Health. Retrieved from <https://www.health.gov.fj/fact-sheet-drought-and-health/>

³⁸⁰ NASA. (2024). Extreme Weather and Climate Change. Retrieved from <https://science.nasa.gov/climate-change/extreme-weather/>

³⁸¹ UNFCCC. (2021). How Fiji is impacted by climate change. Retrieved from <https://unfccc.int/news/how-fiji-is-impacted-by-climate-change>

³⁸² National Climate Change Adaptation Research Facility. (2018). Sustainable Management of Coastal Zones in Fiji. Retrieved from <https://www.preventionweb.net/news/water-getting-scarce-heres-how-three-pacific-island-states-are-securing-their-access>

Ocean acidification is a global problem that has local and global consequences for marine ecosystems. It occurs when the ocean absorbs excess carbon dioxide from the atmosphere, which lowers the pH and makes the water less alkaline. This affects the ability of many marine organisms, especially corals, to build their shells and skeletons from calcium carbonate. Ocean acidification can enhance coral bleaching, reduce reef growth, and increase the mortality of many types of organisms³⁸³, which in turn can lead to the loss of coral reefs and the biodiversity they support. Coral reefs are vital for the livelihoods, food security, and coastal protection of millions of people, especially in the Pacific region. Fiji is threatened by ocean acidification and other impacts of climate change. Although our understanding of ocean acidification in Fiji is growing rapidly, it is estimated that it could take approximately 10,000 years for coral reefs to recover from the current levels of acidification. In Fiji, data show that since the 18th century, the level of ocean acidification has been slowly increasing.

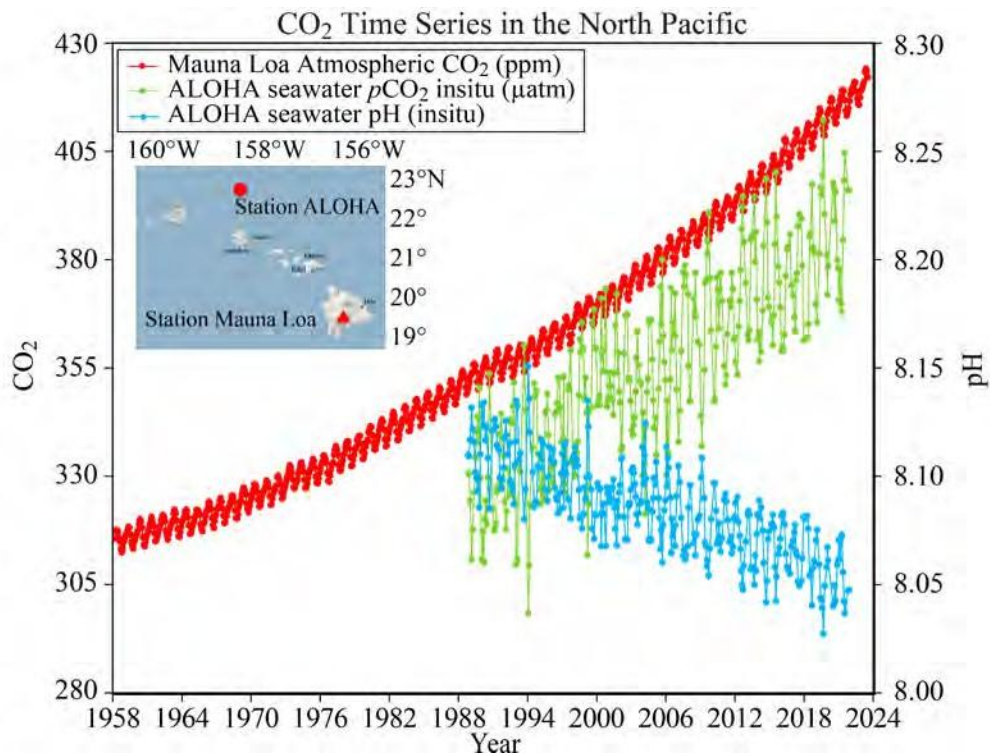


Figure 5-38 Keeling curve shows the increase in atmospheric CO₂ since 1958 (Red), driving the pH (Blue) and seawater CO₂ concentration (Green). Measurements were taken at Maun Loa Hawaii (NOAA, USA) but are applicable (in terms of trends) across the planet (Donner et al. 2006)

Fiji is particularly vulnerable to ocean acidification due to their high dependence on coral reefs and marine resources³⁸⁴. The waters surrounding Fiji are becoming increasingly acidic due to the absorption of carbon dioxide (CO₂ from the atmosphere. This has a number of consequences for the marine environment, including changes in salinity, calcite and aragonite concentrations, and pH levels. These changes can have significant impacts on marine organisms, ecosystems, and the livelihoods of people who depend on them.

As the ocean absorbs CO₂, it reacts with water molecules (H₂O) to form carbonic acid (H₂CO₃). Carbonic acid is a weak acid, but it can still have a significant impact on the chemistry of the ocean. The carbonic acid then dissociates, releasing hydrogen ions (H⁺ and bicarbonate ions (HCO₃⁻). The increase in H⁺ ions lowers the pH of the ocean, making it more acidic. The pH scale is logarithmic, so a small change in pH represents a large change in acidity. For example, a decrease in pH of 0.1 units represents a 30% increase in acidity³⁸⁶. Since the beginning of the Industrial Revolution,

³⁸³ IUCN. (2020). *Oceania Regional Focus: Climate Adaptation Strategies in Pacific Island Nations*. International Union for Conservation of Nature. Retrieved from <https://www.iucn.org/regions/oceania>

³⁸⁴ Case study: Building Local and Regional Resilience through the Pacific Partnership on Ocean Acidification, Pacific Islands - Commonwealth Secretariat, accessed January 20, 2025, <https://thecommonwealth.org/case-study/case-study-building-local-and-regional-resilience-through-pacific-partnership-ocean>

³⁸⁵ United Nations in Fiji, Solomon Islands, Tonga, Tuvalu, and Vanuatu, accessed January 20, 2025, <https://pacific.un.org/en>

³⁸⁶ Ocean Acidification Report for the Pacific Islands | Pacific Environment, accessed January 20, 2025, <https://www.sprep.org/news/ocean-acidification-report-pacific-islands>

the average pH of the ocean has decreased by 0.1 units, making it about 25% more acidic³⁸⁷. This process is directly linked to climate change, as both are driven by increased CO₂ emissions³⁸⁸.

Ocean acidification also affects the concentration of carbonate ions (CO₃²⁻) in seawater. Carbonate ions are essential for marine organisms that build shells and skeletons from calcium carbonate (CaCO₃), such as corals, shellfish, and some plankton. When CO₂ dissolves in seawater, it reacts with water to form carbonic acid. This carbonic acid then reacts with carbonate ions to form bicarbonate. This process reduces the availability of carbonate ions, making it more difficult for marine organisms to build and maintain their shells and skeletons³⁸⁹.

The effects of ocean acidification on salinity, calcite, and aragonite concentrations are complex and not fully understood. However, it is known that ocean acidification can affect the solubility of calcium carbonate minerals. Calcite and aragonite are two forms of calcium carbonate that are commonly found in marine organisms. Aragonite is more soluble than calcite, so organisms that build their shells and skeletons from aragonite are more vulnerable to the effects of ocean acidification³⁹⁰. For example, echinoderms, such as starfish and sea urchins, have skeletons composed of magnesium calcite, which is particularly susceptible to dissolution as ocean pH decreases³⁹¹.

The trend of ocean acidification in Fiji over time is concerning. The pH of the tropical Pacific Ocean, where Fiji is located, has decreased by 0.06 pH units since the beginning of the industrial era, and the current rate of decrease is about 0.02 units per decade. By 2050, the pH of the tropical Pacific Ocean is projected to decrease by a further 0.15 units from the historical 1986–2005 period. This rapid increase in acidity is leaving marine life with little time to adapt³⁹². To better understand the long-term trends of ocean acidification, scientists are using coral cores to generate historical pH records. Corals incorporate boron isotopes into their skeletons, and the ratio of these isotopes can be used to reconstruct past seawater pH levels. This method allows researchers to place modern pH measurements into a historical context, providing valuable insights into the changes that have occurred over time³⁹³.

Ocean acidification is already having a number of impacts on the island of Fiji, the livelihoods of its people, and the environment. These impacts include:

- Coral reef degradation: Ocean acidification is causing coral reefs to become weaker and more susceptible to damage from storms and other stressors. This is a major concern for Fiji, as coral reefs provide important ecosystem services, such as coastal protection, fisheries habitat, and tourism revenue. Ocean acidification can also cause coral bleaching, which further weakens reefs and makes them more vulnerable to disease³⁹⁴. For example, the coral reefs around the islands of Beqa and Kadavu have experienced significant bleaching and degradation in recent years.
- Declines in fish populations: Ocean acidification can affect the growth, survival, and reproduction of fish. This can lead to declines in fish populations, which can have significant impacts on food security and livelihoods in Fiji³⁹⁵. For example, studies have shown that ocean acidification can negatively affect the early life stages of Atlantic salmon, potentially impacting their osmoregulation and growth³⁹⁶. This could have implications for similar species in Fijian waters.

³⁸⁷ Hidden ocean acidification threatens the Pacific. Now there's a plan to stop 'flying blind', accessed January 20, 2025, <https://news-oceanacidification-icc.org/2023/09/12/hidden-ocean-acidification-threatens-the-pacific-now-theres-a-plan-to-stop-flying-blind/>

³⁸⁸ Ocean Acidification - Destabilizing Marine Environments - The Fiji Islands, accessed January 20, 2025, <https://owlfiji.com/ocean-acidification-destabilizing-marine-environments/>

³⁸⁹ www.sprep.org, accessed January 20, 2025,

https://www.sprep.org/sites/default/files/documents/publications/MainstreamingOAintoNationalPolicies_PacificIslandsHandbook_0.pdf

³⁹⁰ Ocean acidification - Coastal Wiki, accessed January 20, 2025, https://www.coastalwiki.org/wiki/Ocean_acidification

³⁹¹ Ocean acidification may increase calcification rates, but at a cost - PMC - PubMed Central, accessed January 20, 2025, <https://pmc.ncbi.nlm.nih.gov/articles/PMC2587798/>

³⁹² Pacific islands ocean acidification vulnerability assessment - SPREP, accessed January 20, 2025,

<https://www.sprep.org/attachments/Publications/CC/ocean-acidification.pdf>

³⁹³ Characterization of ocean acidification over decadal timescales, accessed January 20, 2025, <https://cmeprogramme.org/projects/characterisation-ocean-acidification-over-decadal-timescales>

³⁹⁴ Hidden ocean acidification threatens the Pacific. Now there's a plan to stop 'flying blind', accessed January 20, 2025, <https://news-oceanacidification-icc.org/2023/09/12/hidden-ocean-acidification-threatens-the-pacific-now-theres-a-plan-to-stop-flying-blind/>

³⁹⁵ CLIMATE CHANGE IMPACTS ON HEALTH AND LIVELIHOODS: FIJI ASSESSMENT, accessed January 20, 2025, https://www.climatecentre.org/wp-content/uploads/RCRC_IFRC-Country-assessments-FIJI.pdf

³⁹⁶ Effects of ocean acidification on salinity tolerance and seawater growth of Atlantic salmon *Salmo salar* smolts - PubMed, accessed January 20, 2025, <https://pubmed.ncbi.nlm.nih.gov/29934974/>

- Economic losses: Ocean acidification is expected to cause significant economic losses to Fiji's tourism and fisheries industries. The degradation of coral reefs and declines in fish populations can reduce tourism revenue and fishing yields, impacting the livelihoods of many Fijians.
- Increased coastal erosion: As coral reefs degrade, they become less effective at protecting coastlines from erosion. This can lead to increased coastal erosion, which can damage infrastructure and displace communities. Coastal communities on the island of Vanua Levu are already experiencing increased erosion due to the degradation of nearby reefs.

Upwelling zones, where deep, cold, nutrient-rich waters are brought to the surface, can play a significant role in ocean acidification. The effects of upwelling can vary depending on the location. In some cases, upwelling can exacerbate ocean acidification by bringing water with naturally lower pH and aragonite saturation states to the surface. In other cases, upwelling can buffer the effects of ocean acidification by bringing water with higher alkalinity to the surface³⁹⁷.

While mitigating CO₂ emissions is crucial to addressing ocean acidification, adaptation strategies are also needed to cope with the changes that are already occurring. In the context of aquaculture, for example, there may be opportunities to adapt to increasingly acidic conditions by monitoring natural variability in pH and restricting water intake to periods of optimal conditions. Reducing other stressors, such as pollution and overfishing, can also help to increase the resilience of marine organisms to ocean acidification³⁹⁸.

It is important to recognize that ocean acidification does not occur in isolation. It interacts with other stressors, such as warming temperatures, pollution, and overfishing, to create cumulative impacts on marine ecosystems. These synergistic effects can amplify the negative impacts of each stressor. Therefore, integrated management strategies that address multiple stressors simultaneously are needed to effectively protect marine environments and the livelihoods they support³⁹⁹.

Recognizing the serious threat posed by ocean acidification, regional initiatives are underway to address this issue. The Pacific Islands Ocean Acidification Centre (PIOAC) was recently established through a collaboration between the Pacific Community, the University of the South Pacific, the National Oceanic and Atmospheric Administration, and Otago University, with funding from the Ocean Foundation. The PIOAC aims to build long-term resilience to ocean acidification in the Pacific Islands by providing technical training and equipment to researchers, developing new monitoring technologies, and raising awareness about the issue⁴⁰⁰.

Ocean acidification is a complex issue with far-reaching consequences. In Fiji, it is already having a number of impacts on the environment, livelihoods, and economy. The increasing acidity of the ocean is causing coral reefs to degrade, fish populations to decline, and coastal erosion to increase. These impacts are threatening the livelihoods of many Fijians who depend on marine resources for food and income.

The vulnerability of Pacific Island nations like Fiji to ocean acidification is further heightened by their high dependence on coral reefs and marine resources⁴⁰¹. The degradation of these resources can have cascading effects on the environment, economy, and social well-being of these islands.

Addressing ocean acidification requires a multi-pronged approach. Mitigating CO₂ emissions through global action on climate change is crucial to slowing the rate of ocean acidification. In addition, adaptation strategies are needed to cope with the changes that are already occurring. These strategies may include protecting and restoring coral reefs, managing fisheries sustainably, and developing alternative livelihoods for coastal communities.

Continued research and monitoring are essential to better understand the impacts of ocean acidification and to develop effective mitigation and adaptation strategies. Regional initiatives, such as the establishment of the Pacific Islands Ocean Acidification Centre (PIOAC), are playing a vital role in building capacity and coordinating efforts to address this critical issue.

³⁹⁷ *Ocean Acidification: pH Variability across Space and Time* - University of Florida, accessed January 20, 2025, <https://edis.ifas.ufl.edu/publication/FA227>

³⁹⁸ www.ipcc.ch, accessed January 20, 2025, https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap30_FINAL.pdf

³⁹⁹ www.ipcc.ch, accessed January 20, 2025, https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap30_FINAL.pdf

⁴⁰⁰ *Creating long-term resilience to ocean acidification through training*, accessed January 20, 2025, <https://sdgs.un.org/partnerships/creating-long-term-resilience-ocean-acidification-through-training-equipment>

⁴⁰¹ *Ocean acidification a threat to Pacific Islands people* - SPREP, accessed January 20, 2025, <https://www.sprep.org/news/ocean-acidification-a-threat-to-pacific-islands-people>

Ocean acidification is a significant threat to the sustainable development of Fiji and other Pacific Island nations. By raising awareness, investing in research and monitoring, and implementing effective mitigation and adaptation strategies, we can work towards a future where the ocean remains a healthy and productive resource for generations to come.

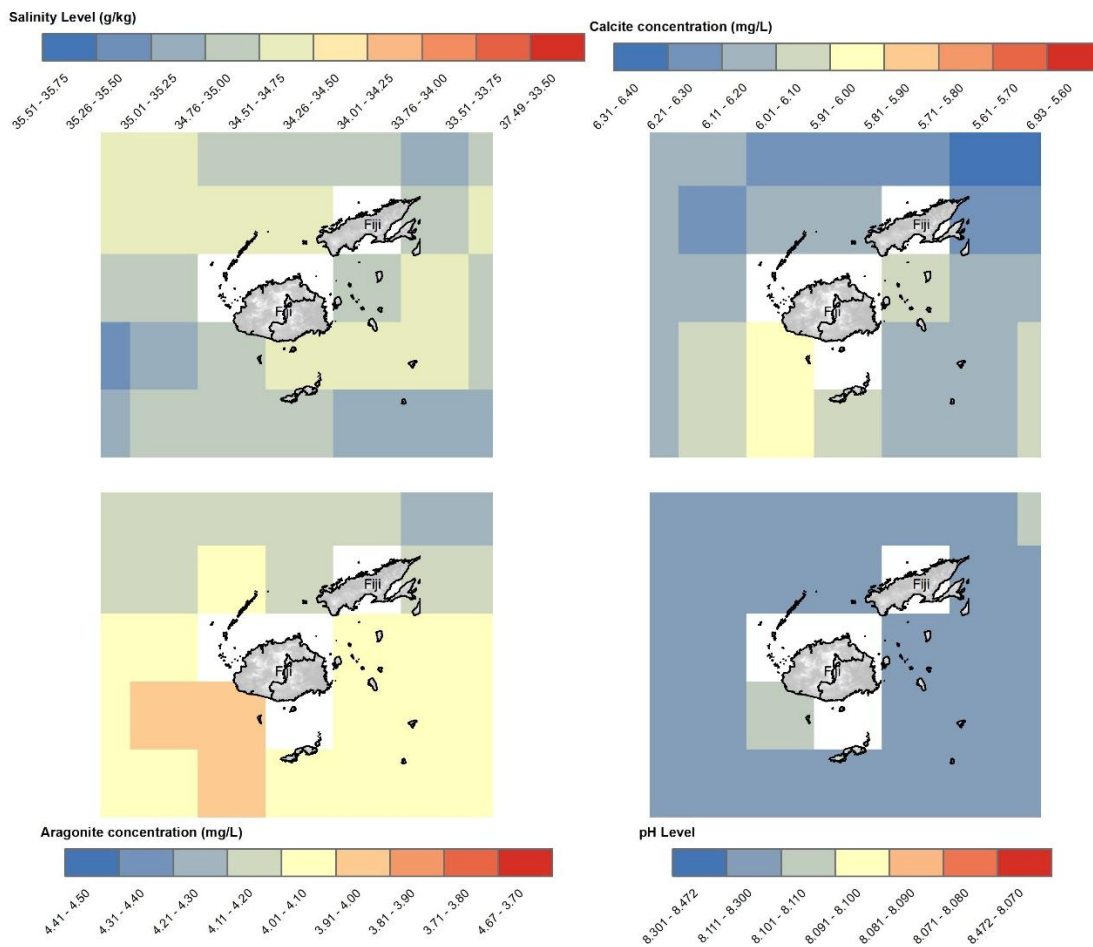


Figure 5-39: Current Ocean acidity characteristics. Salinity (top left), calcite concentration (top right), Aragonite concentration (bottom left), pH level (bottom right)

Prolonged heat waves are another rapidly ongoing phenomenon, with ecosystems and human systems experiencing long periods of heat stress during MHWs. These periods have occasionally been early and dramatic demonstrations of the effect of marine heat waves on coastal and oceanic ecosystems and how they are rapidly increasing in frequency and size. These studies provide valuable insights into the impacts of MHWs on other marine ecosystems in Fiji. They highlight the need for further research and conservation efforts to mitigate the effects of MHWs and protect these vital ecosystems from MHWs. Fiji, like many Pacific Island nations, faces the threat of intensifying MHWs due to climate change.

Increasing temperatures and exposure time can cause 'fish kills', with fish being sensitive to temperature changes and prolonged exposure to extreme heat and stagnation (i.e., low oxygen) can be lethal¹⁶⁵. Aquaculture, including fish farms, faces challenges as water temperatures rise, affecting fish health, respiration, and productivity. Fiji's economy heavily relies on marine resources, including fisheries and tourism. MHWs disrupt migratory patterns of fish and other wildlife, affecting the livelihoods of coastal industry communities.

Depending on healthy coral reefs, tourism suffers when bleaching events reduce attractiveness. Climate models predict more frequent and severe MHWs in the coming decades. Fiji must adapt by implementing conservation efforts, sustainable fishing practices, and monitoring programs.



Figure 5-40 The impact of thermal stress causing bleaching and death in reef-building corals (Fiji Times).

Coral bleaching and mortality⁴⁰² are a highly visible and destructive outcome of MHWs with their brown algal photosynthetic dinoflagellates (or zooxanthellae)⁴⁰³ abruptly leaving the tissues of corals. This leaves the previously brown corals white and deprived of photosynthetic products ('food'), making them more susceptible to disease and death. More recently, many corals have been dying from heat stress without bleaching. Thermal stress and mortality of tropical coral reefs have spread globally, affecting coral reefs everywhere. What was once an occasional event, experienced less than once per decade, has become a near-annual occurrence⁴⁰⁴. The loss of reef-building coral is unprecedented and of great concern, particularly for communities that depend on coral reefs for food, livelihood, coastal protection, cultural connections, and other aspects of their lives. Heat stress has increased relentlessly since 1910, the threshold for many organisms being breached from early 1980 and being followed by increasingly severe mortality of coral and other tropical organisms⁴⁰⁵. According to the latest Global Coral Reef Monitoring Network (GCRMN) report, the cover of coral reefs has decreased by around 14% from 2009 to 2014⁴⁰⁶.

The sensitivity of marine ecosystems to MHW is not just confined to corals. Underwater heatwaves have disrupted the habitats of thousands of species, from invertebrates to fish and seaweeds, seagrass, and mangroves^{407 408} as well

⁴⁰² Holbrook, N.J. et al., 2019. A global assessment of marine heatwaves and their drivers. *Nature Communications*, 10(1), p. 2156. doi:10.1038/s41467-019-10206-z.

⁴⁰³ Guldberg, O.V. et al. 2023. The effect of sudden changes in temperature, light and salinity on the population density and export of zooxanthellae from the reef corals *Stylophora pistillata* Esper and *Seriatopora hystrix* Dana. *Journal of Experimental Marine Biology and Ecology*. doi:10.1016/0022-0981(89)90109-3.

⁴⁰⁴ Guldberg, O.V. et al. 2023. The effect of sudden changes in temperature, light and salinity on the population density and export of zooxanthellae from the reef corals *Stylophora pistillata* Esper and *Seriatopora hystrix* Dana. *Journal of Experimental Marine Biology and Ecology*. doi:10.1016/0022-0981(89)90109-3.

⁴⁰⁵ Guldberg, O.V. et al. 2023. Coral reefs in peril in a record-breaking year: Climate change and its impacts on coral reefs have reached uncharted territory. doi:10.1126/science.adk4532.

⁴⁰⁶ Guldberg, O.V. et al. 2023. Coral reefs

⁴⁰⁷ Jacox, M. G., 2019. Marine heatwaves in a changing climate. *Nature*, 573(7775), pp. 21-22. doi:10.1038/d41586-019-02196-1.

⁴⁰⁸ Global Coral Reef Monitoring network (GCRMN) and International Coral Reef Initiative (ICRI), 2023. Status of coral reefs of the world: 2020 : executive summary Available at: <https://bvearmb.do/handle/123456789/3190>.

⁴⁰⁹ National Geographic, 2020. Ocean heat waves threaten sea life and biodiversity. Available at: <https://www.nationalgeographic.com/environment/article/ocean-heat-waves-threaten-sea-life-biodiversity>.

as ecological processes⁴⁰⁹. In addition to habitat loss, heat stress has also led to the mass death of fish on coral reefs, impacting a range of organisms and processes. These changes are a stark reminder of the interconnectedness of marine ecosystems and the far-reaching impacts of climate change. Other parameters associated with coral reefs, such as ocean acidification, pollution, and overfishing, have also been affected by climate change. These factors further exacerbate the stress on coral reefs, making it even more challenging for these affected ecosystems to recover. It underscores the urgent need for comprehensive strategies to reduce GHG emissions while mitigating the effects of climate change and fostering the resilience of coral reefs and their dependents^{410 411 412}.

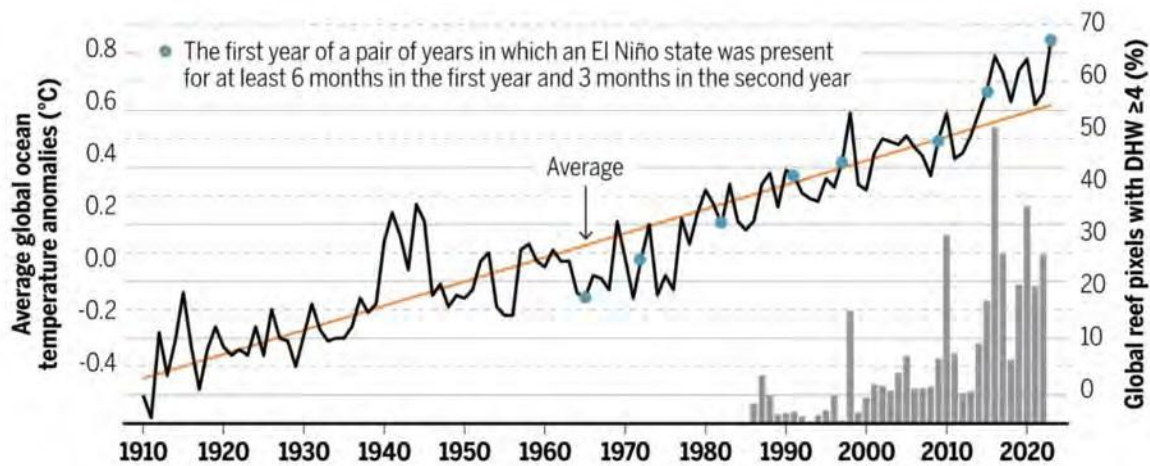


Figure 5-41 The steady rise in global thermal stress since 1910 as well as coral death since the mid-1980

The impacts of MHW in mangrove ecosystems in the Ba and Rewa deltas have been followed in Fiji using multi-temporal Landsat data and surveys. This study assessed mangrove ecosystem variation due to natural factors and human impacts in the Ba and Rewa deltas, Fiji⁴¹³. An exploration of the effects of marine heatwaves in the tropical western and central Pacific Island nations, including Fiji, Samoa, and Palau, revealed that even “Moderate” intensity heatwaves can significantly impact these communities. At their peak, these heatwaves were classified as “Strong”, with the rapid death of fish and invertebrates, coral bleaching and death⁴¹⁴. Recent work by the team revealed that global efforts to curb ocean warming in tropical waters have failed to reduce the emissions enough to prevent serious warming from occurring, which means we must double or triple our efforts to reduce the rate of greenhouse gas emissions.

5.2.4. Coastal flooding

Analysis of the current coastal flooding dynamics used a calibrated and validated state of art 2-D hydrodynamic flow model, Delft3D-Flexible Mesh (FM) that simulates flows from tides and storm surges during tropical cyclones.⁴¹⁵ Our flood model setup involves first creating an unstructured grid to define the model domain. We refine the resolution of the model grid from ~27 kilometres in the deep ocean at the offshore edge of our domain down to 50 meters at the Fiji coastline.

⁴⁰⁹ Holbrook, N.J. et al. 2022. Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities. *Global and Planetary Change*, 203, p. 103680. doi:10.1016/j.gloplacha.2021.103680.

⁴¹⁰ Joyce, P.W.S. et al., 2024. Marine heatwaves as drivers of biological and ecological change: implications of current research patterns and future opportunities. *Marine Biology*, 170(3), p. 43. doi:10.1007/s00227-023-04340-y.

⁴¹¹ Holbrook, N.J. et al., 2019. A global assessment of marine heatwaves and their drivers. *Nature Communications*, 10(1), p. 2156. doi:10.1038/s41467-019-10206-z.

⁴¹² Beyer, H.L. et al. 2018. Risk-sensitive planning for conserving coral reefs under rapid climate change. *Conservation Letters*, 13(2), pp. e12587. doi:10.1111/conl.12587.

⁴¹³ Guldborg, O.V. et al. 2023. Coral reefs in peril in a record-breaking year: Climate change and its impacts on coral reefs have reached uncharted territory. doi:10.1126/science.adk4532.

⁴¹⁴ Guldborg, O.V. et al. 2023. Coral reefs in peril in a record-breaking year: Climate change and its impacts on coral reefs have reached uncharted territory. doi:10.1126/science.adk4532.

⁴¹⁵ Al-Attabi, Z., et al., The impacts of tidal wetland loss and coastal development on storm surge damages to people and property: A Hurricane Ike case-study. *Scientific Reports*, 2023. 13(1): p. 4620. <https://www.nature.com/articles/s41598-023-31409-x>

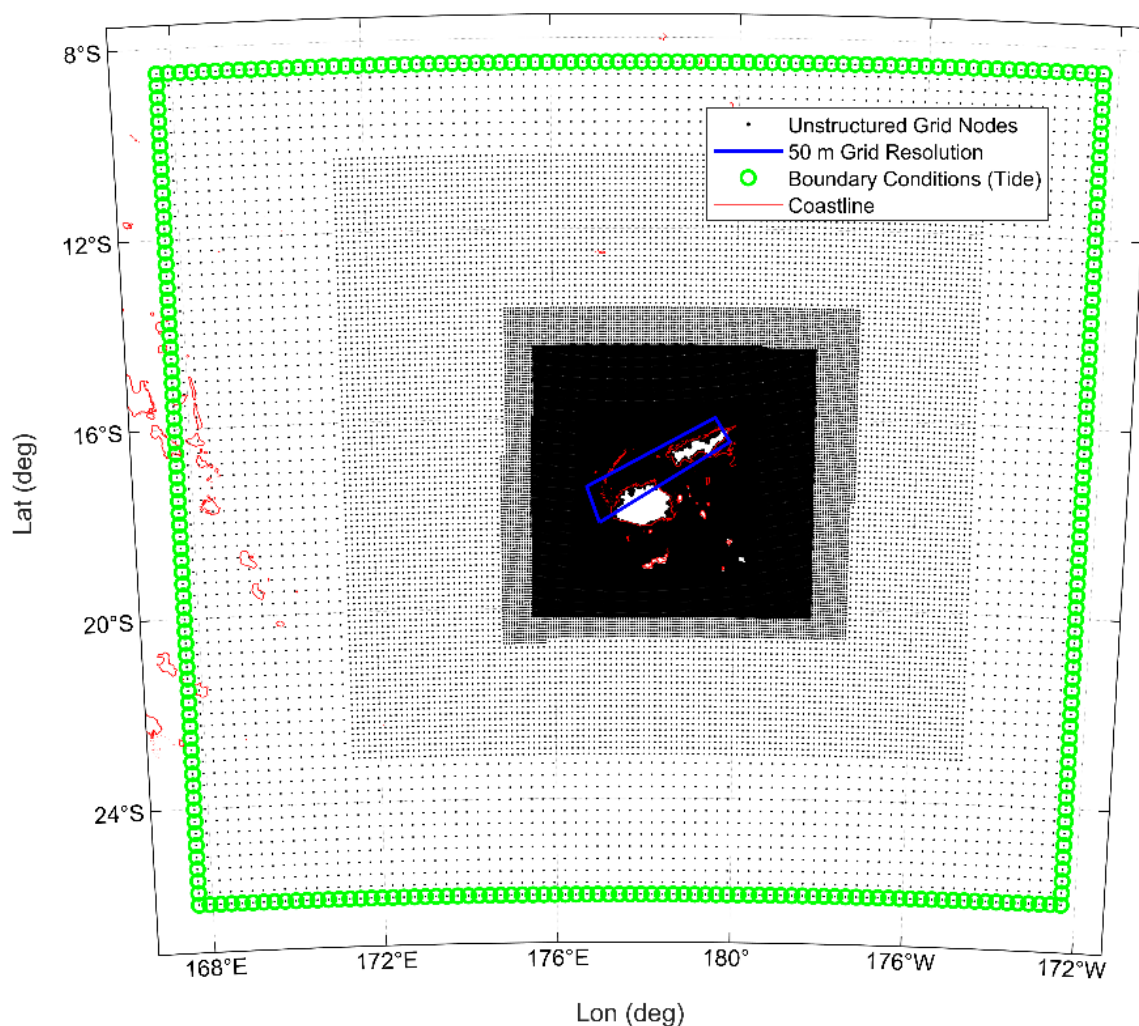


Figure 42: Model Grid Domain for the Southern Pacific and nested grid details for Fiji. Blue rectangle indicates the area of a 50 m resolution nested grid.

Input Datasets

We use multiple spatial datasets to provide inputs to the model at the model boundary and for each model grid cell for the analysis of storm surge flows. These include boundary conditions, forcing conditions such as wind speeds and tides, bathymetric and topographical elevations, and land cover.

We also include available global data on river discharge values greater than $4 \text{ m}^3/\text{s}$ as input to the model to account for the contribution of upstream river discharges from extreme rainfall events to flooding. We use river discharge data from the HydroAtlas basins for rivers in Fiji to set boundary conditions in the Delft3D hydrodynamic model.⁴¹⁶ These boundary conditions are specified at the edges of the model domain. Since we do not have data on discharge during a storm, we select 12 rivers with an annual mean discharge greater than $4 \text{ m}^3/\text{s}$ to include in the model. This allows consideration of the effect of high river discharges on total flood extent within the model.

Table 4: Spatial and temporal datasets used as inputs to the storm surge model.

Dataset	Type	Purpose	Year	Spatial Resolution (km)	Temporal Resolution (hrs)

⁴¹⁶ Lehner, B. and G. Grill, *Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems*. Hydrological Processes, 2013. 27(15): p. 2171-2186.

Allen Coral Atlas	Bathymetry	Water Depth	2019	0.03	-
GEBCO	Bathymetry	Water Depth	2023	0.46	
TanDEM-X	Topography	Land Elevation	2016	0.03	
TPX08	Tide	Boundary conditions	2008	3.7	-
HydroRivers	Annual River Discharge Greater than 4m ³ /s	Boundary conditions		0.46	-
IPCC	Projected sea level	Initial condition	2020-2040	-	-
SeaLevel.info	Historical sea level	Initial condition	1992-2021	-	-
ERA5 ECMWF	Wind field and barometric pressure	External forcing	2012 2016 2020	27.79	6
WorldCover/ESA	Land cover	Friction Coefficient	2021	0.01	
HDX	Population		2018	0.03	

Table 5: Rivers Included in Flood Model

Province	River	Annual Mean Discharge m ³ /s
Ba	Nadi River	9.45
Ba	Ba River	18.27
Ba	Nasivi	5.24
Ra	Penang River	5.25
Bua	Namatatoka	5.36
Bua	Nambitimbiti	4.88
Macuata	Naua	18.82
Macuata	Wailevu	4.10
Macuata	Labasa	6.93
Macuata	Qawa	5.40

Macuata	Waimanu	4.00
Macuata	Wainikoro	4.44

Once the model setup is complete and the input datasets and parameters calibrated, we use the model to simulate tidal water levels for a specific time-period and validate the simulated water levels against observed tide gauge records for the same period from two tidal stations in Fiji, Lautoka in northern Viti Levu and Suva in southern Viti Levu.

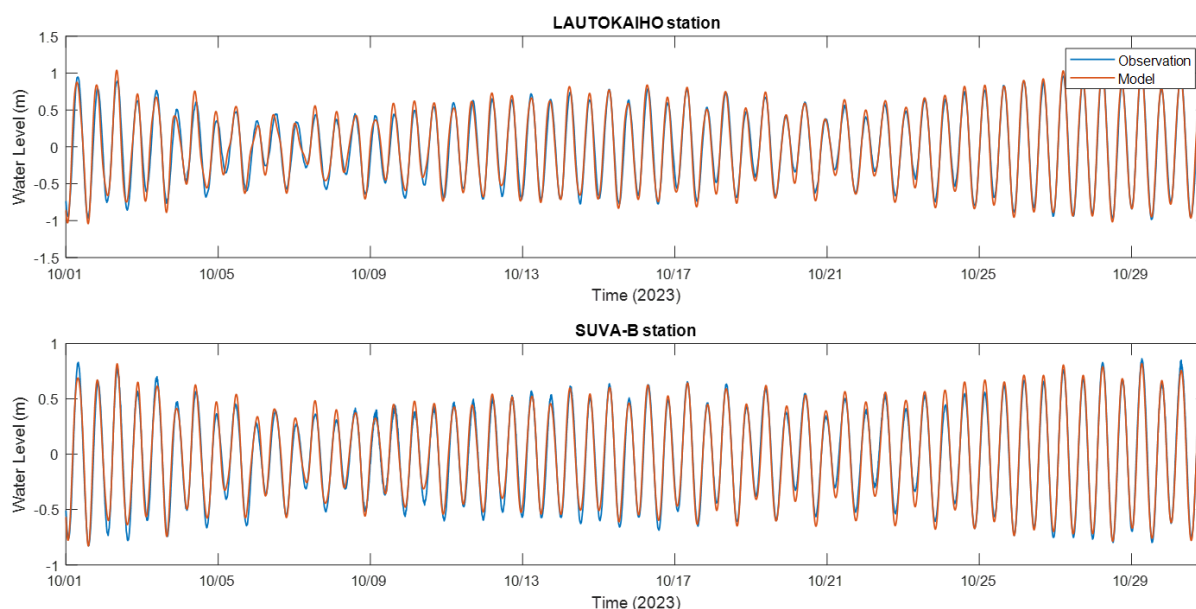


Figure 43: Comparison of tide-levels between the Delft3D-FM model and observed tide gauge data at two stations: Suva in southern Viti Levu, Fiji, and Lautoka in northern Viti Levu, Fiji.

Historical Analysis: Storm Tracks and Selection

The coastlines of northern Viti Levu and Vanua Levu are impacted by tropical cyclones and flooding from storm surges during these cyclones on a regular basis. Between 1964 and 2021, 43 storms passed within 100 kilometres of the Fiji coastline.⁴¹⁷ Tropical cyclone intensities are often expressed as a recurrence interval, or annual percent chance of occurrence, with the less frequent storms typically causing higher storm surges. In Fiji, tropical cyclone Winston in 2016 was the most severe of all historic cyclones to make landfall, with a minimum pressure of 884 hPa and a maximum sustained windspeed of 278 km/hr^{418 419}, corresponding to a ~1% annual storm by wind-speed. Two other storms also caused flooding on these coastlines. These were tropical cyclone Evan in 2012 corresponding to a ~2% storm, and more recently, tropical cyclone Yasa in 2020, corresponding to a ~6% storm. Two other cyclones that were also severe in terms of wind speed, Sina in 1990 and Tomas in 2010, did not cause as much damage from storm surges on these coastlines due to their tracks remaining a considerable distance offshore of the two main islands.

⁴¹⁷ Knapp, K.R., et al., *The international best track archive for climate stewardship (IBTrACS) unifying tropical cyclone data*. Bulletin of the American Meteorological Society, 2010. 91(3): p. 363-376.

⁴¹⁸ Deo, A., et al., Severe tropical cyclones over southwest Pacific Islands: economic impacts and implications for disaster risk management. Climatic Change, 2022. 172(3): p. 38.

⁴¹⁹ Terry, J.P. and A.Y.A. Lau, Magnitudes of nearshore waves generated by tropical cyclone Winston, the strongest landfalling cyclone in South Pacific records. Unprecedented or unremarkable? Sedimentary Geology, 2018. 364: p. 276-285. <https://www.sciencedirect.com/science/article/abs/pii/S0037073817302282>

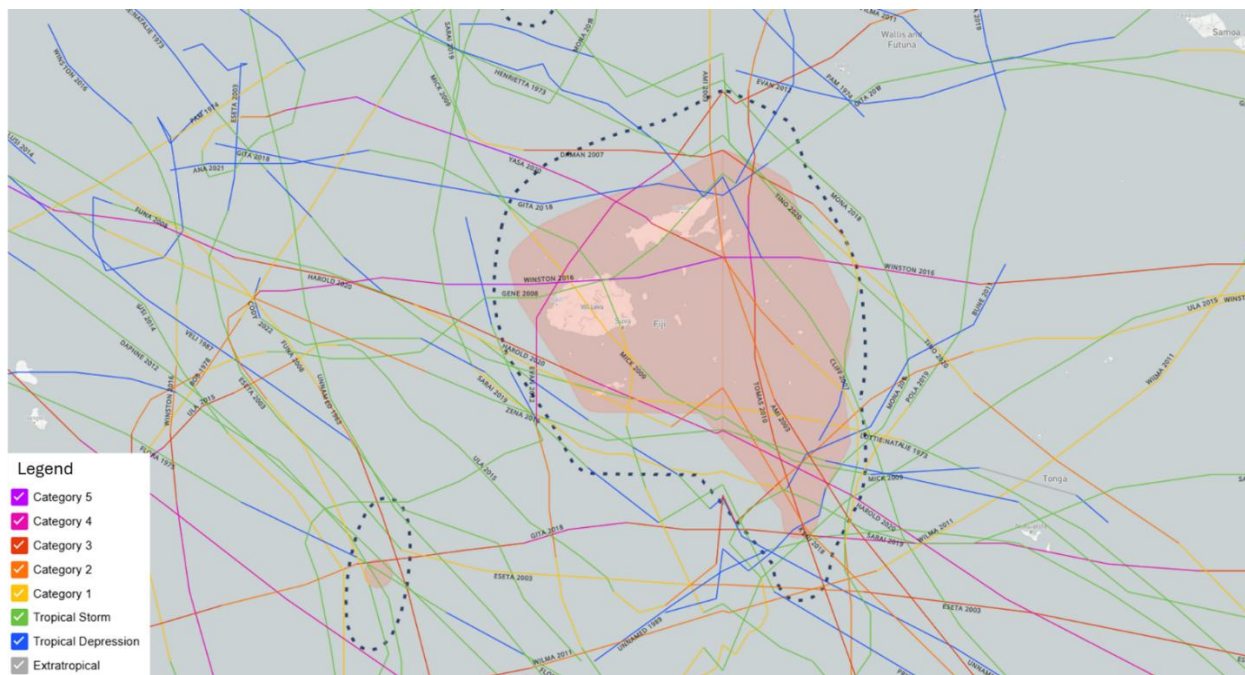


Figure 44: Historical storm tracks, 1963-2025, by storm category, within 100 km from the Fiji coastline. Sourced from the NOAA CSC Historic Hurricane Track Mapper (<https://www.ncei.noaa.gov/products/international-best-track-archive>). Orange shaded region shows the 100-kilometer buffer around the Fijian archipelago.

Table 6. Top five ranked historical storms in Fiji between 1964 and 2021. *Storms selected for flood analysis

Storm	Max Wind speed (kt)	Min pressure (mb)	Category	Year	Rank	Return Period (yrs)	Annual % Chance	Landfall in Fiji
WINSTON*	155	907	H5	2016	1	85	1.2	Yes
EVAN*	125	929	H4	2012	2	43	2.4	Yes
YASA*	120	943	H5	2020	3	28	3.6	Yes
SINA	115	0	H4	1990	4	21	4.8	No
TOMAS	115	937	H4	2010	5	17	5.9	No

Historical Analysis: Baseline Sea Level

For the historical analysis of flooding from storm surges, we consider the period 1992 – 2014, 1992 being the first year when tidal data were available from the Lautoka tidal station. For our baseline mean sea-level we use the mean sea-level recorded for 2014 at the Lautoka tide-gage. We note that the rate of sea-level rise is higher in Suva on the southern coastline of Viti Levu but is not applicable to our study domains located on the coastlines to the north, based on data from the permanent service for mean sea level and the global sea level observing system.⁴²⁰ The 2014 mean sea-level at Lautoka was 0.11 m above the 1992 baseline MSL from when tidal records were available for this gage.

⁴²⁰ Woodworth, P.L., The permanent service for mean sea level and the global sea level observing system. *Journal of Coastal Research*, 1991: p. 699-710. <https://www.jstor.org/stable/44868628>

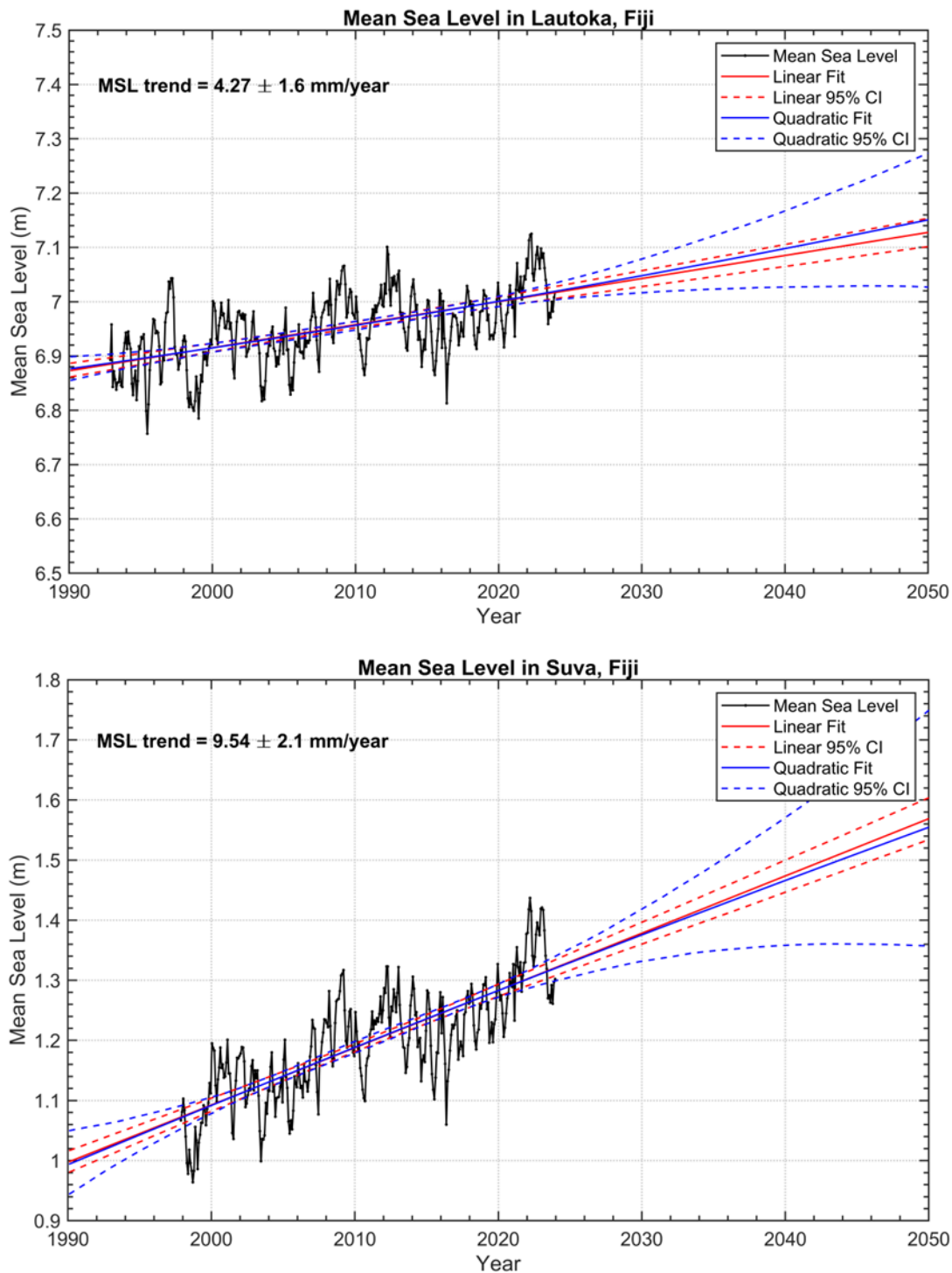


Figure 45: Top: Historic mean sea-level trend and forecast for Lautoka tide gage, Viti Levu. Bottom: Historic mean sea-level trend and forecast for Suva tide gage, Viti Levu, Fiji.

Historical Analysis: Peak Flood Heights from Storm Surges

Using the validated model, we simulate peak flood heights on land due to storm surges from the three historical cyclones, Winston, Evan and Yasa on the 2014 historic mean sea-level.



Figure 46: Maximum flood extent from Hurricane Winston on a 2014 historic mean sea-level.

5.3. Projected future climate

Climate change can amplify and interact with other extreme weather events. For example, higher temperatures can exacerbate droughts and heatwaves, while increased evaporation rates can intensify storms and flooding. These interactions can create a cascade of impacts, affecting ecosystems, agriculture, infrastructure, and human health. For example:

- Heatwaves become more frequent and intense as global temperatures rise due to climate change. Prolonged heatwaves can lead to dehydration, heat-related illnesses, and fatalities;
- Elevated temperatures enhance evaporation rates, causing soil moisture to evaporate faster. This exacerbates drought conditions, affecting agriculture, water availability, and ecosystems;
- Warmer temperatures accelerate evaporation from oceans, lakes, and rivers. This moisture-laden air contributes to more intense storms;
- A warmer atmosphere can hold more water vapour. Consequently, storms bring heavier rainfall, leading to flooding and landslides;
- Rising sea levels due to climate change amplify the impact of coastal storms;
- Ecosystems: Extreme weather events disrupt ecosystems. For instance, severe storms can uproot trees, alter habitats, and harm wildlife;

Climate change amplifies extreme weather events, leading to cascading consequences across multiple sectors. Addressing climate change is crucial for minimizing these synergistic (or antagonistic) impacts and building a more resilient future^{421 422 423}.

⁴²¹ <https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health>

⁴²² Center for Climate and Energy Solutions (C2ES), n.d. *Extreme Weather and Climate Change*. Available at: <https://www.c2es.org/content/extreme-weather-and-climate-change/>

⁴²³ The Royal Society, n.d. *Climate Change and Biodiversity*. Available at: <https://royalsociety.org/topics-policy/projects/biodiversity/climate-change-and-biodiversity/>

Climate change also significantly impacts biodiversity, agriculture, and human health. Changes in temperature and precipitation patterns can alter habitats and disrupt ecosystems, leading to shifts in species distributions and potential loss of biodiversity. In agriculture, climate change can affect crop yields and livestock production, potentially threatening food security. For human health, increased heat stress, changes in vector-borne disease patterns, and impacts on air and water quality are all potential concerns⁴²⁴. It's important to note that these impacts are interconnected, and changes in one area can have ripple effects on others.

Fiji is vulnerable to climate change. Rising sea levels, intensified storms, and disruptions to agriculture (from heat and flooding) are among the challenges faced by this South Pacific nation. Heat stress and disease increase as average global temperatures rise, while severe storms damage infrastructure. Additionally, the intrusion of saltwater as sea level increases harms existing farmland in coastal areas. On Fiji's main island of Viti Levu, these climate threats are projected to cause economic damages of up to \$52 million per year, equivalent to roughly four percent of Fiji's gross domestic product⁴²⁵. Urgent action is essential to address these challenges and protect vulnerable communities. The Intergovernmental Panel on Climate Change (IPCC) released its Sixth Assessment Report (AR6) in 2021⁴²⁶. The report includes global and regional climate projections and scenarios, which are based on the consensus of key future scenarios⁴²⁷. For Fiji, specific climate projections are provided by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Secretariat of the Pacific Regional Environment Programme (SPREP). This report, titled 'NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Fiji', is used here to provide detailed climate projections for Fiji⁴²⁸.

Additionally, the World Bank Climate Change Knowledge Portal (WBCKKP) provides country-level climate data projections for Fiji, derived from the Sixth phase of the Coupled Model Intercomparison Project (CMIP6), which forms the data foundation of the IPCC Assessment Reports⁴²⁹. Climate models are becoming increasingly accurate as demonstrated by their ability to 'back-project' past outcomes using today's rapidly developing models. This is also done at increasingly smaller scales. This chapter focuses on how Fiji's climate will likely change over the coming decades and century. Fiji has been at the forefront of using climate change models to answer the all-important question: How will Fiji's climate vary under a range of assumptions, such as increased or decreased greenhouse gas concentrations, storms, or factors such as dryness, fuel, and local weather in the context of wildfires. Over 30 years ago, the amount of scientific information was far less than the substantial amount available today from world-class Panels such as the Intergovernmental Panel on Climate change (IPCC). Future changes suggest changes in synoptic dynamics influencing the high-level future climate states.

⁴²⁴ Government of Fiji, 2020. Republic of Fiji's Updated NDC 2020. Available at: <https://unfccc.int/sites/default/files/NDC/2022-06/Republic%20of%20Fiji%27s%20Updated%20NDC%2020201.pdf>

⁴²⁵ Government of Fiji. (2020). Updated Nationally Determined Contributions (NDCs) from Fiji. Retrieved from <https://unfccc.int/sites/default/files/NDC/2022-06/Republic%20of%20Fiji%27s%20Updated%20NDC%2020201.pdf>

⁴²⁶ <https://www.ipcc.ch/assessment-report/ar6/>

⁴²⁷ <https://www.ipcc.ch/assessment-report/ar6/>

⁴²⁸ CSIRO. (2021). 'NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Fiji. Retrieved from https://www.met.gov.fj/media/documents/Country_Report_Fiji_ul6cujP.pdf

⁴²⁹ <https://climateknowledgeportal.worldbank.org/country/fiji>

	Scenario 1 SPCZ moves north	Scenario 2 SPCZ moves south
Low emissions (RCP2.6)	Warmer & drier - Annual temperature: +0.5°C - Annual rainfall: -10% - More heatwaves - Less humidity - More solar radiation - Heavier rainfall events - Greater tropical cyclone impacts - Sea level rise: 17-30 cm	Much warmer & wetter - Annual temperature: +1.1°C - Annual rainfall: +10% - More heatwaves - More humidity - Less solar radiation - Much heavier rainfall events - Greater tropical cyclone impacts - Sea level rise: 17-30 cm
High emissions (RCP8.5)	Much warmer & drier - Annual temperature: +0.9°C - Annual rainfall: -20% - More heatwaves - Less humidity - More solar radiation - Heavier rainfall events - Greater tropical cyclone impacts - Sea level rise: 21-37 cm	Hotter & wetter - Annual temperature: +1.6°C - Annual rainfall: +10% - Many more heatwaves - More humidity - Less solar radiation - Much heavier rainfall events - Greater tropical cyclone impacts - Sea level rise: 21-37 cm

Figure 5-47 Standardised scenarios for Fiji for 2040-2059 relative to 1986-2005 for low and high emission pathways and two climate change scenarios defined by the physical change 'storyline'⁴³⁰.

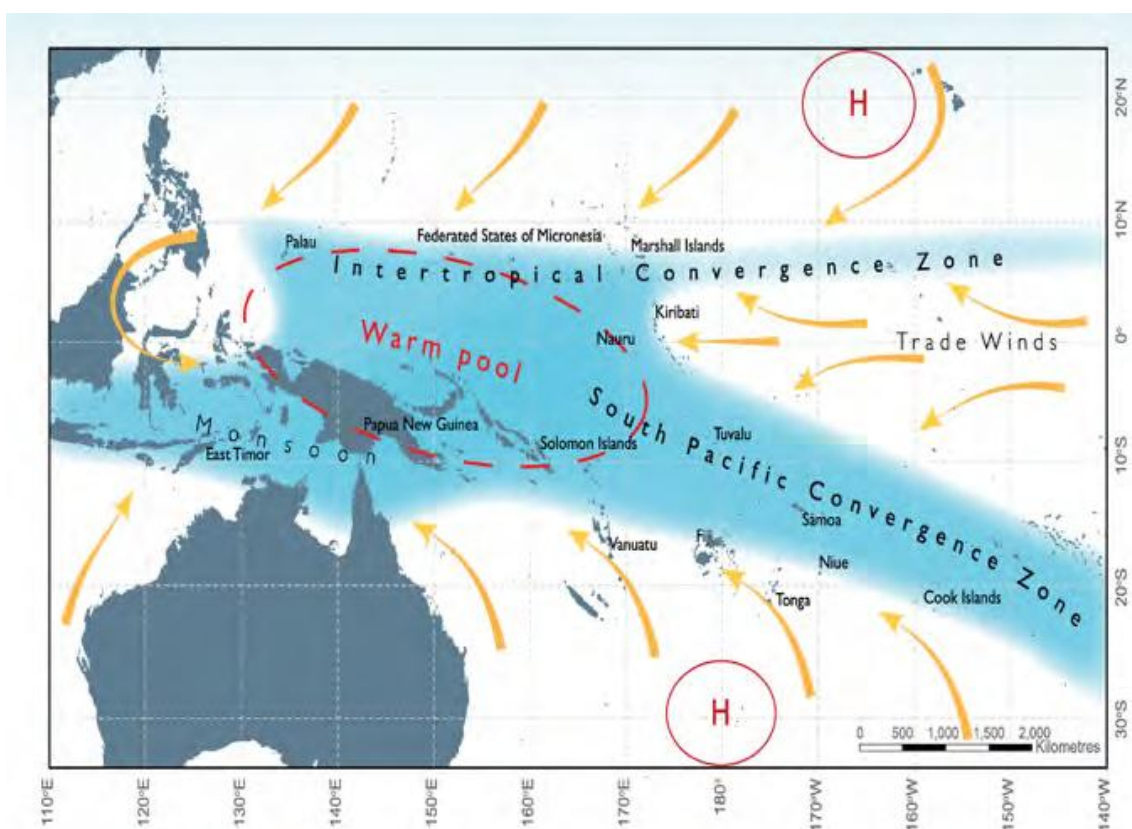


Figure 5-48 Average positions of the major climate features of the South Pacific Convergence Zone (SPCZ) from November to April. The arrows show near-surface winds, the blue shading represents the bands of rainfall convergence zones, the dashed oval shows the West Pacific Warm Pool and H represents typical positions of moving high-pressure systems. Shifts in the position of these features can have a major impact on climate responses in Australia and the western Pacific.

The future climate changes suggest an increase in maximum temperatures of between 0.2-0.8°C under the SSP2 scenario from 2020-2040. There is however less certainty in the direction of changes in future rainfall anomalies with

⁴³⁰ CSIRO. (2021). 'NextGen' Projections for the Western Tropical Pacific: Current and Future Climate for Fiji. Retrieved from https://www.met.gov.fj/media/documents/Country_Report_Fiji_ul6cujP.pdf

some models suggesting a decrease of up to 10% will others show an increase of +11%. There is more certainty of the peak single-day temperatures and the warm spell duration with both showing increases in the future.

The inconsistency in future rainfall is also translated to the rainfall characteristics. The peak single-day rainfall anomaly and the average single-day rainfall intensity models mostly show decreases in the future; there is however high variability among the models. Likewise, the number of wet days has models that show an increase of up to 18 days annually, but most of the models indicate decreased wet days with a median of ~1 day less annually. The SPEI range shows most models indicating a negative future value indicating future drought scenarios. There is however some small variability in these models.

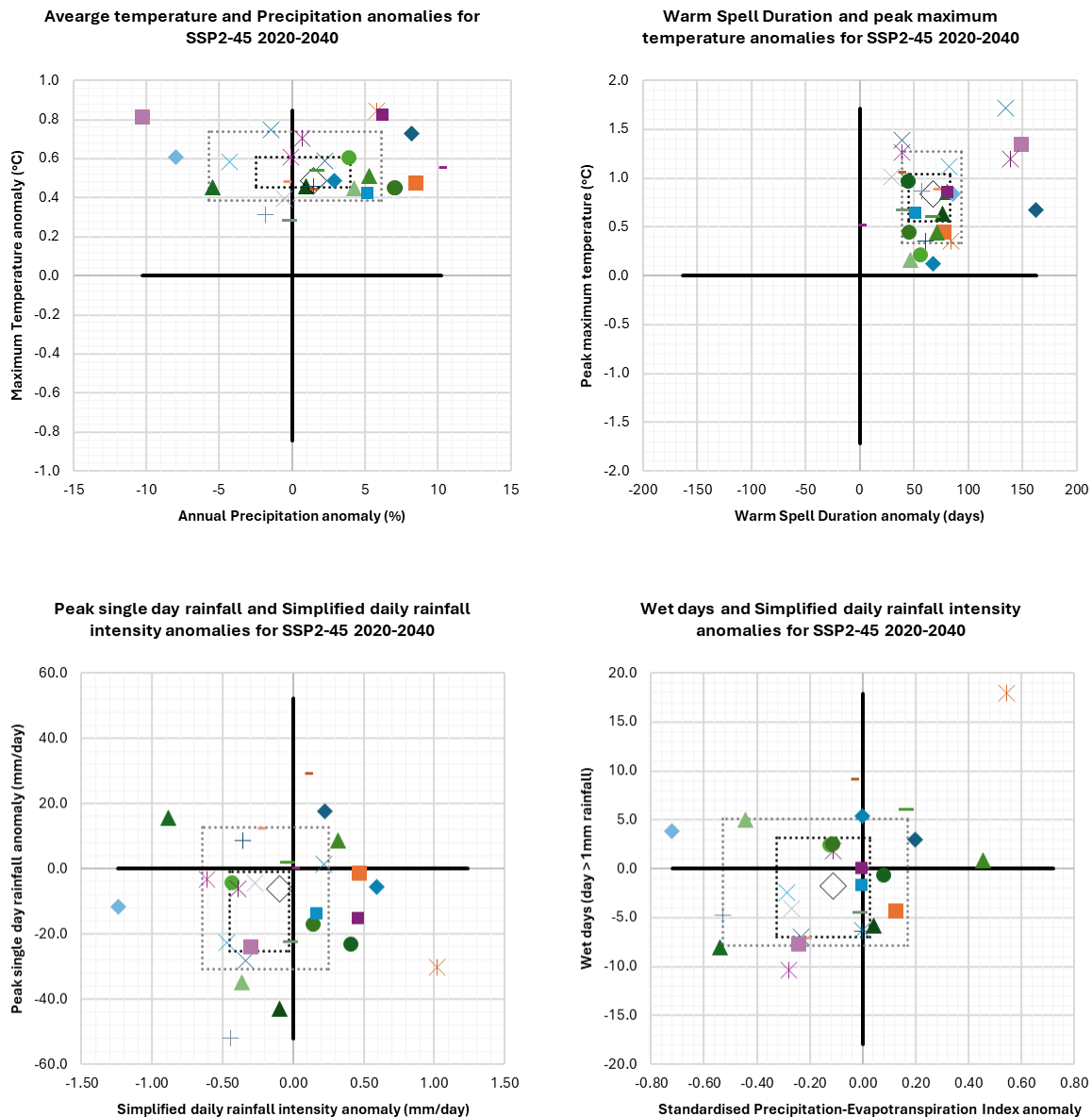


Figure 5-49. Climate biplots. Maximum temperature vs annual rainfall (top left), Warm spell duration vs Peak maximum temperature (top right), Peak single day rainfall vs average rainfall intensity (bottom left), and SPEI vs number of wet days (bottom right)

5.3.1. Precipitation

Under the SSP2-4.5 climate scenario, Fiji's rainfall patterns from 2020 to 2050 are expected to exhibit both subtle decreases in overall precipitation and changes in the intensity and distribution of extreme rainfall events. These changes, while largely not statistically significant, highlight trends that could have important implications for water resources, agriculture, and disaster risk management.

Climate projections for Fiji suggest a complex picture of rainfall changes in the coming decades. While the overall trend for annual rainfall shows a slight decrease of 0.29% -0.51% per decade (equivalent to 7.54 mm less per decade), this decrease is not statistically significant. This means that while a slight reduction in average annual rainfall is projected, it's not yet certain. The average annual rainfall for the period 2015-2035 is estimated to be around 2618 mm, with a 95% confidence range of 2561.32 - 2674.35 mm per year. Looking further ahead, the projected annual rainfall for 2020-2050 is estimated to be 2600 mm.

Rainfall decreases are expected to be concentrated in specific months, particularly December (-11.67 mm), January, February, and September. In contrast, slight increases are projected for March and July, with the largest average increase of +2.51 mm occurring in July. Overall, the shifts suggest enhanced variability in seasonal rainfall patterns, with a potential for drier conditions during the traditionally wetter months and modest increases during otherwise drier periods.

Similarly, the number of days with heavy rainfall (above 20 mm and 50 mm) is also projected to decrease slightly, but again, these trends are not statistically significant. This suggests that while the frequency of extremely heavy rainfall days might reduce slightly, the changes are not yet conclusive.

Interestingly, the intensity of extreme rainfall events is projected to increase. The magnitude of single-day peak rainfall is expected to rise by 0.46 mm per decade, while the 5-day peak rainfall is projected to increase by 1.18 mm per decade. Although these increases are not statistically significant, they point towards a potential trend of more intense rainfall events in the future.

The most significant change is projected in the peak monthly rainfall magnitude. This is expected to increase by 2.87 mm per decade, and this trend is statistically significant. This suggests that Fiji can expect to see more intense monthly rainfall totals in the future, with the average peak monthly rainfall for 2015-2035 estimated to be around 489mm and a 95% confidence range of 478.1 - 499 mm.

While the projections suggest a slight decrease in overall rainfall and the frequency of heavy rainfall days, these trends are not yet statistically significant. However, the projected increase in the intensity of extreme rainfall events, particularly the peak monthly rainfall, is a statistically significant trend and highlights the potential for increased flood risks in Fiji in the future.

Climate projections for Fiji indicate a complex scenario for drought, dry spells, and humidity changes in the coming decades. The Standardized Precipitation Evapotranspiration Index (SPEI), a key indicator of drought conditions, shows a statistically significant decrease of -0.01 SPEI per decade. This trend suggests that Fiji can expect more severe and frequent droughts in the future.

Despite the projected increase in drought severity, the number of consecutive dry days is not expected to change significantly. The average number of consecutive dry days is projected to remain around 11.29 days, with a 95% confidence range of 10.96 - 11.61 days. This suggests that while droughts may become more severe, the length of individual dry periods might not change drastically.

Conversely, the number of consecutive wet days is projected to increase slightly, although this trend is not statistically significant. This indicates a potential for longer periods of continuous rainfall, which could have implications for flood risk and water resource management.

Interestingly, relative humidity is projected to increase significantly, with a trend of 0.05% per decade. This increase, coupled with an average relative humidity of 83.02% for 2015-2035, suggests a more humid climate in the future. The projected future value for relative humidity is 83.13% for the period 2020-2050.

Fiji's future climate is likely to be characterized by more severe and frequent droughts, despite no significant change in the length of dry spells. While the number of consecutive wet days might increase slightly, the most notable change will be a significant increase in relative humidity. These changes could have significant implications for various sectors, including agriculture, water resources, and human health.

Spatial differences in rainfall trends are projected to persist, with the western parts of the islands becoming drier compared to the more humid elevated and southern regions. The northern areas are likely to experience a greater reduction in consecutive wet days and longer dry spells, underscoring the need for localized water resource management strategies.

Fiji's rainfall projections for 2020–2050 under SSP2-4.5 highlight a nuanced interplay between decreased annual totals, increased variability, and shifting rainfall extremes. While the overall drying trend is modest, the potential for longer dry spells, more severe droughts, and localized reductions in wet days could challenge water availability and ecosystem stability. Adaptive measures focusing on water conservation, climate-resilient agriculture, and improved disaster preparedness will be essential to mitigate these impacts.

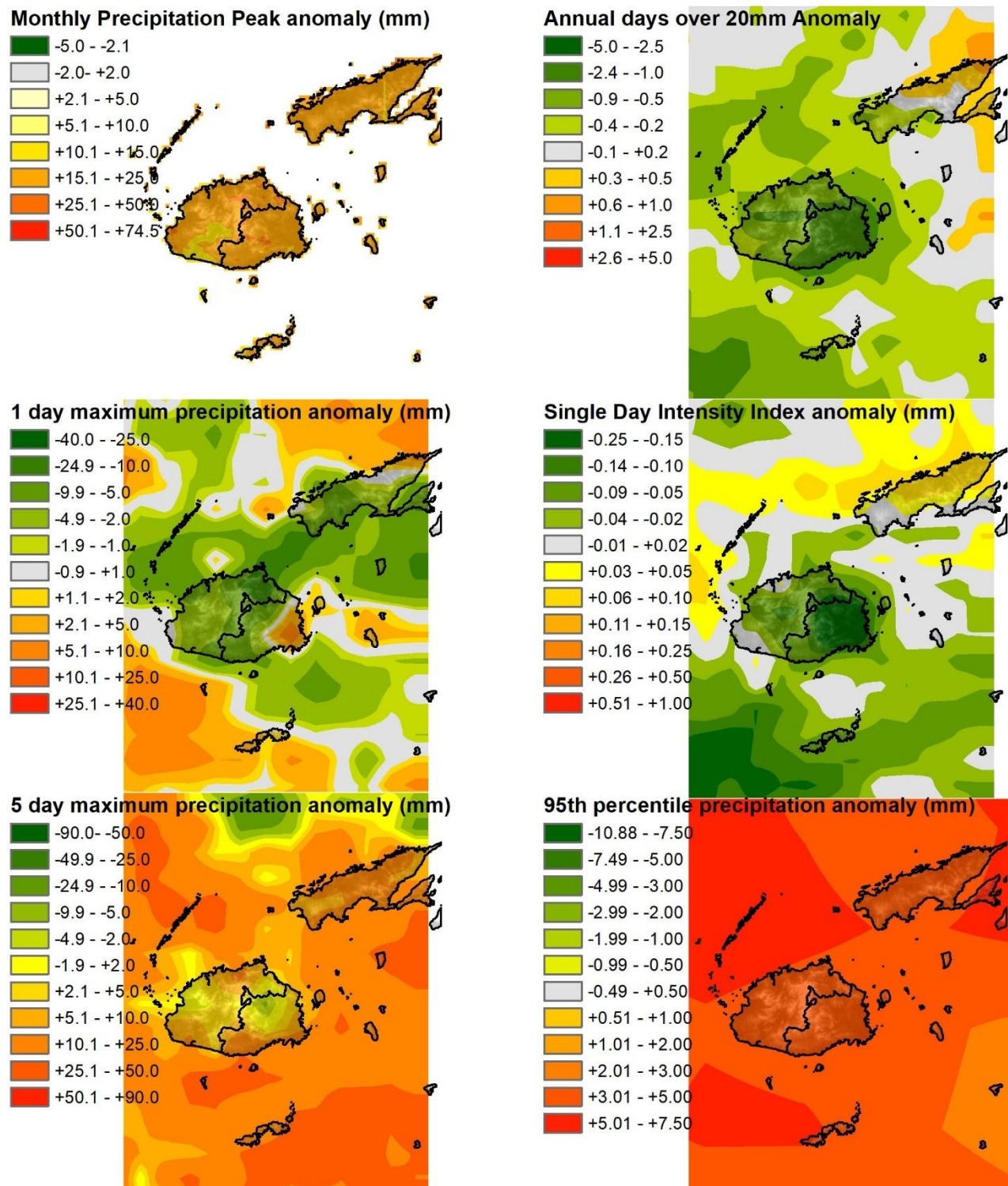


Figure 5-50: Projected flooding and extreme rainfall characteristics. Flood areas (left), extreme rainfall anomaly characteristics (right)

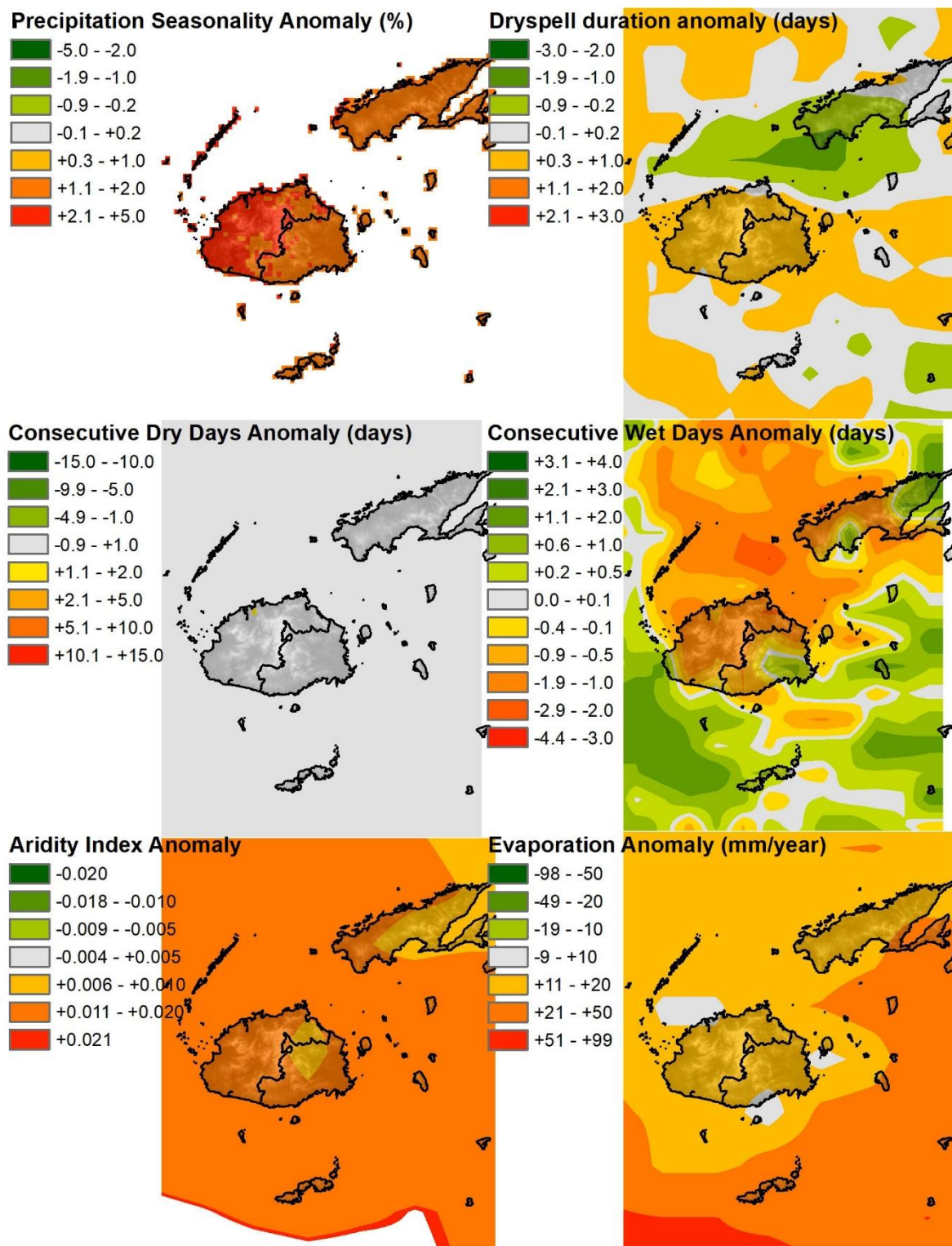


Figure 5-51: Projected Drought and drying rainfall characteristics. Flood areas (left), extreme rainfall characteristics (right)

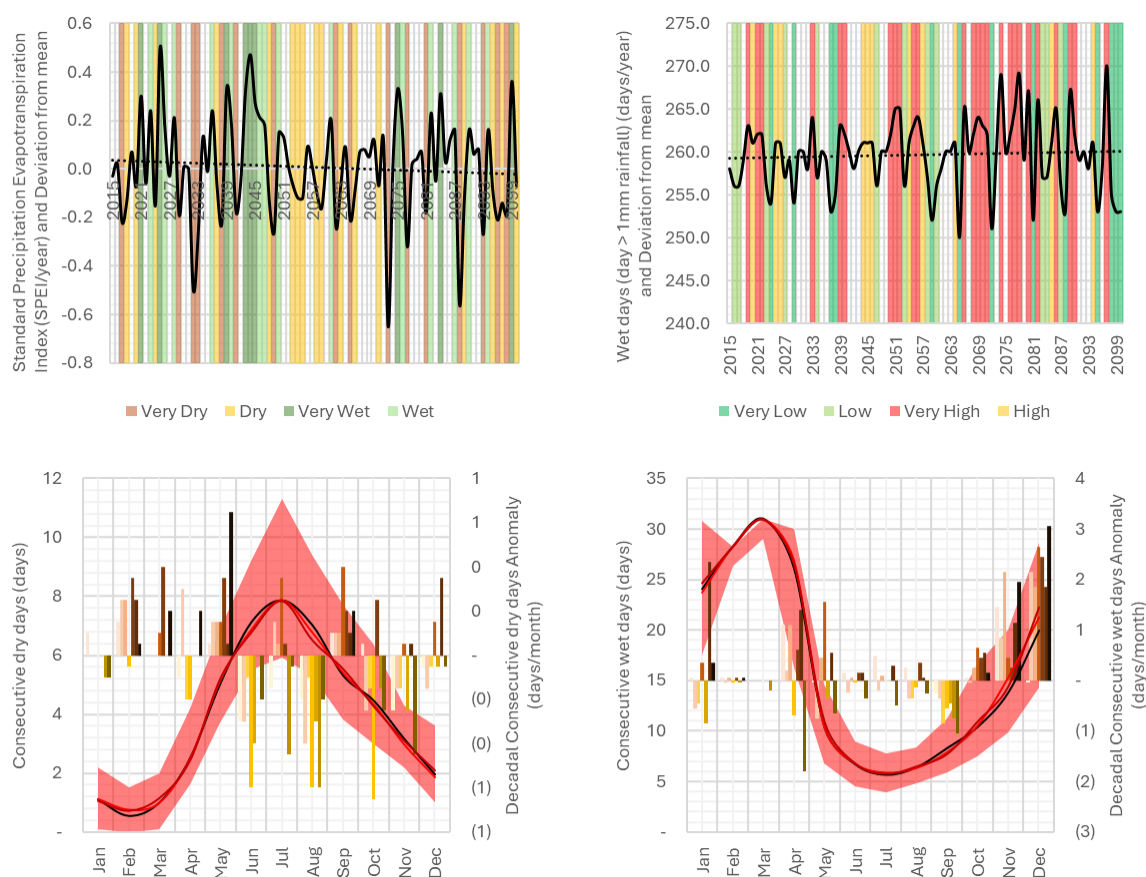


Figure 5-52. Projected changes to rainfall in Fiji. Annual and Monthly rainfall changes (top left and right), days above 20mm and average daily rainfall intensity (2nd row), peak 1 and 5- days monthly anomalies (3rd row), SPEI and wet days Warm spell duration (4th row), Consecutive wet and dry days (bottom)

Table 5-7. National level Projected change in rainfall from 2020-2050

	Precipitation	1-Day max rainfall	5-Day max rainfall	1-Month max rainfall	Days above 20mm rainfall	Days above 50mm rainfall	Consecutive Wet Days	Consecutive Dry Days	Drought index	Relative humidity
Mean 2020-2050	2212.68	85.97	206.14	432.51	24.70	4.07	48.21	12.42	0.08	80.96
95% confidence interval	2175.18 - 2250.18mm	84.33 - 87.62mm	202.69 - 209.59mm	426.09 - 438.93mm	24.1 - 25.31 days	3.93 - 4.22 days	46.83 - 49.58 days	12.21 - 12.62 days	0 - 0.15	80.9 - 81.03%
Statistical Trend	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant
Trend (change per decade)	-0.51%	1.75mm	3.46mm	3.52mm	-0.005 days	0.0745 days	-0.38 days	0.16 days	-0.01	0.07%

Although the frequency of cyclones affecting Fiji is projected to decrease overall, there is considerable uncertainty in predicting future cyclone trends due to the complex interplay of various factors like ocean temperatures, wind patterns, and atmospheric conditions⁴³¹. Models do however suggest a link between certain factors and Hurricane formation. The frequency and intensity of Hurricanes are strongly related to anomalous sea surface temperature (SST) in the main development region, the weakening of vertical wind shear (VWS) in the mid-troposphere during

⁴³¹ CLIMATE RISK COUNTRY PROFILE, accessed January 20, 2025, https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/15854-WB_Fiji%20Country%20Profile-WEB.pdf

depression development, and the La Nina phase of the El Nino Southern Oscillation (ENSO). Each of these factors may change as a result of future climate change, influencing the characteristics of Hurricanes. ENSO and wind-shear characteristics are highly dynamic and will change on synoptic and annual time scales in response to current conditions. SST changes, on the other hand, will be more linear, and while they will exhibit a seasonal cycle, the baseline trend will not likely revert to oscillations around current SST means. The IPCC highlights the following projected changes in the South Pacific:

- Total hurricane activity is projected to decrease with a likely (67% confidence) 0% to -50% range with a median of ~25%. This is in line with the average for the southern hemisphere.
- The changes to more intense Category 4 and 5 tropical cyclones are anticipated to be negligible.
- There will be a slight disparity in the lifetime duration of the maximum intensity achieved in a tropical cyclone event with the ranges between +5 and -5% but a median showing no changes.
- There is projected to be an increase in the precipitation rate associated with these hurricane events of up to 10% suggesting an increase in average rainfall intensity. This trend of increasing intensity is consistent with global observations, where warmer ocean temperatures provide more energy for cyclone development⁴³². Projections also suggest a possible shift in the distribution of cyclones due to the warming environment⁴³³.
- There is only low confidence in the IPCC projections for future tropical cyclone activity in the area. While the overall frequency of tropical cyclones in the region is uncertain, the intensity of the rainfall and possibly the wind speeds associated with these cyclones is projected to rise, leading to stronger winds, heavier rainfall, and higher storm surges.⁴³⁴

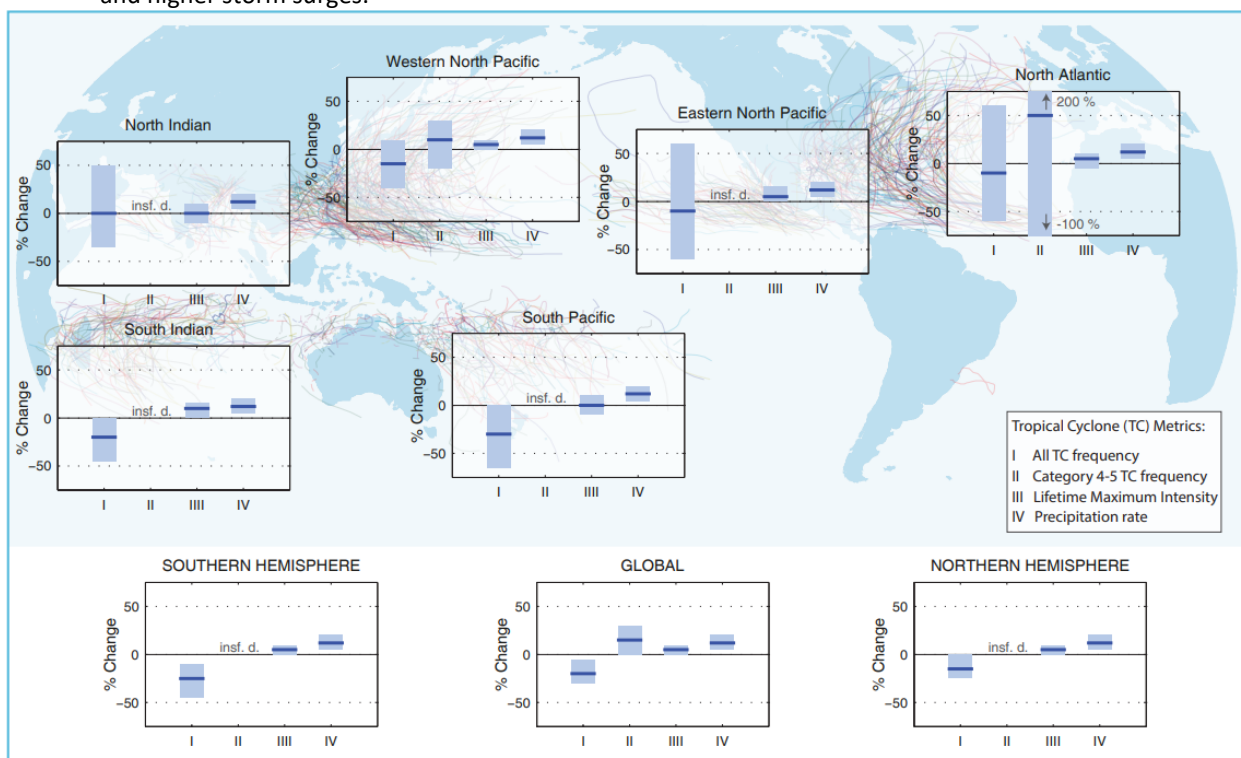


Figure 5-53. IPCC changes in hurricane characteristics⁴³⁵.

The Fiji Meteorological Service has predicted an increase in the destructive potential of cyclones over time, with no significant reduction in frequency. Extreme rainfall and associated flood hazards are projected to increase as global temperatures continue to rise. These changes are increasingly impacting the natural and human systems in Fiji.

⁴³² Fiji - Tropical Cyclones - Projections | Climate Change Knowledge Portal, accessed January 20, 2025, <https://climateknowledgeportal.worldbank.org/country/fiji/tropical-cyclones-projections>

⁴³³ Impacts of tropical cyclones on Fiji and Samoa - NASA ADS, accessed January 20, 2025. Available from <https://ui.adsabs.harvard.edu/abs/2013EGUGA..15.3715K/abstract>

⁴³⁴ Knutson, T.R., et al., 2020. Tropical cyclones and climate change assessment: Part II. Projected response to anthropogenic warming. *Bulletin of the American Meteorological Society*, 101(3), pp.E303-E322.

⁴³⁵ Christensen, J.H., Kumar, K. Krishna, et al., "Climate Phenomena and Their Relevance for Future Regional Climate Change," in *Climate Change 2013 - The Physical Science Basis*, ed. Intergovernmental Panel on Climate Change (Cambridge: Cambridge University Press, 2013), 1217–1308, <https://doi.org/10.1017/CBO9781107415324.028>. <https://www.cambridge.org/core/books/abs/climate-change-2013-the-physical-science-basis/climate-phenomena-and-their-relevance-for-future-regional-climate-change/E995BB137D2366E4537E659DB914A57C>

Tropical cyclone categories are projected to see a small increase in annual occurrence. This is however right at the interface between increases in the north and decreased occurrences in the more southern areas. This high variability is also noted in the categories 3 to 5 which see both small increases and decreases in the occurrences and no changes in the category 5 scenario. The possible direction of changes remains highly varied for the areas immediately around Fiji. The areas further west closer to Australia see a more consistent projected increase in future tropical cyclone occurrence.

Tropical cyclone annual occurrence anomaly 2035-2064 for SSP2-4.5

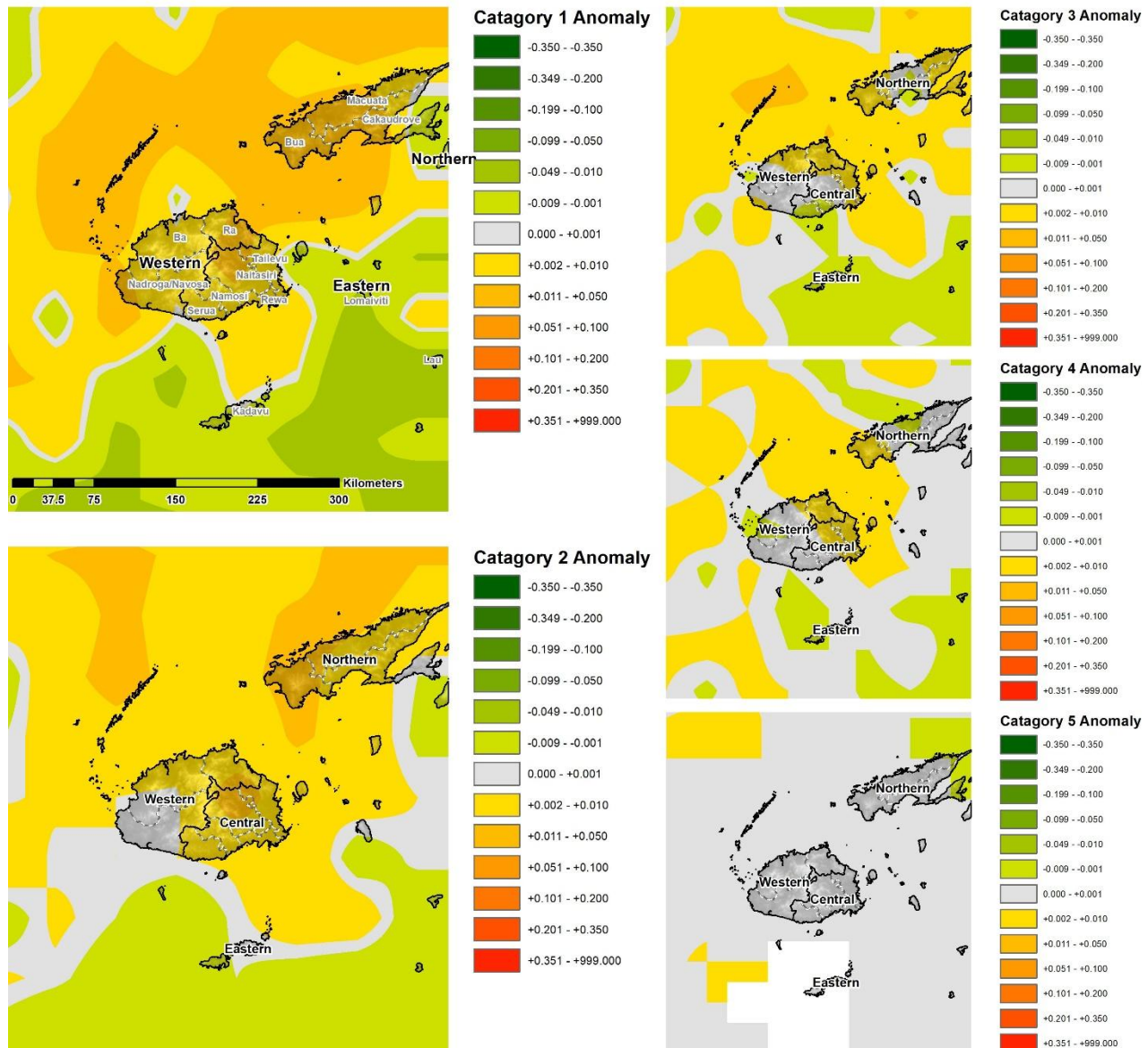


Figure 5-54: Projected anomaly annual tropical cyclone occurrence per category. Category 1 and 2 (left), categories 3,4, and 5 (right)

Climate change is expected to alter the frequency and intensity of extreme rainfall events, leading to changes in landslide hazards⁴³⁶. Studies suggest that warming temperatures will cause more intense rainfall in some areas, potentially increasing landslide activity⁴³⁷. The changes noted in the rainfall patterns suggest heavy rainfall may see an increase in landslides particularly on the south side of the main island as well as in the northern district.

⁴³⁶ Evaluation of potential changes in landslide susceptibility and landslide occurrence frequency in China under climate change - PubMed, accessed January 22, 2025, <https://pubmed.ncbi.nlm.nih.gov/35981587/>

⁴³⁷ Climate Change Could Trigger More Landslides in High Mountain Asia - NASA, accessed January 22, 2025, <https://climate.nasa.gov/news/2951/climate-change-could-trigger-more-landslides-in-high-mountain-asia/>

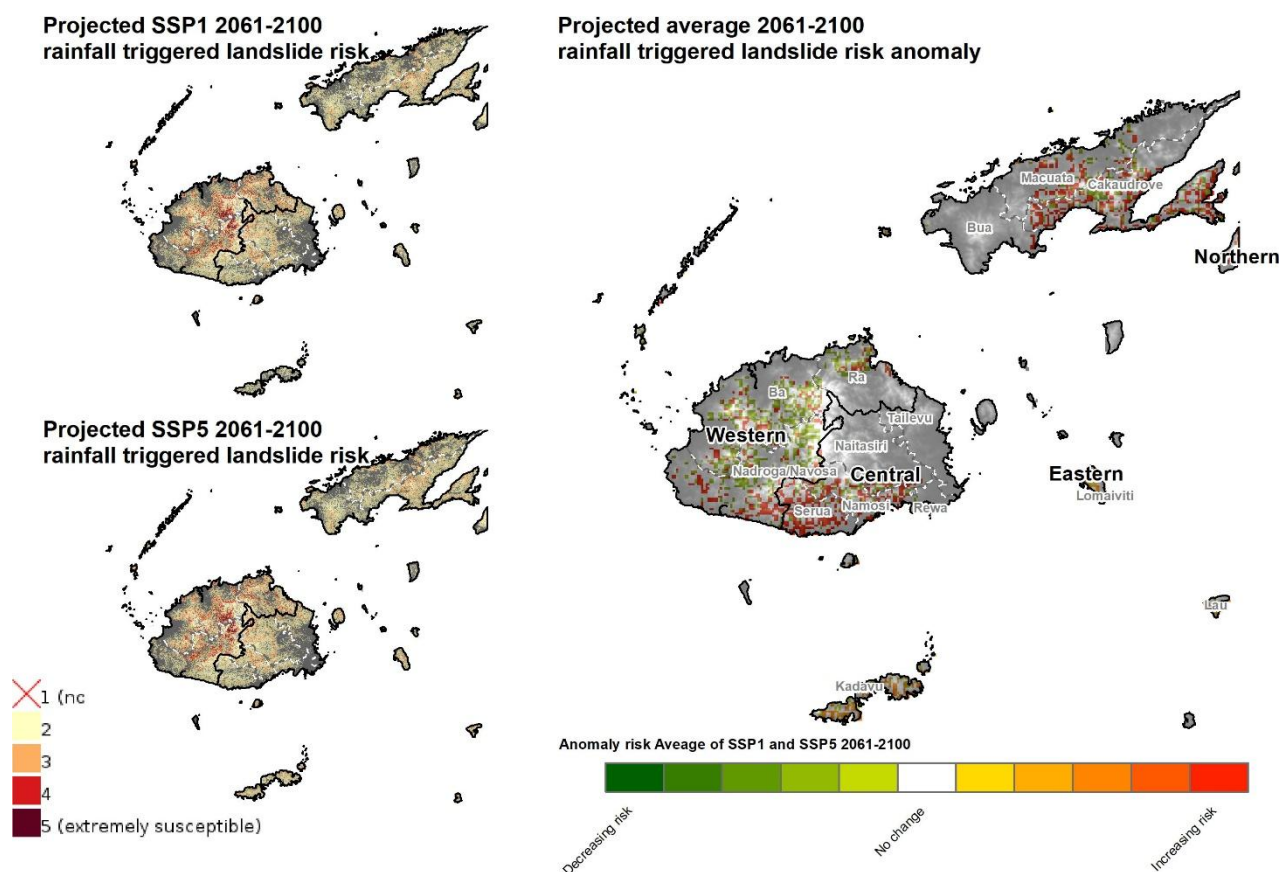


Figure 5-55. Projected future SSP1 and SSP5 2061-2100 rainfall triggered landslide risk (left two figures) and average risk anomaly (right)

Climate change is expected to significantly impact the hydrological cycle of Fiji in the coming decades and century. Fiji's low-lying atolls are highly susceptible to sea-level rise, which is expected to increase due to global warming. This could lead to more frequent and severe flooding, especially during tropical cyclones. Increased Storms: Warmer ocean temperatures are expected to lead to increasingly destructive storms. These storms can cause significant damage to infrastructure and disrupt the normal hydrological cycle. Saltwater Intrusion: Rising sea levels can lead to the intrusion of saltwater (salinization) into freshwater resources. This could disrupt agriculture and damage existing farmland. Changes in Rainfall Patterns: Climate change can lead to changes in rainfall patterns, potentially leading to an increased risk of landslides due to extreme rainfall⁴³⁸.

5.3.2. Temperature

Under the SSP2-4.5 climate scenario, Fiji is expected to experience significant warming trends across all temperature parameters from 2020 to 2050. Proximity to the ocean contributes to relatively uniform temperature changes across the islands, with some small spatial variations.

Climate projections for Fiji indicate a clear warming trend in the coming decades. All temperature indicators, including maximum, mean, and minimum temperatures, show statistically significant increases. Maximum temperatures are projected to rise by 0.162°C per decade, with an average maximum temperature of 27°C for the period 2015-2035. This warming trend is expected to continue, with a projected maximum temperature of 27°C for the period 2020-2050. Similarly, mean temperatures are also projected to increase by 0.17°C per decade. The average mean temperature for 2015-2035 is 23.99°C, and this is expected to rise to 24.2°C for the period 2020-2050. Minimum temperatures are also showing a statistically significant increase of 0.16°C per decade. The average minimum temperature for 2015-2035 is 19.14°C, with a projected increase to 19.35°C for the period 2020-2050.

These projections show a consistent picture of warming across all temperature indicators. This warming trend could have significant impacts on various sectors in Fiji, including agriculture, water resources, and human health. Increased

⁴³⁸ Australian Government Bureau of Meteorology. (2020). Oceanic and Atmospheric Changes Affecting the Pacific Islands. Retrieved from <http://www.bom.gov.au/>

temperatures can lead to more frequent and severe heatwaves, coral bleaching, and changes in rainfall patterns, all of which can have significant consequences for Fiji's ecosystems and economy.

Fiji's future climate is projected to experience a significant increase in extreme temperatures, with several key indicators pointing towards hotter and more prolonged warm spells. One of the most notable changes is the projected increase in warm spell duration. The Warm Spell Duration Index is expected to rise by 31.55 days per decade, with a projected future value of 97.35 days for the period 2020-2050, up from an average of 58.1 days between 2015-2035. This statistically significant increase suggests that Fiji will experience longer periods of unusually high temperatures, potentially leading to heat stress and adverse effects on human health and ecosystems.

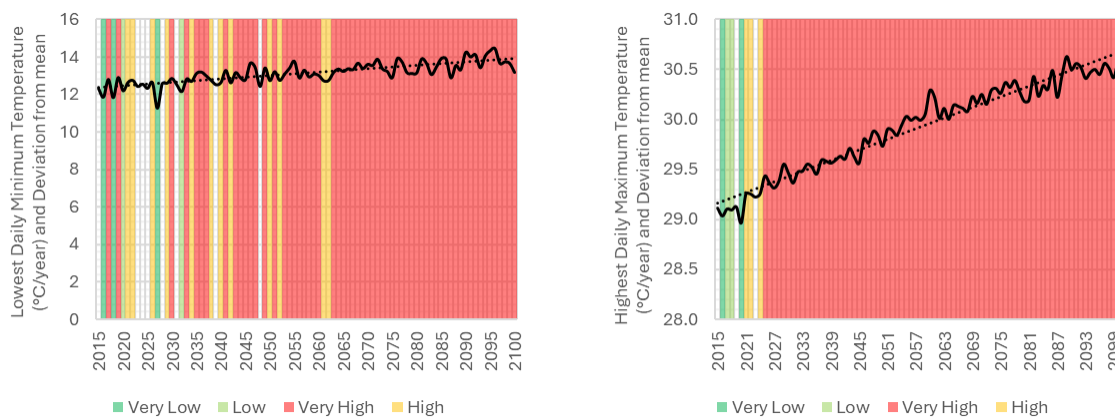
The number of days with temperatures exceeding 25°C (Summer Days) is also projected to increase significantly, with a trend of 7.31 days per decade. This translates to a projected 309.9 summer days per year for the period 2020-2050, up from an average of 299.24 days between 2015-2035. This increase highlights the overall warming trend and the potential for more frequent and intense heatwaves.

While Fiji is not projected to experience extremely hot days above 35°C or 40°C, the peak single-day temperatures are expected to rise. The trend shows a statistically significant increase of 0.18°C per decade, with a projected future value of 29.51°C for 2020-2050, up from an average of 29.3°C for the period 2015-2035.

Furthermore, the number of tropical nights (nights above 20°C) is also projected to increase significantly, by 10.48 nights per decade. This trend suggests warmer nights, which can disrupt sleep patterns and contribute to heat stress, particularly in urban areas. The projected future value for tropical nights is 148.42 nights for 2020-2050, up from an average of 135.1 nights between 2015-2035.

Even the lowest daily temperatures are projected to increase, with a trend of 0.19°C per decade and a projected future value of 12.73°C for 2020-2050. This indicates that even the coolest periods will become warmer, contributing to the overall warming trend.

Fiji's future climate is likely to be characterized by more frequent and prolonged warm spells, hotter days and nights, and an overall increase in temperatures. These changes pose significant challenges for human health, agriculture, and ecosystems, highlighting the urgent need for adaptation and mitigation measures to address the impacts of climate change in Fiji.



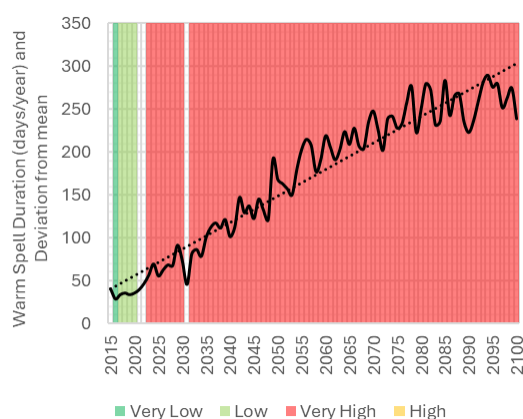


Figure 5-56. Projected changes to temperatures in Fiji. Monthly minimum and maximum temperatures (top left and right), Topical nights and summer days (2nd row), Lowest nighttime and hottest day time temperatures (3rd row), Warm spell duration (bottom)

Table 5-8. National level projected change in temperatures from 2020-2050

	Minimum Temperature	Mean Temperature	Maximum Temperature	Lowest Minimum Temperature	Highest maximum Temperature	Days above 25°C	Days above 30°C	Days above 40°C	Nights above 20°C	Warm Spell Duration Index
Mean 2020-2050	23.06	25.33	27.59	18.22	30.10	337.52	20.67	0.51	325.41	97.19
95% confidence interval	23 - 23.12°C	25.26 - 25.39°C	27.52 - 27.65°C	18.13 - 18.32°C	30.03 - 30.17°C	335.5 - 339.54 days	18.02 - 23.32 days	0.42 - 0.61 days	323.99 - 326.84 days	84.09 - 110.29 days
Statistical Trend	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant
Trend (change per decade)	0.18°C	0.18°C	0.19°C	0.22°C	0.21°C	5.47 days	7.99 days	0.28 days	4.16 days	39.99 days

The annual number of cool days is expected to decrease, while the number of warm days is projected to increase significantly due to climate change. Climate change is projected to increase the number of warm nights and decrease the number of cool days in Fiji, which follows trends after the past century. Under a high emissions scenario, the number of days of a warm spell is projected to increase from about 25 days in 1990 to about 350 days on average in 2100. This increase in warm days is due to the region experiencing a temperature rise of 0.15°C every decade since 1950. Furthermore, the annual and decadal trends show signs of continuous long-term warming in the Fiji region. For instance, in 2019, above-average temperatures were recorded throughout the year except for November⁴³⁹. These changes are part of a broader climate change impact on Fiji, which includes higher rates of disease as average temperatures rise, increasingly destructive storms as oceans get warmer weather patterns become more severe, and disruptions to agriculture as the intrusion of saltwater damages existing farmland⁴⁴⁰.

⁴³⁹ Fiji National Disaster Management Office (NDMO). (2021). Fiji's National Climate Change Adaptation Plan.

https://fijiclimatchangeportal.gov.fj/wp-content/uploads/2022/01/Brief__Fiji_National_Adaptation_Plan_Policy.pdf

⁴⁴⁰ FAO. (2021). Adapting Coastal Ecosystems in Fiji to Climate Change. Retrieved from <https://www.fao.org/3/cb6670en/cb6670en.pdf>

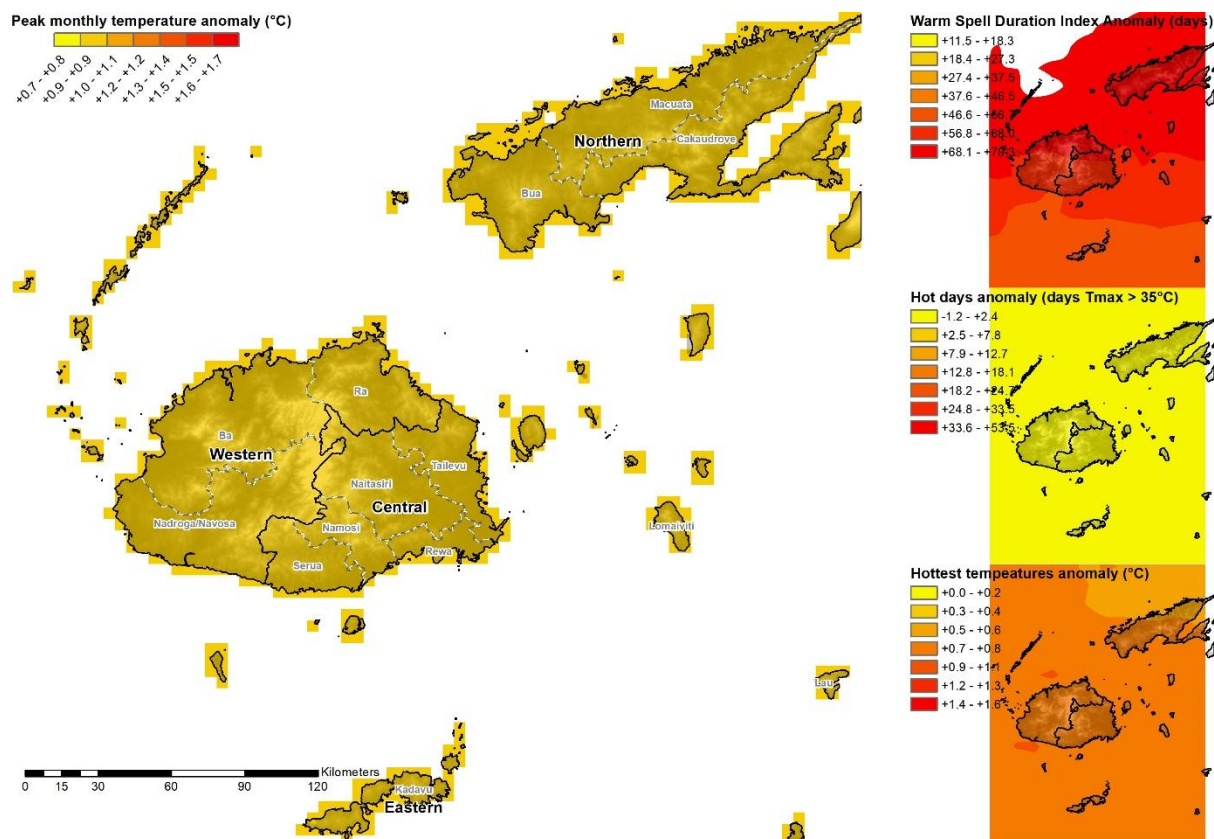


Figure 5-57: Projected heatwave and extreme temperature characteristics. Peak monthly temperatures (left), extreme temperature characteristics (right)

5.3.3. Ocean Characteristics

Surface sea temperatures have been on a steady rise over the past 50 years or more, with profound consequences already for both ecosystems and human populations if not solved. These impacts are already evident, from mass coral bleaching and mortality events to the amplification of storms to the deadly interaction between heat and humidity. However, the ocean's thermal inertia will take centuries to recover from these changes. The implications are far-reaching, especially for the millions of people who rely on ocean and coastal regions for sustenance, livelihoods, and well-being.

Fiji's ocean temperatures are projected to continue warming throughout the 21st century, though at a slightly moderated pace compared to recent decades. From 2020 to 2050, the average sea surface temperature is expected to be around 28.59°C, with a statistically significant warming trend of 0.15°C per decade.

During this period, the lowest monthly temperatures are projected to average 26.93°C, while the maximum monthly averages are expected to reach 29.92°C. As the century progresses, warming is anticipated to accelerate again, with projections for 2050 to 2080 indicating a further rise. During this later period, the lowest monthly averages are expected to increase to 27.4°C, while the maximum monthly averages could reach as high as 30.42°C.

This gradual but consistent warming has critical implications for Fiji's marine ecosystems, coastal resilience, and broader climate dynamics.

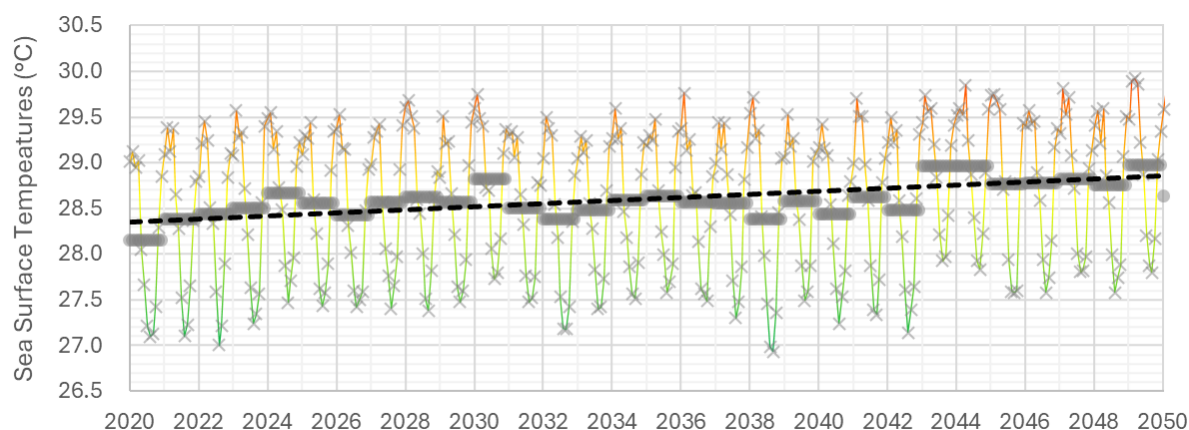


Figure 5-58. Longitudinal projected change in Sea surface temperatures. West of Fiji (Longitude: 176.1E, Latitude: 17.1S)

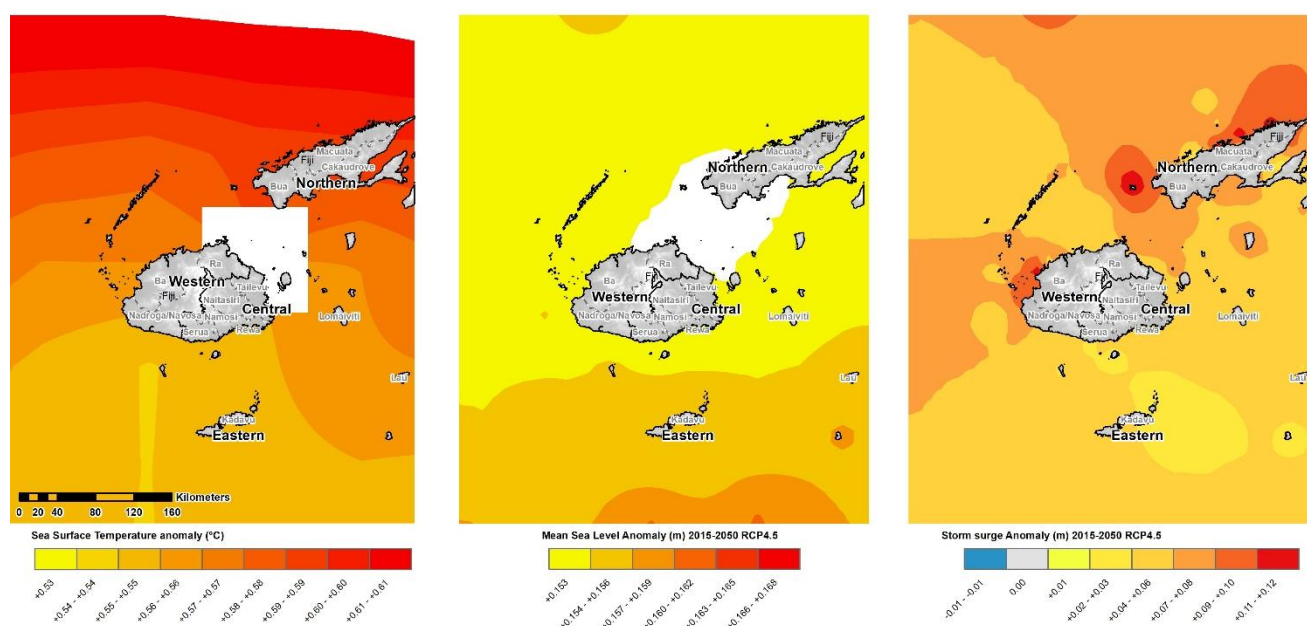


Figure 5-59: Projected Ocean characteristic anomalies. Sea surface temperatures (left), mean sea level (centre), and average storm surge (right)

Sea level rise will vary regionally along many coasts because of land and sea level changes. Coastal erosion and inundation of low-lying coastal regions, particularly during extreme sea level events, are expected to increase. It also leads to saltwater intrusion into aquifers, deltas, and estuaries, plus damage from storms, sediments, aquaculture, and fertiliser are threatening agriculture, aquaculture, and valuable farming land.

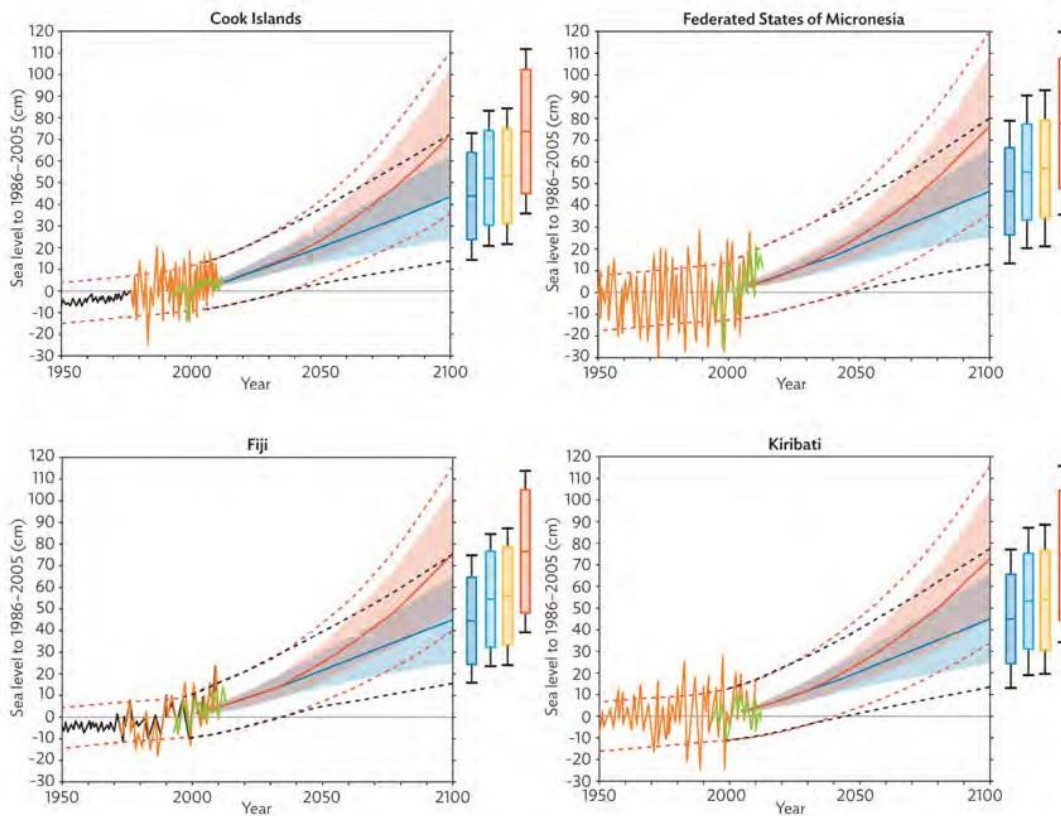


Figure 5-60 Past and future Sea Level Rise (SLR) in Fiji and three other island nations

The tide gauge records of relative sea level since the late 1970s and indicated in orange, and the satellite record since 1993 is in green. The reconstructed sea level since 1950 is shown in black. Multimodal mean projections in 1995–2100 are given for RCP8.5 (red solid line) and RCP2.6 (blue solid line), with the 5%–95% uncertainty range shown by the red- and blue-shaded regions. The ranges of projections for four emission scenarios (RCP2.6, RCP4.5, RCP6.0, RCP8.5) by 2100 are shown by the bars on the right. The dashed lines estimate interannual variability in sea level (5%–95% uncertainty range about the projections) and indicate that individual monthly averages of sea level can be above or below longer-term averages.

In Fiji in particular, projected Sea Level Trends under the SSP2-4.5 emissions scenario see sea-level rise around Fiji is anticipated to accelerate significantly. Projections suggest an increase of approximately 0.061 meters per decade from 2020 to 2050, which is more than double the historical rate. The average sea-level rise over this future period is expected to average 0.156 meters between 2020-2050. Furthermore, the highest average annual sea level before 2050 is projected to rise sharply, reaching 0.26 meters.

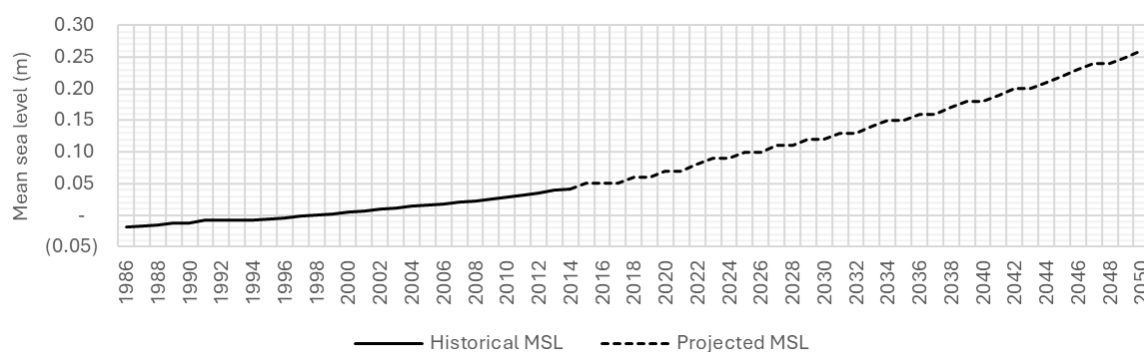


Figure 5-61. Current and projected sea level to the west of Fiji⁴⁴¹ for SSP2-45

Sea-level rises and storm surges pose imminent dangers. As sea levels climb, risks of coastal flooding during storm surges become more frequent. Urban areas face the brunt of this vulnerability, endangering lives and businesses, infrastructure, and livelihoods. Rising sea levels pose a significant threat to Fiji, with its 332 islands, including low-lying atolls, highly susceptible. As global temperatures rise, sea levels are projected to increase. Additionally, intensified storms due to warmer oceans will lead to more frequent and severe storm surges, exacerbating coastal flooding. The economic impact is substantial, with projected damages of up to \$52 million annually on Fiji's main island of Viti Levu, roughly equivalent to four percent of the country's gross domestic product⁴⁴².

Ocean acidity

Ocean acidification affects not only marine ecosystems but also the natural food chain⁴⁴³. The balance of marine life is disrupted as certain species struggle to survive in more acidic sea water (hence ocean acidification), leading to shifts in species composition and potentially altering the entire⁴⁴⁴. Ocean acidification also affects a wide range of other marine animals, plants, and processes, such as fish, molluscs, crustaceans, seagrasses, phytoplankton, zooplankton, reproductive stages, and nutrient cycles, which are essential for the functioning and resilience of the ocean⁴⁴⁵ that requires global and local actions to reduce carbon emissions and protect marine ecosystems.

The food supply in the ocean is also affected by ocean acidification. Many marine organisms, including those commercially important for fisheries, find it harder to grow and reproduce in more acidic waters. This could lead to declines in fish stocks and other seafood, impacting the food security of millions of people who rely on the ocean for their dietary needs⁴⁴⁶. The economy is another area that is impacted by ocean acidification.

Changes in marine ecosystems can lead to substantial revenue declines, loss of employment and livelihoods, and other indirect economic costs⁴⁴⁷. Industries such as fisheries, aquaculture, and tourism, which are heavily dependent on healthy marine ecosystems, could be particularly hard hit⁴⁴⁸. In Fiji, this also includes indigenous and coastal communities who rely on coastal and marine resources for subsistence.

Tourism and recreation, particularly in areas with coral reefs or other unique marine attractions, can also be affected by ocean acidification⁴⁴⁹. Coral reefs are especially vulnerable to both ocean acidification and when it occurs in synergy with MHW. Acidification slows corals' ability to grow their skeletons, leading to weaker and less resilient reefs. Reducing carbon dioxide emissions is the most effective way to prevent further ocean acidification. High levels of

⁴⁴¹ Location (18.02S 177E) based on Global sea level change indicators from 1950 to 2050 derived from reanalysis and high resolution CMIP6 climate projections, Copernicus Climate data store. <https://cds.climate.copernicus.eu/datasets/sis-water-level-change-indicators-cmip6?tab=overview>

⁴⁴² <https://unfccc.int/news/how-fiji-is-impacted-by-climate-change>

⁴⁴³ Jin, P. et al. 2020. The Impacts of Ocean Acidification on Marine Food Quality and Its Potential Food Chain Consequences <https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2020.543979/full>

⁴⁴⁴ National Oceanic and Atmospheric Administration (NOAA), n.d. Understanding Ocean Acidification. Available at: <https://www.fisheries.noaa.gov/insight/understanding-ocean-acidification>

⁴⁴⁵ United States Environmental Protection Agency (EPA), n.d. Effects of Ocean and Coastal Acidification on Marine Life. Available at: <https://www.epa.gov/ocean-acidification/effects-ocean-and-coastal-acidification-marine-life>

⁴⁴⁶ Phys.org, 2022. Ocean Acidification Impact on Marine Food Webs

⁴⁴⁷ Frank, T and NEWS, E.E.2, 2025. Ocean Acidification Threatens the U.S. Economy. Scientific American. Available at: <https://www.scientificamerican.com/article/ocean-acidification-threatens-the-u-s-economy>

⁴⁴⁸ Winner, C., 2010. The Socioeconomic Costs of Ocean Acidification. Oceanus Magazine. Available at: <https://www.who.edu/oceanus/feature/the-socioeconomic-costs-of-ocean-acidification>

⁴⁴⁹ Oceana, n.d. Effects of Ocean Acidification on Corals. Available at: <https://usa.oceana.org/effects-ocean-acidification-corals>

carbon dioxide in the atmosphere, primarily from burning fossil fuels, are the main drivers of ocean acidification. In addition to reducing carbon dioxide emissions, managing and reducing other pressures on ecosystems can also help them cope with ocean acidification. This can include measures such as establishing policies that curb overfishing, protecting and restoring important habitats like mangroves and seagrasses, and reducing pollution. By taking a holistic approach to managing our marine resources, we can enhance the resilience of marine ecosystems and help them adapt to changing ocean conditions.

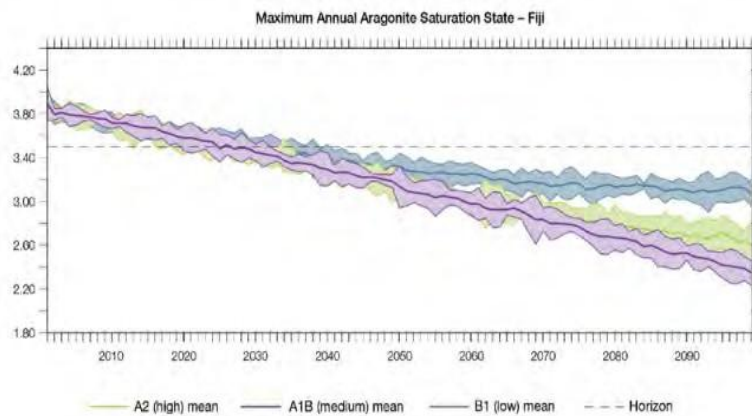


Figure 5-62 Multi-model projections, and their associated uncertainty (shaded area represents two standard deviations), of the maximum annual aragonite saturation state in the sea surface waters of the Fiji region under the different emissions scenarios

While projected changes in salinity for Fiji appear minimal, the predicted alterations in seawater chemistry, specifically the decline in calcite and aragonite concentrations and the decrease in pH, could have significant consequences for marine ecosystems. This is because these factors are crucial for the health and survival of many marine organisms, particularly those that rely on calcium carbonate for their shells and skeletons.

Calcite and aragonite are forms of calcium carbonate that many marine organisms, including corals, shellfish, and some plankton, use to build their shells and skeletons. A decrease in the availability of these minerals can hinder the growth and development of these organisms. This can lead to:

- **Weakened coral reefs:** Corals are particularly vulnerable to reduced aragonite saturation. This can lead to slower growth rates, weaker skeletons, and increased susceptibility to damage from storms and erosion.⁴⁵⁰ This weakening of coral reefs can have cascading effects on the entire reef ecosystem, as they provide habitat and food for a vast array of marine life.
- **Impacts on shellfish:** Shellfish, such as oysters, clams, and mussels, also rely on calcium carbonate to build their shells. Reduced availability of these minerals can lead to thinner, weaker shells, making them more vulnerable to predators and environmental stressors.⁴⁵¹ This can have significant impacts on shellfish aquaculture and fisheries.
- **Disruptions in the food web:** Plankton, which forms the base of the marine food web, can also be affected by reduced calcium carbonate availability. Impacts on plankton populations can ripple through the food chain, affecting fish and other marine animals that rely on them for food.⁴⁵²

The decrease in pH, although marginal, indicates a trend towards ocean acidification. As the ocean absorbs more carbon dioxide from the atmosphere, it becomes more acidic. This can have a range of impacts on marine organisms⁴⁵³:

- **Reduced calcification rates:** Ocean acidification makes it more difficult for marine organisms to build and maintain their shells and skeletons. This can affect their growth, reproduction, and overall survival.

⁴⁵⁰ Hoegh-Guldberg, O., Mumby, P. J., Hooten, A. J., Steneck, R. S., Greenfield, P., Gomez, E., & Knowlton, N. (2007). Coral reefs under rapid climate change and ocean acidification. *Science*, 318 (5857), 1737-1742.

⁴⁵¹ Gazeau, F., Parker, L. M., Comeau, S., Gattuso, J. P., O'Connor, W. A., Martin, S. & Ross, P. M. (2013). Impacts of ocean acidification on marine shelled molluscs. *Marine Biology*, 160(8), 2207-2245.

⁴⁵² Beaugrand, G., Reid, P. C., Ibañez, F., Lindley, J. A., & Edwards, M. (2002). Reorganization of North Atlantic marine copepod biodiversity and climate. *Science*, 296 (5573), 1692-1694.

⁴⁵³ Doney, S. C., Fabry, V. J., Feely, R. A., & Kleypas, J. A. (2009). Ocean acidification: The other CO₂ problem. *Annual Review of Marine Science*, 1(1), 169-192.

- Physiological stress: Acidification can also cause physiological stress in marine organisms, affecting their metabolism, respiration, and immune systems.⁴⁵⁴
- Changes in behaviour: Some studies have shown that ocean acidification can alter the behaviour of marine animals, affecting their ability to find food, avoid predators, and reproduce.⁴⁵⁵

The combined effects of decreased calcite and aragonite concentrations and ocean acidification can lead to a loss of biodiversity as marine organisms struggle to survive in a changing ocean environment. This can disrupt the balance of marine ecosystems and have cascading effects on food webs and ecological processes. Changes in the abundance and health of marine organisms can have significant impacts on fisheries and aquaculture industries, affecting livelihoods and food security. The degradation of coral reefs and other marine ecosystems can also have economic consequences, affecting tourism and other industries that rely on healthy oceans.

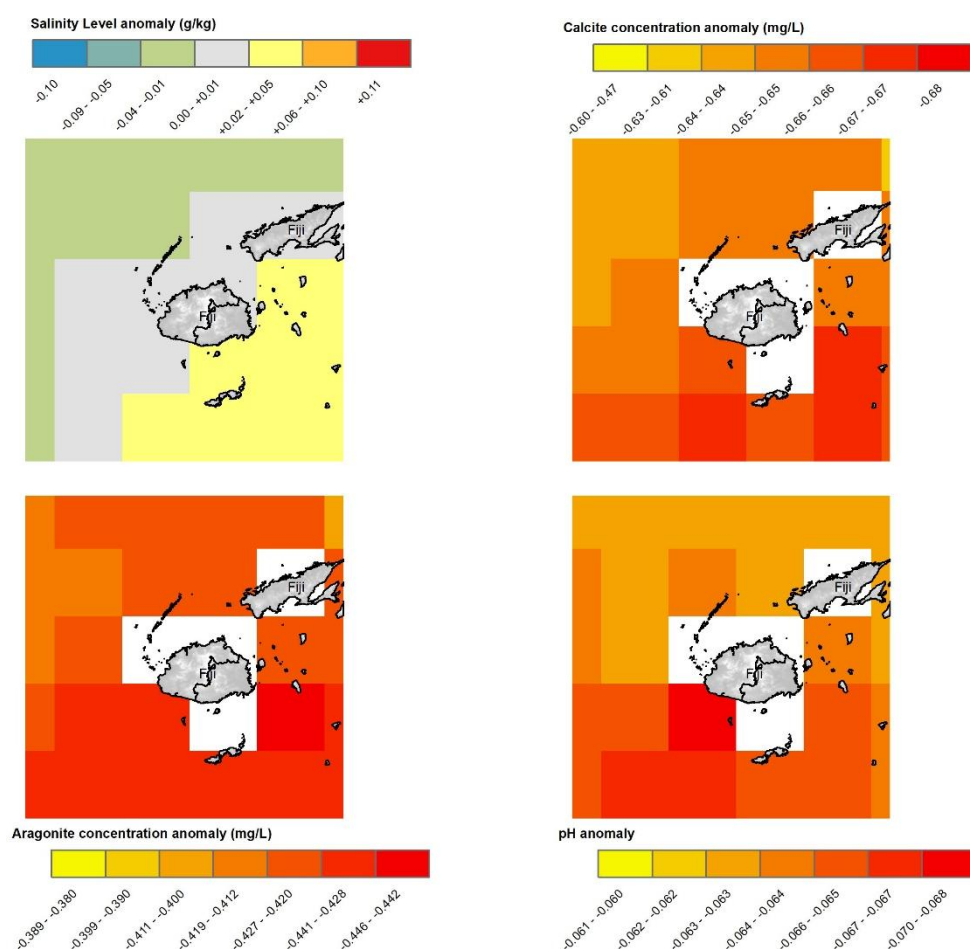


Figure 5-63: Projected anomaly ocean acidity characteristics. Salinity (top left), calcite concentration (top right), Aragonite concentration (bottom left), pH level (bottom right)

MHWs can have devastating effects on marine ecosystems and the communities that depend on them⁴⁵⁶. CMIP6 simulations, using climate models, indicate a significant increase in the intensity and frequency of MHWs in Fiji.

Table 5-9. Projected changes in the number of days per year with marine heatwaves in Fiji⁴⁵⁷

⁴⁵⁴ Pörtner, H. O., Karl, D. M., Boyd, P. W., Cheung, W. W., Lluich-Cota, S. E., Nojiri, Y. & Zavialov, P. O. (2014). Ocean systems. In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 411-484). Cambridge University Press.

⁴⁵⁵ Munday, P. L., Dixon, D. L., Donelson, J. M., Jones, G. P., Pratchett, M. S., Devitsina, G. V., & Doving, K. B. (2009). Ocean acidification impairs olfactory discrimination and homing ability of a marine fish. *Proceedings of the National Academy of Sciences*, 106(6), 1848-1852.

⁴⁵⁶ Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities - University Of Tasmania, accessed January 27, 2025,

https://figshare.utas.edu.au/articles/journal_contribution/Impacts_of_marine_heatwaves_on_tropical_western_and_central_Pacific_Island_nations_and_their_communities/23003147

⁴⁵⁷ Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities - University Of Tasmania, accessed

	Historical (1995-2014)	Projected (2050) - SSP1-26	Projected (2050) - SSP5-85
Moderate MHW (days per year)	10–50	>100 (>200 near the equator)	>200 (>300 near the equator)
Extreme MHW (days per year)	<1	<5	>50

The Pacific Ocean plays a major role in driving climate variability for Fiji, and changes in ocean temperature gradients can lead to shifts in rainfall patterns and cyclone development, with significant impacts on both marine and terrestrial ecosystems.⁴⁵⁸ With increasingly intense MHWs affecting nearshore regions, key habitat-forming species, seagrass, and corals, are likely to experience increasing stress. This can lead to the decline of these species, with potential impacts on biodiversity, ecological function, and the provision of ecosystem services.^{459 460}

Coastal communities in Fiji are heavily reliant on marine resources for their livelihoods and food security. Increased MHWs will likely lead to coral bleaching and mortality, with further effects on fish populations and the wider marine ecosystem. This could result in reduced fish catches, impacting the income and food security of fishing communities. This has implications for the long-term sustainability of fishing practices and the well-being of fishing communities.⁴⁶¹ The economic impacts of MHWs extend beyond fisheries. Damage to coral reefs will negatively affect tourism, a crucial sector of the Fijian economy.^{462 463 464}

5.3.4. Coastal flooding

For the future analysis, we used the projected mean sea-level for AD 2040 based on an SSP (Shared Socioeconomic Pathway) 2 -4.5 scenario from the Intergovernmental Panel on Climate Change (IPCC) which represents a mid-range scenario of expected sea-level rise due to future greenhouse gas emissions⁴⁶⁵. This scenario resulted in an increase in mean sea-level from the 1992 baseline of 0.15 m.

Synthetic Storm Dataset

As observed in the historical analysis, flooding from historical storms is confined to a narrow band along the mainland coastline due mainly to the steep nearshore profile and partly due to intervening offshore reef features.

Due to the widespread lack of observations from storms in the Southern Pacific, relative to, for example, the North Atlantic, the historical record of storms is inadequate for robust analyses of future impacts from storm surges. In such a situation, the generation of plausible synthetic storm tracks is a common approach for understanding potential future storm impacts.⁴⁶⁶ Using the three top-ranked storms that made landfall in Fiji, causing significant storm surge flooding, we created several synthetic storm tracks, to assess the potential future impacts of similar storms occurring along different tracks on the northern coastlines of the two islands. For each storm we generated synthetic tracks, assuming a 30 kilometer shift for each track, either on an east-west or a north-south axis, depending on the storm's initial track. For each storm, we generated enough tracks to study storm surge impacts on the northern coastlines of both islands. This exercise resulted in 5 tracks for Winston, 6 tracks for Evan, and 11 tracks for Yasa.

January 27, 2025,

https://figshare.utas.edu.au/articles/journal_contribution/Impacts_of_marine_heatwaves_on_tropical_western_and_central_Pacific_Island_nations_and_their_communities/23003147

⁴⁵⁸ Fiji: Ocean temperature record unlocked from coral - Oceanographic Magazine, accessed January 27, 2025,

<https://oceanographicmagazine.com/news/ocean-temperature-record-unlocked-from-coral-in-fiji/>

⁴⁵⁹ Marine heatwaves & oceanic changes - Deep South Challenge, accessed January 27, 2025, <https://deepsouthchallenge.co.nz/research-project/marine-heatwaves-oceanic-change/>

⁴⁶⁰ Global impacts of marine heatwaves on coastal foundation species ..., accessed January 27, 2025,

<https://pmc.ncbi.nlm.nih.gov/articles/PMC11176324/>

⁴⁶¹ Fiji summary report, accessed January 27, 2025, https://wwfesa.awsassets.panda.org/downloads/fichas-climate-crowd-fiji-2022_1.pdf

⁴⁶² Financing for Oceans and Climate Change - Pacific Islands Forum Secretariat, accessed January 27, 2025,

<https://forumsec.org/sites/default/files/2024-09/14.Financing%20for%20Oceans%20%26%20Climate%20Change.pdf>

⁴⁶³ Marine heatwaves & oceanic changes - Deep South Challenge, accessed January 27, 2025, <https://deepsouthchallenge.co.nz/research-project/marine-heatwaves-oceanic-change/>

⁴⁶⁴ Climate change transforms Pacific Islands - World Meteorological Organization WMO, accessed January 27, 2025,

<https://wmo.int/news/media-centre/climate-change-transforms-pacific-islands>

⁴⁶⁵ Lee, H., et al., IPCC, 2023: Climate Change 2023: Synthesis Report, Summary for Policymakers. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland. 2023.

⁴⁶⁶ McInnes, K.L., et al., Quantifying storm tide risk in Fiji due to climate variability and change. Global and Planetary Change, 2014. **116**: p. 115-129.

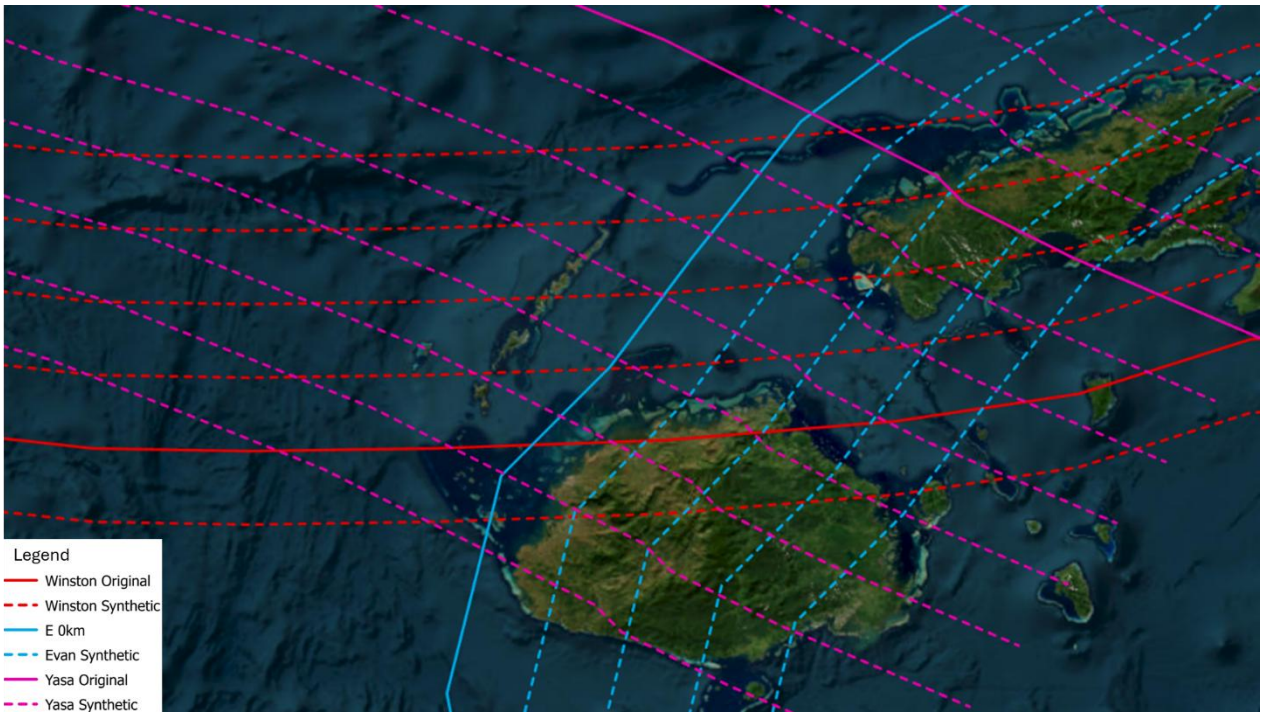


Figure 64: Modeled storm tracks for Tropical Cyclones Winston (red), Evan (blue) and Yasa (pink). Original tracks are shown as solid lines, and all synthetic tracks are shown as dashed lines. The tracks for each cyclone are a uniform 30 kilometres apart. World Imagery Basemap from ArcGIS.

Future Flooding from Storm Surges

We use the synthetic storm tracks and the future sea-level to calculate the potential flood heights and extents from storm surges across the entire study region. First, using the 2040 projected mean sea-level, we calculate peak flood heights from storm surges for each of the 22 cyclone tracks generated as described in Section 3.2. For each grid cell, we identify the maximum peak flood height (Max PFH) across all storm scenarios. We only consider a grid cell flooded when the peak flood height in that cell is greater than 10 cm. We delineate the maximum potential flood extent in 2040 by applying a 100-meter buffer to the flooded pixels, for a conservative estimate of maximum potential future flood extents.



Figure 65: Maximum potential future flood extent across 22 modelled storm tracks for an AD 2040 Mean Sea-Level under an SSP 2-4.5 climate scenario.

We then identify for each flooded grid cell, the specific storm scenario that contributed the maximum peak flood height value for that cell, to assess the relative importance of the 22 modelled storms at each flooded location (Figure 10). We find that out of the ~40,000 flood points, ~59% of all maximum peak flood heights are caused by the tracks associated with Storm Evan, ~40% by Storm Winston and less than 1% are caused by tracks associated with Storm Yasa.

Based on this analysis we eliminate Yasa and focus on the 11 tracks associated with two storms, Winston (a ~1% storm) and Evan (a ~2% storm) for the assessment of baseline future flooding impacts and the effects of project interventions on baseline flood impacts. For all flood analyses, we consider a grid cell flooded only if the peak flood height in that cell is greater than 10 centimetres, to account for model uncertainties.



Figure 66: Map indicating the storm track responsible for the maximum peak flood height at each flooded location. Shades of green indicate Storm Yasa tracks; shades of brown indicate Storm Winston tracks and shades of blue indicate Storm Evan tracks.

Future Flood Impacts with No Interventions (Baseline)

Before analyzing the effect of any interventions, we first analyze the maximum extent of peak flood heights across all five synthetic tracks from Winston, a ~1% storm, and 6 synthetic tracks from Evan, a ~2% storm on a 2040 SSP 2-4.5 mean sea-level. (Figure 10). We apply a 100-meter buffer to this extent, to ensure that we completely account for future flood risks from storm surges. This extent informs our assessment of future flood impacts for the baseline, i.e., no intervention, scenario. The maximum flood extents obtained by this approach correspond ultimately correspond to the flood extents from a ~1% chance storm surge event.

We then calculate future expected impacts within this flooded area for the baseline scenario, using the input datasets described in Table 1.1, for the following metrics:

1. Total area flooded (hectares)
2. Number of people flooded.
3. Area of urban/impervious land flooded (hectares)
4. Area of cropland/agricultural land flooded (hectares)
5. Number of buildings flooded.
6. Length of roads flooded (kilometres)

6. Reducing vulnerability and increasing resilience

This section summarises current and potential interventions to address the impacts of land use change and degradation, as well as climate impacts, on the Great Sea Reef and associated human populations. Current interventions undertaken by communities use local techniques to protect themselves from these impacts, with assistance from government and NGO initiatives, which are discussed in more detail in the following sections.

Given the goals outlined for the project, we focus on actions that prioritise protecting coral reefs that are least exposed to climate change but are in an optimal recovery position, enabling resident corals and coral reefs to repopulate adjacent coral reefs once environmental conditions have re-stabilised. In addition, the current project sites also

encompass some of the most vulnerable human populations to climate change. Approximately 25% of the Fijian population, for example, lived below the poverty line from 2020-2021⁴⁶⁷.

Systematic data analysis was coupled with structured interviews to conceptualise project areas (in the context of EbA and GI potential) and assess possible interventions. Local stakeholders and communities indicated that current adaptation measures aim to reduce soil loss and pollutants, manage human waste, manage sea level rise, storm surges, and flood control, and increase resilience to expected extreme events, with less successful attempts to manage fisheries. All communities expressed a need for better protection against flooding and extreme storms following the devastating and long-lasting impacts of Cyclone Winston. The information gathered during the field assessment and stakeholder consultations was used to assess the feasibility of potential interventions and engagement with project stakeholders. The data and information gathered during the field missions were used to inform the models, allowing them to (1) identify the best potential intervention sites and (2) assess the benefits of solutions for selected project sites under the expected impacts of climate change to both nature and people. Furthermore, one goal of the field missions was to collect local knowledge to combine international best practices with local knowledge to achieve Fiji CRR project goals. Successful reduction of the preceding barriers (i.e., successful delivery outputs) will lead to numerous benefits for the GSR and the Fijian population, which we aim to estimate here.

6.1. Composite Climate Risk Rating:

The four provinces adjacent to the Great Sea Reef (GSR), Ba, Ra, Bua, and Macuata, are home to approximately 360,000 people whose lives and livelihoods are closely tied to coastal and marine ecosystems, and who are increasingly exposed to sea level rise, coastal and riverine flooding, coastal erosion, and intensifying tropical cyclones (*Annex 2a, Section 4, pp. 46–70; Annex 6 ESMF, Section 2.3; FP Section B.1*). Sea level around Fiji is rising at approximately 6 mm per year and the project's storm surge modelling, based on the three most damaging historical cyclones (Winston, Evan, and Yasa) on a 2040 mean sea level under an SSP2-4.5 scenario (+0.15 m), predicts maximum flood heights of up to 5 m above mean sea level (*GCF Coastal Flooding Report, Sections 2–3; Annex 2a, Sections 5.2–5.3*). While the overall frequency of cyclones may decline, their intensity and rainfall are projected to rise, increasing the severity of coastal flooding. Against this shared climate backdrop, the four provinces differ markedly in their physical exposure, the number of people at risk, and their capacity to cope, differences in this assessment measures to explain how interventions were prioritized.

Risk Assessment Method

This assessment uses the risk framing of the IPCC Sixth Assessment Report (AR6). Under this framing, climate risk is the result of three factors working together: Risk = f (Hazard, Exposure, Vulnerability). In plain terms, hazards are the physical climate threat, such as flooding or storm surge. Exposure is the people and assets that sit in the path of that threat. Vulnerability is how easily those people are harmed and how well they can recover, which depends on their sensitivity (how dependent they are on climate affected livelihoods and how degraded their protective ecosystems are) and their adaptive capacity (their income, access to finance, and services). A province is only at high risk when all three factors are high. A severe flood over empty land, or over a community that can easily cope, produces less risk than the same flood over a crowded, poor, and exposed coastline. This approach is consistent with the composite disaster risk index already used in the Feasibility Study (*Annex 2a, Section 5.1.10, pp. 86 to 88*).

Each factor is measured for the four provinces using the indicators shown in the tables below. Every indicator is scored from 1 to 5 by ranking the four provinces against each other and by how far apart their values sit, drawing on data already in the Funding Proposal, the Feasibility Study (*Annex 2a*), and the ESMF (*Annex 6*). Each table includes a basis for scores column that states the reason for each rating. The scores translate to bands as follows: Very Low (0 to 1), Low (> 1 to 2), Medium (> 2 to 3), High (> 3 to 4), and Very High (> 4 to 5). The rating for each factor is the average of its indicator scores, and the overall risk is the average of the three factor ratings.

The three factors carry equal weight for two reasons. First, the IPCC AR6 framework treats hazard, exposure, and vulnerability as co-determinants of risk, with none inherently more important than the others. Second, the site-specific data that would justify weighting one factor more heavily will only be collected during implementation, so equal weighting avoids building an unsupported bias into the ranking. The assessment works at the province level because that is what the current data supports, while the precise siting of each intervention is confirmed later, during

⁴⁶⁷ Ministry of Waterways and Environment Strategic Plan 2020-2024. Available at: <https://faolex.fao.org/docs/pdf/fji199861.pdf>

implementation, through site validation activities including localized risk assessments, that let the design adjust to local conditions.

Hazard Rating:

The hazard rating captures the physical climate threat each province faces, independent of who lives there, combining modelled flood extent and height, riverine discharge, and sea-level-rise-driven flood susceptibility.

Province	Flood extent & height	Score	Riverine discharge	Score	SLR & flood-susceptible area	Score	Hazard (avg)
Ba	1156 ha of maximum modelled flood extent	5	Three rivers (Ba 18.27, Nadi 9.45, Nasivi 5.24 m ³ /s)	4	~6 mm/yr; 26% area flood-susceptible	3	High (4.0)
Macuata	489 ha of maximum modelled flood extent	3	Five rivers (Naua 18.82, Labasa 6.93, Qawa 5.40, Wailevu 4.1, Waimanu 4 m ³ /s)	5	~6 mm/yr; 13% area flood-susceptible	2	High (3.3)
Ra	135 ha of maximum modelled flood extent	2	Penang River (5.25 m ³ /s)	1	~6 mm/yr; 43% area flood-susceptible	5	Medium (2.7)
Bua	65 ha of maximum modelled flood extent	1	Two-discharge rivers (Namatatoka 5.36, Nambitimbiti 4.88 m ³ /s)	2	~6 mm/yr; 31% area flood-susceptible	4	Medium (2.3)

Note: the sea-level-rise rate is uniform (~6 mm/yr) across all provinces, so the third column reflects topographic flood-susceptibility rather than a higher rate of rise; Ra and Bua have the most flood-prone land by area despite smaller absolute flood extents.

Exposure Rating:

Exposure measures how many people and assets sit in the hazard's path, which is why a highly flood-prone province with few residents can still be low-exposure. It is assessed through the population within the modelled flood zone and population density as a proxy for the concentration of people and assets on the low-lying coast.

Province	People in flood zone (direct beneficiaries)	Score	Population density	Score	Exposure (avg)
Ba	24,014	5	94.0 /km ²	5	Very High (5.0)
Macuata	8,689	3	32.9 /km ²	2	Medium (2.5)
Ra	1,913	2	22.7 /km ²	2	Low (2.0)
Bua	725	1	11.2 /km ²	1	Very Low (1.0)

Note: exposure runs inverse to the hazard table's susceptibility column; Ra and Bua are the most flood-prone by land area but the least exposed by population, because their coastlines are sparsely settled.

Vulnerability Rating:

The vulnerability rating measures how easily people in each province are harmed by climate hazards and how well they can recover. It combines two things: sensitivity, meaning how dependent people are on climate affected

livelihoods such as fishing and farming, the condition of the ecosystems that buffer their coast, and social factors such as poverty and gender-based vulnerability; and adaptive capacity, meaning their income, access to finance, and services. Adaptive capacity is scored in reverse, so weaker capacity to cope produces a higher vulnerability score. The scores draw on the community consultations carried out across the four provinces in early 2024, recorded in the feasibility study, alongside the most recent Fiji Bureau of Statistics data, including the 2017 Census (rural share, disability rates, and population change) and the 2019 to 2020 Household Income and Expenditure Survey (division poverty rates). Because the Bureau reports poverty and income by division rather than by province, rural share and division poverty are used as proxies for household income, with the two Western provinces (Ba and Ra) and the two Northern provinces (Bua and Macuata) taking their respective division figures. A key consideration is that low exposure can mask high vulnerability: Bua, for example, is almost entirely rural with the highest poverty and disability rates of the four provinces, so its vulnerability is very high even though few people live in its flood zone.

Province	Sensitivity (livelihood + ecosystem + social)	Score	Adaptive capacity (finance, income, services)	Score	Vulnerability (avg)
Ba	31% rural; dependent on sugar, coastal farming, and fishing; 120 ha mangrove lost	3	Poverty 32.4% (Western); commercial centers at Lautoka and Ba Town give better finance and services; disability 13.0%	3	Medium (3.0)
Macuata	59% rural; dependent on farming and fishing; degraded reefs and declining fish stocks	4	Poverty 35.2% (Northern); limited finance and services outside Labasa; disability 14.7%	3	High (3.5)
Ra	80% rural; dependent on subsistence farming and fishing; silted rivers and degraded land	4	Poverty 32.4% (Western); very limited finance and services; disability 15.4%	4	High (4.0)
Bua	96% rural; dependent on subsistence farming and fishing; mangrove loss from mining and pine runoff	5	Poverty 35.2% (Northern); very limited finance and services; disability 16.9% (highest)	5	Very High (5.0)

Note: adaptive capacity is scored inversely (a higher score denotes weaker capacity); Bua has the highest on vulnerability, combining strong livelihood dependence with the weakest coping capacity.

Climate Risk Rating:

The overall climate risk for each province is the arithmetic mean of its hazard, exposure, and vulnerability ratings carried from Tables 1–3. A province rates high risk only where the physical threat, the exposed population, and the vulnerability are all elevated, so that the largest investments are directed where the combined determinants of risk are greatest.

Province	Hazard	Exposure	Vulnerability	Overall risk (avg)	Resulting intervention priority (FP Tables 8–10)
Ba	largest flood extent, moderate river discharge, moderate flood prone land - 4.0	largest exposed population, densest coast - 5.0	least rural, farming and fishing dependent, moderate poverty - 3.0	High (4.0)	Highest priority: 541 ha mangrove, 896 ha riparian, 3.29 km living shoreline (995 ha flood reduction; 24,014 direct).

Macuata	moderate flood extent, highest river discharge, low flood prone land - 3.3	second largest exposed population, moderate density - 2.5	moderate rural, farming and fishing dependent, high poverty - 3.5	High (3.1)	Highest priority: 6.67 km living shoreline (446 ha flood reduction), 721 ha riparian, 102 ha mangrove (8,689 direct).
Ra	smallest flood extent, lowest river discharge, highest flood prone land - 2.7	small exposed population, sparse density - 2.0	heavily rural, farming and fishing dependent, moderate poverty - 4.0	Medium (2.9)	192 ha mangrove, 424 ha riparian, 0.57 km living shoreline (1,913 direct).
Bua	small flood extent, low river discharge, high flood prone land - 2.3	smallest exposed population, sparsest density - 1.0	heavily rural, farming and fishing dependent, high poverty - 5.0	Medium (2.8)	483 ha riparian, 1.46 km living shoreline (725 direct).

Note: the overall risk is the equal-weighted average of the three determinant scores from Tables 1–3.

Conclusion: The results show that Ba carries the highest overall climate risk (4.0), combining high hazard with the largest exposed population (24,014 direct beneficiaries) and high vulnerability. It accordingly receives the largest restoration areas and a major living-shoreline segment. Macuata is the second priority (3.1), where high vulnerability and a substantial exposed population justify the longest living-shoreline segment and extensive riparian restoration. Ra (2.9) and Bua (2.8) illustrate the central dynamic of the assessment: both have high areal flood-susceptibility and high vulnerability, but their low exposure, few people living in the flood zone, reduces their overall risk, so their allocations are scaled to that smaller exposed base. This province-level ranking provides the evidence base for prioritization of the interventions, with precise siting confirmed during implementation to accommodate the context-specific conditions of each site.

6.2. Current Adaptation and Intervention Objectives

Healthy ecosystems are critical for solving many of the world’s pressing challenges, including food and water insecurity and climate change. For ecosystems to continue to provide services and benefits to society under increasing anthropogenic pressures and environmental change, effective management, restoration, and protection measures are needed. This is reflected in many international and national priorities, including the Sustainable Development Goals⁴⁶⁸ and the Kunming-Montreal Global Biodiversity Framework⁴⁶⁹. Nature-based solutions (NbS) aim to leverage ecosystem processes and functions to benefit humans and nature⁴⁷⁰. The FS here refers to the planned and deliberate use of ecosystems and ecosystem services to improve coastal and marine water quality and the increased resilience to climate change, particularly for coral reefs, coastal ecosystems and adjacent human communities. NbS is an umbrella term encompassing many approaches to leverage ecosystems for provisioning, regulation, cultural and supporting services⁴⁷¹. This report focuses on two categories of NbS: ecosystem-based adaptation (EbA) and living shorelines. The current adaptation measures are summarised within the two categories below.

- (1) **Ecosystem-Based Adaptation (EbA).** EbA involves the conservation, sustainable management, and restoration of ecosystems that can help people adapt to the impacts of climate change. EbA solutions are actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively. EbA actions simultaneously provide human livelihood, well-being and biodiversity benefits. EbA programs have emerged as key strategies to enhance the resilience of people,

⁴⁶⁸ <https://sdgs.un.org/>

⁴⁶⁹ <https://www.cbd.int/gbf>

⁴⁷⁰ FLMMA Operations Guide. Available at: https://www.sprep.org/attachments/pipap/flmma_operations_guide_1.pdf.

⁴⁷¹ https://www.un-redd.org/sites/default/files/2021-10/Fiji%20REDD%20Policy_final.pdf

promote sustainable development, and safeguard vulnerable ecosystems in Fiji.⁴⁷² ⁴⁷³ Several EbA programs in Fiji aim to address climate-induced stressors and build adaptive capacity. These programs often involve the restoration and conservation of critical ecosystems for reducing human vulnerability, including mangroves, seagrass meadows, and coral reefs, as well as the connections between ecosystems and human activities (e.g., food, and shelter). Local and international organisations collaborate with government agencies and communities to implement landscape initiatives and activities such as ridge-to-reef planning, with varying levels of success.

EbA involves a variety of strategies to enhance the resilience of ecosystems and communities to climate change, including regular ecosystem health assessments and monitoring to identify changes and threats, implementing sustainable fishing practices to prevent overfishing and maintain marine biodiversity, rehabilitating degraded ecosystems through restoration and regeneration efforts like reforestation and wetland restoration, and engaging local communities in conservation efforts to ensure that adaptation measures are culturally appropriate and locally supported. These actions help maintain crucial ecosystem services such as clean water, food, and protection from natural disasters.

- (2) Living shorelines. A protected and stabilized shoreline that is made of natural materials such as plants, sand, or rock. Living shorelines are sometimes referred to as green or soft shorelines. Unlike traditional “hard” shoreline stabilization techniques, such as concrete seawalls, living shorelines are made of natural materials such as plants, sand, rock, or oyster shells.⁴⁷⁴



Figure 0-1 GI-solution applied to mangroves generates actions that will protect, sustainably manage and restore natural or coastal ecosystems. Here, communities have built rock walls and caging wire designed to support the penetration of young mangrove seedlings while also stabilising the shoreline (Labasa, March 2024; OHG).

GI is founded on a strategic urban planning and environmental management theme, which has evolved as a vital tool for climate change adaptation. Rooted in integrating natural systems into the built environment, GI addresses the multifaceted challenges of climate change while enhancing ecosystem services and promoting sustainable development. GI encompasses a diverse range of components, including urban parks, green roofs, permeable pavements, wetlands, green seawalls, and reforestation projects. These elements work synergistically to absorb and manage stormwater, storm surges and sea level rise, as well as reduce urban

⁴⁷² Convention on Biological Diversity (CBD), 2017. Technical Series No. 93: Marine Spatial Planning and Biodiversity Conservation. Available at: <https://www.cbd.int/doc/publications/cbd-ts-93-en.pdf>.

⁴⁷³ Climate Change Laws of the World, 2018. Fiji National Climate Change Policy 2018-2030. Available at: https://climate-laws.org/documents/national-climate-change-policy-2018-2030_676a?id=national-climate-change-policy-2018-2030_4019.

⁴⁷⁴ https://link.springer.com/referenceworkentry/10.1007/978-3-319-73645-7_46.

heat island effects, enhance biodiversity, and provide recreational spaces. Importantly, they contribute to the overall adaptive capacity of communities.

GI is set to play a pivotal role in enhancing Fiji's climate resilience. The country's town councils are actively strengthening both natural and built infrastructure to help vulnerable settlements. Natural infrastructure harnesses the benefits of ecosystems like mangrove forests, while 'built' infrastructure refers to manmade structures like sea walls. This combination of natural and built infrastructure is crucial for building resilience against climate change.

For coral reefs, GI can reduce land-based run-off and nutrient pollution to improve water quality and reduce the risk of diseases and pathogens. This can have additional impacts on fisheries (healthier fish populations), tourism, human well-being and adaptive capacity (coastal/infrastructure protection), and human health (reduced pathogen exposure). Investments in GI often yield long-term economic and social benefits due to operational cost and resource savings, increased value of natural and built assets, and improvement in human well-being. This is only guaranteed if 1) the solutions include considerations of the nature of future climate scenarios 2) consistent post-implementation monitoring is implemented and maintained.

There are several ongoing initiatives related to living shorelines in Fiji. For example, the Green Growth Framework was developed in 2014 to strengthen environmental resilience, build social improvement and inclusion while reducing poverty, and strengthen economic growth, food security and capacity to withstand and manage the adverse effects of climate change⁴⁷⁵. The framework has served as the cornerstone of the National Development Plan and combined with the Fijian Sustainable Bond Framework⁴⁷⁶ has the potential to support significant change.

Alongside these national-level priorities and frameworks, individual projects supported by diverse funders are also taking place. In the water, sanitation and hygiene (WASH), the Wildlife Conservation Society is leading the Watershed Interventions for Systems Health (WISH) project to support improved sanitation for ecosystem and human health. The Asian Development Bank has supported GI initiatives in Fiji since the 1970s and is working to improve sanitation at the largest wastewater treatment plant in Kinoya, build resilience to natural disasters, and support renewable energy⁴⁷⁷. Fiji was also a priority location for China's Belt and Road Initiative⁴⁷⁸ - which presents both opportunities and major concerns for GI development - with discussions of a reboot of the program in the near term. More work could be done to ensure nature-based solutions and GI are incorporated into these plans to achieve multiple benefits for the environment and vulnerable human communities.

Table 0-1 Review of ecosystem-based adaptation projects and interventions in Fiji. Adapted from Prasad et al. (2022)⁴⁶⁹.

Program / Intervention	Project implementation	Project Location(s)	Theme	URL	Description	Status
Coral gardening	Reef Explorer	Coral Coast	EbA	https://www.fiji-journal.com/bula-reef-worlds-largest-underwater/#:~:text=Video:%20Bula%20Reef:%20A%20Rescue, Fun%20Fact%201	Establishment of coral nurseries and "planting" of "super corals" that are more tolerant to heat stress.	Ongoing

⁴⁷⁵ <https://faolex.fao.org/docs/pdf/fij164896.pdf>.

⁴⁷⁶ Fijian Government (2022) Fijian Sustainable Bond Framework. Available at: <https://fijiclimatchangeportal.gov.fj/wp-content/uploads/2022/11/Fijian-Sustainable-Bond-Framework.pdf>.

⁴⁷⁷ Asian Development Bank (2025) 'Where we work: Fiji', Asian Development Bank. Available at: <https://www.adb.org/where-we-work/fiji>.

⁴⁷⁸ World Bank (2025) 'Belt and Road Initiative', World Bank. Available at: <https://www.worldbank.org/en/topic/regional-integration/brief/belt-and-road-initiative>.

Adaptive co-management in Kubulau Marine Protected area Network	Wildlife Conservation Society	Kubulau	EbA	https://pubmed.ncbi.nlm.nih.gov/24112643/	Since 2005, the Wildlife Conservation Society (WCS) has worked closely with communities in Kubulau District, Fiji, to develop a network of locally implemented and managed marine protected areas (MPAs). This collaborative effort combines customary, periodically harvested closures (tabu areas) with permanent no-take areas and represents one of the first attempts to design and implement an ecologically functional MPA network in Oceania.	2005-2014
Pacific Ecosystem-based Adaptation to Climate Change (PEBACC) project	Kiwa Initiative, SPREP	Fiji – national scale	EbA	https://www.sprep.org/pebacc-plus	PEBACC+ is organised around three components: Component 1: Strengthen stakeholders' experience in the practical implementation of EbA and Nature-based Solutions (NbS) as a climate change adaptation strategy in Fiji, Vanuatu & the Solomon Islands. Component 2: Integrate and support the implementation of the EbA and NbS approach as a strategy contributing to climate change adaptation in New Caledonia and Wallis & Futuna. Component 3: Strengthen regional cooperation between Pacific Countries and Territories in the area of EbA by promoting the sharing of experiences and lessons learned from projects to increase the resilience of populations and ensure the sustainability of EbA implementation activities.	2015-2020
Climate Vulnerability Assessment	Fijian government	Fiji – national scale	EbA	https://documents1.worldbank.org/curated/en/163081509454340771/pdf/Climate-Vulnerability-Assessment-Making-Fiji-Climate-Resilient.pdf	Review of disaster risk reduction and climate change adaptation policy	2018
Vetiver grass nursery and COWRIE Project (Towards Coastal and Watershed Restoration for the Integrity of Island)	University of the South Pacific	Naroko, Ra Province	EbA	https://www.scribd.com/document/513015363/Vetiver-TheMiracleGrasses	Capacity building, adaptation, and use of riparian buffers through vetiver grass cultivation and restoration.	2009-2011

Environments)						
Ridge-2-Reef programme	GEF-5	Fiji – national scale (two main islands)	EbA	https://www.pacific-r2r.org/sites/default/files/2020-03/Fiji.pdf	Ridge to reef management of priority water catchments on the two main islands of Fiji to preserve biodiversity, and ecosystem services, sequester carbon, improve climate resilience and sustain livelihoods	2015-2018
Gau Island forest protection (Lomani Gau)	National Trust of Fiji	Fiji - Gau Island	EbA	https://catalog.ipbes.net/assessments/74	Preservation of cloud forest and coastal habitat using EbA management, participatory approaches and integrated resource management	Ongoing
Water for Women Project	Water for Women Fund, Australian Aid	Fiji – 18 communities across the Ra and Ba Provinces	GI	https://www.waterforwomenfund.org/en/project/water-for-women---fiji.aspx	Community-based projects focused on the delivery of water sanitation and hygiene promotion assistance. Some aspects of WASH are NbS.	Ongoing
Water and Nature Initiative (WANI)	IUCN	Fiji - Nadi River Basin and Kadavu Island Watersheds	EbA	https://waterandnature.org/all-initiatives/wani/	Projects focused on good governance, payments for ecosystem services and learning and leadership, to improve the quality and sustainability of water resources in the region.	2001-2012
Conservation International SAMBIO - GEF Project	Conservation International, Department of Environment, Ministry of Environment	Fiji – national scale	EbA	Safeguarding Marine & Terrestrial Biodiversity in Fiji (SAMBIO)	To establish new marine and terrestrial protected areas within priority areas of biodiversity and strengthen Fiji's protected area network, improve the management of key biodiversity areas in forests and coastal ecosystems to protect Fiji's most threatened biodiversity, and strengthen policy and financing pathways to secure ecosystem services and other benefits to island communities into the future.	Ongoing
IUCN Oceania Mangrove Ecosystems for Climate Change Adaptation and Livelihoods (MESCAL) Project	IUCN Oceania	Fiji – national scale (and other countries)	EbA	https://vanuatu-data.sprep.org/system/files/mangroves_biodiversity_assessment_report_vanuatu.pdf	An IUCN Oceania project to address the key challenges of mangrove management to increase the resilience of the Pacific people to climate change and improve livelihoods	2012-2014

Watershed Intervention for Systems Health (WISH) Fiji	Wildlife Conservation Society	Fiji – national scale (5 river sub-catchments)	GI	https://wishfiji.sydneym.edu.au/	Implementation of improved sanitation infrastructure and capacity building to improve human and ecosystem health.	Ongoing
Revitalising Informal Settlements and their Environments (RISE) project	Monash University and a consortium of communities, researchers, governments, non-profit and industry partners (see URL)	Fiji – national scale (and other countries)	GI	https://www.rise-program.org/	RISE aims to enable communities to recycle their wastewater, harvest rainwater, create greenspace for water cleansing and food cultivation, restore natural waterways to encourage diversity, reduce vulnerability to flooding and climate change to improve community health, increase food production, and decrease gender inequalities.	Ongoing
WWF Great Sea Reef Programme	WWF	Focused on the Vanua Levu coastline – Dreketi, Macuata, Sasa and Mali	EbA	https://www.wfpacific.org/priority_places/fiji/great_sea_reef_seascape/	The programme looks at practical and transformational ways of affording the GSR protection, employing a ridge-to-reef approach, from sustainable land use practices, influencing green lending policies, and working with the Fijian government for the legal protection of this important reef system.	Ongoing
WWF Mali Fiji Community Development Programme	WWF	Mali	EbA	https://wwf.panda.org/es/?222512/Innovative-island-solutions-for-thriving-oceans---a-Fiji-case-study	WWF Pacific has injected funds into the setup of income-generating projects in the four villages of Mali district, Vesi, Ligaulevu, Nakawaga and Matailabasa, in Macuata province, Fiji, to alleviate the pressure sustained on marine resources. Alternative sources of income that are being explored include compost piggery, cash cropping and a nursery filled with all kinds of food-bearing trees.	Ongoing
FAO Strengthening small-scale fisheries in the Pacific Islands	FAO	Fiji – national scale (and other countries)	EbA/CSA	Unavailable	This project is implemented across Fiji, Solomon Islands and Vanuatu to improve the resilience of coastal communities through improved capacity to adapt management of nearshore resources to climate change and reduce vulnerabilities through a focus on gender equity.	2021-2023
RESCCUE Project	European Commission	Fiji – national scale but	EbA	https://toolkit.resccue.eu/	RESCCUE developed its activities in Kadavu and Ra in an integrated coastal management and climate change resilience perspective. In line with its	2016-2018

		focused in Kadavu and Ra (and other countries)			overall rationale, the project endeavoured to reduce non-climate stressors on the ecosystems to increase their resilience as well as the resilience of communities depending on them. Activities were divided into six broad areas synergetic with one another.	
Climate Resilient Food Systems (CRFS) Alliance	UNFCCC	Fiji-national scale (and other countries)	CSA	https://www.unfoodsystemshub.org/food-systems-coalitions/climate-resilient-food-systems-alliance-(crfs)/en	The project aims to promote self-sufficiency to build resilience through local production, provide leadership and resourcing, enable collaboration for Fiji food systems dialogues, create an environment to bolster primary sector performance, and ensure relevant agencies are accountable for the delivery of agreed objectives.	Ongoing
Fijian Government 30 Million Trees project	Ministry of Forestry	Fiji – national scale	EbA	https://www.parliament.gov.fj/wp-content/uploads/2021/03/WR-37-of-2021.pdf	This government-led initiative aims to plant 30 million trees in 15 years to increase the resources forests provide to address environmental decline, and rising temperatures, and offset emissions from highly industrialized sectors.	Ongoing
Strengthening Fiji's network of Locally Managed Marine Areas (LMMAs) to support globally significant marine biodiversity	UNDP – GEF6, Ministry of Environment, Ministry of Fisheries	Fiji – national scale	EbA	https://www.thegef.org/projects-operations/projects/9944	To strengthen and integrate LMMAs into Fiji's Marine Protected Area system through improved institutional and local capacity, managing planning and monitoring	2019-2023
Pacific-European Union Marine Partnership Program	European Union, Sweden, IUCN, WWF, SPREP, Pacific Community, University of the South Pacific	Fiji – national scale (and other countries)	EbA	https://www.eeas.europa.eu/eeas/pacific-eu-marine-partnership_updated_en	The program's overall objective is to: Improve the economic, social and environmental benefits for 15 Pacific ACP states (PACPs) arising from stronger regional economic integration and the sustainable management of natural resources and the environment. The specific objective (outcome) is to: Support sustainable management and development of fisheries for food security and economic growth while addressing climate change resilience and conservation of marine biodiversity.	2019-2023
Vibrant Oceans Initiative and Ocean Initiative	Bloomberg Philanthropies	Fiji-climate resilient reefs (as defined in this	EbA	https://thecommonwealth.org/spotlight/bloombergvo	This project aims to strengthen community-based fisheries management in the Lau Seascape and other sites through improvements in coastal management, including mainstreaming women in fisheries management.	2020-2023

		project), including other countries				
Lau Seascope GEF7	Blue Nature Alliance	Lau	EbA	https://www.bluenaturealliance.org/locations/lau-seascope-fiji/	Lau Seascope initiative aims to strengthen offshore and inshore protection commitments in partnership with the government and indigenous peoples.	2020-2022
Biodiversity Finance Initiative (BIOFIN I, BIOFIN II)	UNDP	Fiji – national scale (and other countries)	EbA/GI/CSA	https://www.biofin.org/	The project maps the impact of economic sectors on biodiversity, identifies the main financing mechanisms being used and reviews which subsidies have an impact on biodiversity. It also reviews the overall financing architecture for biodiversity in the 17 GEF-7 PIF Template-March 15, 2019 (revised) country and generates specific recommendations for an improved institutional framework.	2012-2022
Building climate resilience in the Pacific	KIWA Initiative	Fiji – national scale (and other countries)	EbA	https://kiwainitiative.org/en/about-kiwa-initiative	The mission of the Kiwa Initiative is to help the authorities of the Pacific Island Countries and Territories (PICTs) to implement their climate change adaptation strategies through Nature-based Solutions, thanks to a unique system of financing and project development assistance. https://kiwainitiative.org/en/about-kiwa-initiative	2017-2024
FAO Forest and Landscape Management Mechanism	FAO	Fiji – national level with field activities in Mamanuca and Yasawa islands	EbA	https://www.fao.org/in-action/forest-landscape-restoration-mechanism/en	Global Partnership on Forest and Landscape Restoration (GPFLR), more than 2 billion hectares (ha) of the world's deforested and degraded landscapes have potential for forest and landscape restoration (FLR).	Ongoing

Given the close relationship between land-use practices and coastal and marine ecosystem health, several EbA programs recognise the interconnectedness of terrestrial and marine ecosystems - which is a primary pressure threatening Fiji's coral reefs and the GSR. Integrated coastal zone management is another subset of EbA⁴⁷⁹. Due to Fiji's immense coastal and marine resources, integrated coastal zone management is a key strategy for maintaining these resources. "Ridge to reef" management (also known as land-sea planning) features prominently in many of Fiji's integrated coastal zone management plans - making it a leader in this space and emphasising the importance of upstream actions on downstream ecosystems.

Table 0-2 Review of integrated coastal zone management plans in Fiji (2005–2022)

Integrated Coastal Zone Management Program	Date	Scale
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⁴⁷⁹ <https://leap.unep.org/en/countries/fj/national-legislation/integrated-coastal-management-framework-republic-fiji-2011>

Kubulau "ridge to reef" management plan (WCS)	2005	Sub-national
Lekutu "ridge to reef" management plan (WCS)	2015	Sub-national
Nadi "ridge to reef" management plan (WCS)	2015	Sub-national
Wainunu "ridge to reef" management plan (WCS)	2015	Sub-national
Solevu "ridge to reef" management plan (WCS)	2015	Sub-national
Wailevu "ridge to reef" management plan (WCS)	2015	Sub-national
Western Bua "ridge to reef" management plan (WCS) (Dama, Lekutu, Vuya, Bua, Navakasiga)	2012	Sub-national
Ovalau "ridge to reef" management plan (WCS)	2015	Sub-national
Koro "ridge to reef" management plan (WCS)	2015	Sub-national
Coral Coast Integrated Coastal Management Pilot plan	2003	Sub-national
Integrated Coastal Management Plan for the Republic of Fiji	2011	National
Kadavu Integrated Coastal Management Plan	2017-2022	Sub-national
United Nations Integrated Coastal Management to Preserve Ecosystems Services, Improve Climate Resilience and Sustain Livelihoods in Fiji - Ra Province	2017-2030	Sub-national
The INTEGRE project: Pacific Territories Initiative for Regional Management of the Environment	2014-2017	Multi-national
The RESCUE project: Restoration of ecosystem services and adaptation to climate change	2014-2018	Multi-national
Coral Reef Initiatives for the Pacific (CRISP)	2008	Multi-national

While EbA programs bring significant benefits, both environmental and socio-economic, challenges persist. Adequate funding, technical capacity, and long-term commitment are essential for sustained success. Moreover, climate change poses evolving threats that require adaptive management strategies. Collaborative efforts, both nationally and internationally, are crucial to overcoming these challenges and seizing opportunities for continued success. Successful EbA programs integrate local communities into decision-making processes, which is particularly important in Fiji due to its rich cultural heritage.

6.3. Barriers to change

Understanding the types of barriers that are potentially standing in the way of effective management interventions can be very insightful. There are several challenges and barriers to implementation that, if addressed through this project, could lead to meaningful change.

Barriers to managing the GSR sustainably and enhancing climate resilience:

Barrier 1: Limited evidence of EbA and living shorelines as viable solutions to address climate change risks on vulnerable landscapes and seascapes in Fiji. In Fiji, there is limited consolidated, context-specific, and decision-useful evidence which demonstrates the benefits of NBS interventions as viable adaptation solutions to address climate change at a scale which impacts vulnerable landscapes and seascapes and, as a result, existing regulatory and planning frameworks do not sufficiently integrate these approaches in Fiji's strategic documents which direct public and donor climate efforts and finance. Fiji's reliance on its natural assets, and prominently the GSR, to sustain its fisheries and tourism industries require NBS solutions to climate change which reduce the vulnerability of people and communities and sustain the ecosystem services they provide. Current restoration efforts are fragmented, are not implemented at a sufficient scale to achieve measurable ecosystem benefits which reduce community vulnerability and are not harmonized and coordinated under integrated plans for seascapes and landscapes. Past efforts have also failed to sufficiently consider future medium to long-term climate threats and scenarios. The GoF has also not had sufficient financial resources to implement EbA and GI at the scale required to generate sufficient evidence of their potential to enhance the climate resilience of people and nature and promote their adoption into future R2R planning.

Barrier 2: EbA, living shorelines, and R2R planning are not sufficiently integrated in Fiji's National Adaptation Plan (NAP), National Biodiversity Strategy (NBSAP), and Provincial Adaptation Plans. Because there is limited evidence of EbA and living shorelines as viable adaptation solutions to climate change impacts on landscapes and seascapes in Fiji, they are not sufficiently included in the country's NAP, National Biodiversity Strategy (NBSAP), and Provincial Adaptation Plans. These plans therefore need to be updated to identify seascapes and landscapes with high

vulnerability to climate change, determine a suite of viable adaptation solutions (with a priority for EbA and living shorelines which have high potential to provide sustained ecosystem goods and services to people and enhance biodiversity) and include EbA and living shorelines in R2R planning and management principals with a sufficient timescale to considerably reduce climate risks threatening communities and the GSR which is so critical for livelihood security in Fiji. A knock-on effect of this regulatory gap is that government staff in the MECC, MoWR, and Divisional Departments such as the Provincial Departments, as well as local communities, do not have sufficient and necessary technical and institutional capacity to implement, monitor, operate and maintain EbA and living shoreline interventions, nor do they have access to essential tools and technologies to conduct this work. Current restoration efforts are fragmented, are not implemented at a sufficient scale to achieve measurable ecosystem benefits which reduce community vulnerability and are not harmonized and coordinated under integrated plans for seascapes and landscapes. Past efforts have also failed to sufficiently consider future medium to long-term climate threats and scenarios. The GoF has also not had sufficient financial resources to implement EbA and living shorelines at the scale required to generate sufficient evidence of their potential to enhance climate resilience of people and nature and promote their adoption into future R2R planning. As a result, the country is unable to take full advantage of investing in EbA and living shorelines to enhance biodiversity, improve ecosystem services, and increase resilience of people and nature to climate change impacts.

Barrier 3: Lack of available finance for communities in Fiji to implement locally led adaptation approaches. There is currently insufficient finance available in Fiji for local communities in the four target provinces to access finance to implement locally led adaptation approaches (including EbA and GI) to reduce the impacts of climate change on their livelihoods. This is largely because these communities (who are often involved in small-scale fisheries and subsistence farming to support their livelihoods and household income) do not have sufficient collateral to access finance from traditional banks and financial institutions (FIs). Communities also have limited capacity to prepare funding applications to access concessional finance from donors, philanthropies and other sources, which further limits pathways to finance. This problem is compounded by existing adaptation-focused programs being designed and implemented at the national level, resulting in missed opportunities for end beneficiaries to be involved in the decision-making, sustainable implementation, and monitoring of these programs, and leaving communities unable to access the necessary knowledge and technical assistance to adopt and implement adaptation approaches effectively. There is, therefore, an urgent need for concessional finance to be provided to these communities on the front lines of climate change impacts, not only to empower them to identify, design, implement and monitor adaptation solutions themselves, but also to connect community-driven adaptation strategies with national climate ambition to deliver on the targets set out in Fiji's NDC.

Barrier 4: Fiji's national policies have no accompanying plans and long-term operational procedures to execute, EbA, GI, and R2R plans in vulnerable landscapes and seascapes. To date, there are no sustained planning arrangements in the GSR for addressing increasingly frequent and severe SLR, coastal erosion and flooding brought on by climate change. There has also been no operationalization of the 2020 Climate Change Act's objectives in Fiji's vulnerable landscapes and seascapes, such as the GSR, with the necessary geographic scope, duration, and long-term operational procedures. As a result, the country remains locked into managing climate threats and disasters reactively without the necessary plans and management arrangements involving the government and communities. Despite strong policy commitments to reduce the vulnerability of its people to climate change hazards, Fiji's national policies currently lack the necessary plans and long-term operational procedures to effectively implement EbA, GI, and Ridge-to-Reef (R2R) planning in vulnerable ecosystems. There is also a need for capacity building, regulatory and planning harmonization, and improved governance to provide a blueprint for how priority landscapes and seascapes, such as the GSR, can be properly managed to reduce communities' exposure to climate change threats while creating new economic opportunities. Past efforts have been made in the GSR to execute NBS and apply R2R management, but these efforts have been curtailed by the following factors: these efforts had short implementation periods which made it difficult to achieve sustained and measurable reductions in climate and non-climate threats in the target geographies. The scope of previous initiatives mostly focused on single watersheds rather than including necessary efforts across multiple provinces to fully address threats to the GSR's connected landscapes and seascapes. Finally, there was no clear exit strategy built into these past efforts for the GoF to assume key roles, responsibilities, and important country ownership over defining future operational arrangements once the projects were concluded.

Barrier 5: Limited access to capital for reef-positive businesses that reduce pressure on coral reefs and coastal ecosystems. Fiji has a growing pool of reef-positive businesses that positively address key drivers of reef

degradation while enhancing benefits for local communities. These businesses, however, struggle to operate and scale due to limited access to capital. The financial institutions in Fiji, despite having high levels of liquidity, provide limited or no capital to such businesses, instead focusing on larger projects in tourism, coastal development and commercial agriculture. Small-scale reef-positive businesses are typically seen as not being investment-ready, lacking the formal structures, business plans, financial documentation, and market access that would make them attractive to lenders or investors. While there is a growing network of business development support (BDS) providers in Fiji that work with businesses to improve their capacity and competitiveness, most existing BDS providers tend to prioritize businesses with proven track records and strong financial returns, making it difficult for the early-stage, often informal, small-scale reef-positive businesses to attract the business development support they need to formalize, grow and access commercial capital.

6.4. Options analysis

Context and rationale

Section 6.2 identifies five key barriers to sustainable management of Fiji's Great Sea Reef (GSR): (1) limited evidence and technical capacity for ecosystem-based adaptation (EbA) and living shorelines; (2) inadequate integration of EbA/GI and ridge-to-reef (R2R) planning into national and provincial frameworks; (3) limited finance for locally led adaptation; (4) lack of long-term operational plans to implement EbA/GI and R2R; and (5) limited access to capital for reef-positive businesses. These barriers lead to fragmented restoration efforts and reactive disaster response.

In the absence of action (business-as-usual, or BAU), degradation of coral reefs and mangroves will continue. Destruction of riparian strips and deforestation causes heavy soil loss into rivers; sediments are transported 25–50 km offshore and smother coral reefs. Excessive sediments impede coral growth and can kill reefs. Without integrated R2R management, sediment, nutrient, and sewage pollution will worsen, resulting in further coral mortality and loss of ecosystem services.

All options presented in this analysis are assessed against the following four criteria, consistent with GCF guidance on investment justification:

1. **Technical Feasibility:** Whether the intervention can be implemented given local biophysical, institutional, and logistical conditions in the four target provinces (Ba, Ra, Bua, Macuata) within the project timeframe.
2. **Cost-Effectiveness:** Whether the approach delivers the required adaptation outcomes per unit of investment, with reference to comparable programmes and peer-reviewed cost data.
3. **Local Context Fit:** Whether the intervention is appropriate for Fiji's socio-cultural, environmental, tenure, governance, and climate risk context, including alignment with national policies and the iTaukei concept of vanua.
4. **Long-term Sustainability:** Whether the intervention can be maintained, monitored, and scaled by government and communities without indefinite external support, and whether it can adapt to future climate change (including sea-level rise).

At the highest level, five strategic implementation modalities were assessed to determine which approach, or combination of approaches, would most effectively and efficiently deliver climate resilience outcomes for coastal communities adjacent to the Great Sea Reef (GSR). The table below applies the four evaluation criteria explicitly across each option.

Strategic Modality Comparison, Evaluated Against Selection Criteria

Option / Scenario	Description	Strengths	Weaknesses	1. Technical Feasibility 2. Cost-Effectiveness 3. Local Context 4. Long-term Sustainability	Barriers Addressed	Overall Assessment
Option 1: Business as Usual (BAU)	Continue fragmented, site-based	No additional cost	Coral and mangrove degradation	1. Low 2. Low	None of the 5 barriers is addressed	Not suitable

	restoration and reactive post-disaster response without coordinated R2R or NbS planning.		continues; heavy sedimentation and nutrient pollution; communities remain vulnerable; does not build capacity	3. Low 4. Low		
Option 2: Grey / Hard Infrastructure Only	Construct conventional concrete seawalls, breakwaters, and drainage channels to reduce flooding and erosion, without addressing upstream drivers.	Immediate coastal protection; familiar engineering	High cost; negative ecological impacts; does not reduce land-based pollution; fails to build EbA/GI capacity	1. Medium 2. Low 3. Low 4. Low	4 (partial)	Not suitable
Option 3: Regulatory / Policy Reform Only	Update legislation, strengthen enforcement and revise policy frameworks without demonstration projects or on-the-ground investments.	Improves the legal framework	Limited community buy-in; does not generate evidence for EbA/GI; fails to develop local capacity or finance mechanisms	1. Medium 2. Medium 3. Low 4. Medium	2 (partial)	Not suitable
Option 4: Community-Led Initiatives Only	Provide small grants to communities and reef-positive enterprises to implement localised adaptation without broader coordination or R2R integration.	Builds local ownership; reduces pressure on reefs	Limited scale; fragmented interventions; EbA/GI not mainstreamed into national planning; no large-scale sediment reduction	1. High 2. Medium 3. High 4. Medium	3 & 5	Partial, insufficient scale
Option 5: Integrated NbS / R2R Approach (PREFERRED)	Scale up EbA (mangrove and riparian restoration) and green infrastructure (living shorelines) to restore degraded habitats, coupled with R2R planning, policy mainstreaming,	Addresses root causes by restoring degraded habitats and filtering sediments; improves ecosystem health and resilience; builds evidence and technical capacity; mainstreams	Requires multiyear investment and coordination; success dependent on capacity building and policy alignment	1. High 2. High 3. High 4. High	1–5 (all)	PREFERRED

	community finance, and business-development support.	NbS into national frameworks; establishes local finance facilities; supports reef-positive enterprises				
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Analysis and justification

BAU / no-action scenario

Under the BAU scenario, existing small-scale restoration efforts continue without additional interventions. This leaves the GSR vulnerable to sediment and nutrient pollution arising from deforestation and the destruction of riparian strips. Heavy rains cause soil loss into rivers and coastal waters; this sediment smothers corals and disrupts entire marine ecosystems. Without R2R planning, sediment and nutrient inputs will continue to increase. Communities will face ongoing exposure to storm surges and coastal flooding, and reef-dependent livelihoods will deteriorate. This option does not address any of the identified barriers.

Hard infrastructure option

Building hard structures such as conventional seawalls and breakwaters offers immediate protection against erosion and storm surges. However, these structures are expensive, can damage coastal habitats and do not address upstream drivers of reef degradation (e.g., sediment and nutrient pollution). They also fail to build local technical capacity or mainstream EbA and GI into national planning. This option only partially addresses Barrier 4 and leaves other barriers untouched.

Regulatory measures only

Revising policies and strengthening enforcement can improve the legal framework for coral reef conservation. Yet without demonstration projects or community engagement, such measures risk becoming top-down directives with limited local buy-in. They do not generate evidence for EbA or GI or provide communities with the financial or technical capacity needed to implement adaptation measures. This option partially addresses Barrier 2 but leaves the other barriers unaddressed.

Community-led initiatives only

Empowering communities through small grants or enterprises to implement adaptation measures builds local ownership and can reduce direct pressure on reefs, however, without coordination and integration into wider R2R planning, community initiatives risk being small in scale and fragmented. They do not provide the systemic changes needed to reduce sediment and nutrient runoff at catchment scale nor mainstream EbA/GI into national frameworks. Such initiatives address Barriers 3 and 5 but leave Barriers 1, 2 and 4 unresolved.

Integrated nature-based solutions and R2R approach (preferred)

The integrated approach is supported by a substantial and growing body of comparative evidence from analogous programmes. The GEF/UNDP Fiji Ridge-to-Reef Project demonstrated the viability of coordinated R2R management across Fiji's main islands, demonstrating measurable improvements in ecosystem health and community resilience through integrated land-sea approaches. The IUCN-led Mangrove Ecosystems for Climate Change Adaptation and Livelihoods (MESCAL) Programme (2009–2013) validated community-led mangrove management across five Pacific nations, including Fiji, Samoa, Solomon Islands, Tonga, and Vanuatu, finding that integrated EbA approaches delivered co-benefits in coastal protection, fisheries, and livelihood security that no single-modality option could provide. Conservation International's Lau Seascape Strategy 2018–2030, the most ambitious R2R programme currently operating in Fiji, explicitly applies the integrated land-sea management principle that this project builds upon.

The FS proposes an integrated package of nature-based solutions coupled with R2R planning. This option includes:

- **EbA and GI interventions** such as restoring degraded mangrove and riparian habitats and constructing living shorelines. These measures improve water quality by trapping sediments and nutrients, thus enhancing coral reef resilience.
- **Policy mainstreaming and capacity building** to integrate EbA/GI and R2R planning into national frameworks and provincial plans, addressing the lack of long-term operational procedures.
- **Community finance facility** to provide concessional finance for locally led adaptation and reef-positive enterprises, coupled with business-development support.
- **Long-term planning** to develop multi-year operational plans across provinces and watersheds, ensuring coordination and sustainability.

Within the selected integrated NbS/R2R modality, the analysis compares the specific types of EbA and living shorelines interventions selected for

against credible NbS alternatives. Options are grouped by the primary climate risk they address (coastal flooding protection; catchment-scale sedimentation reduction; coastal habitat restoration), reflecting the multi-hazard nature of climate vulnerability in the GSR.

EbA Intervention Comparisons

Intervention Type	Description & Evidence	Rationale for Selection / Rejection	Cost Comparison (per unit)	Scalability in the Fiji Context	Selection Status
Coastal flooding protection options					
Concrete/hard seawalls and breakwaters	Conventional reinforced concrete structures provide direct coastal protection. Widely used in Fiji, the Government's 5-Year Seawall Financing Strategy targets other provinces (Nadroga, Serua, Namosi, Caukadrove, not GSR provinces).	High initial and lifecycle cost; no ecological benefit; causes coastal squeeze; does not address land-based sedimentation drivers of reef degradation; cannot self-adapt to sea-level rise; disrupts natural hydrological processes. Already being deployed in non-GSR provinces under a separate programme, reducing duplication.	~\$1,022/linear foot; ⁴⁸⁰ several hundred times higher per metre than mangrove restoration. ⁴⁸¹	Low	Not selected (primary approach)
Living shorelines (selected)	Nature-based shoreline stabilisation using mangrove plantings, natural rock, and natural materials. Absorbs wave energy, allows natural	Significantly lower capital and maintenance costs than concrete alternatives; proven wave attenuation (70–90% wave energy reduction); ecological co-	~\$361/linear foot, approximately 1/3 the cost of concrete bulkheads. ⁴⁸³	High	Selected

⁴⁸⁰ EESI (2019). *Nature as Resilient Infrastructure: An Overview of Nature-Based Solutions*. Environmental and Energy Study Institute, Washington DC

⁴⁸¹ Springer Nature (2026). *Do nature-based solutions deliver climate adaptation equally? Comparing mangroves and seawalls in the Global South*. Climatic Change. doi:10.1007/s10584-026-04151-2

⁴⁸³ EESI (2019). *Nature as Resilient Infrastructure: An Overview of Nature-Based Solutions*. Environmental and Energy Study Institute, Washington DC

	sediment dynamics, provides habitat, and self-adapts to sea-level rise through sediment accretion. Used as primary flood-protection intervention.	benefits; scalable to community scale with local materials and labour; endorsed by GoF in hybrid seawall strategy. Studies show mangroves averted USD 1.5 billion in damages during Hurricane Irma. ⁴⁸²			
Beach and dune renourishment	Artificial addition of sediment to eroded shorelines. Used in some SIDS to restore beach profiles.	Requires ongoing and costly sediment inputs; does not address wave attenuation or reef degradation; high risk of increasing sediment loads on adjacent reefs; specialist equipment required; generally unsuitable for reef-fringed coastlines of the GSR. Coastal Restoration Challenges review highlights turbidity risks in reef-adjacent settings. ⁴⁸⁴	High recurring cost; no long-term ecological benefit.	Low	Not selected
Sedimentation reduction options					
Riparian buffer zone restoration (selected)	Restoration of native vegetation strips along river and stream banks across GSR watersheds (2,524 ha in Ba, Ra, Bua, Macuata). Intercepts sediment and nutrients before they enter river systems and reach reefs.	Highest-evidence, lowest-cost approach for catchment-scale sediment reduction. Meta-analyses confirm a 47% reduction in sediment loads and 32% in nitrogen concentrations. ⁴⁸⁵ Tropical riparian buffers achieve 45–75% sediment interception efficiency. InVEST modelling for this project confirms	Lower per-hectare restoration cost than engineered alternatives; modelled to deliver sediment reduction benefits at 25–50 km range to reef sites.	High	Selected

⁴⁸² Beck, M. et al. (2026). Mangrove restoration and coastal flood adaptation: A global perspective on the potential for hybrid coastal defenses. *PNAS*. doi:10.1073/pnas.2510980123

⁴⁸⁴ MDPI (2024). *Coastal Restoration Challenges and Strategies for Small Island Developing States in the Face of Sea Level Rise and Climate Change*. doi:10.3390/coasts4020014

⁴⁸⁵ Springer Nature (2025). *Mitigating riparian buffer zone degradation through policy interventions and learnings from best practices*. *Discover Environment*. doi:10.1007/s44274-025-00288-6

		significant reductions in sediment export under restoration scenarios. Scalable with community labour; builds on existing customary land tenure.			
Agricultural best management practices only (contour ploughing, no-till, cover crops)	Improved farming techniques to reduce soil erosion at the field level without structural riparian restoration.	Effective at field scale but insufficient to intercept sediment reaching stream channels; requires sustained behaviour change without enforcement; cannot substitute for the continuous sediment-filtering function of vegetated riparian zones; limited coverage of non-agricultural land sources of erosion. Addresses field-level erosion but leaves in-channel and bank erosion unaddressed.	Lower direct cost but must be combined with riparian measures to deliver catchment-level benefits.	Medium	Not selected as primary (complementary measure under LLAF)
Engineered sediment traps, check dams, and dredging	Physical structures within stream channels or periodic dredging to intercept sediment before it reaches coastal areas.	High capital cost; high maintenance burden; requires specialist equipment and skills not available locally; does not address root causes of erosion; risk of trap failure during high-flow events, releasing stored sediment in pulses; no ecological co-benefits; creates ongoing government liability. Not suitable for remote community contexts.	High unit cost; ongoing operational expenditure.	Low	Not selected
Coastal habitat restoration options					
Mangrove restoration (selected)	Active restoration of degraded mangrove areas	Multi-function intervention delivering wave attenuation (up to	Restoration: \$500–\$5,000/ha (vs \$61,000/km for seawalls in	High	Selected

	(835 ha across Ba, Ra, and Macuata) using hydrological restoration and community-led planting of native species. Addresses both coastal flooding and sedimentation.	66% wave height reduction over 100m belt), sediment trapping, nursery habitat for fisheries, carbon sequestration. Global evidence ⁴⁸⁶⁴⁸⁷ confirms mangrove restoration is 2–5 times cheaper than engineered breakwaters for equivalent wave protection on sheltered coastlines. Validated by IUCN MESCAL programme in Fiji and the Pacific (2009–2013). Aligns with GoF 30 Million Trees Initiative. Restoration feasibility confirmed through GIS and field assessments under this FS.	the Pacific) ⁴⁸⁸ ; delivers fisheries co-benefits valued at multiple times the restoration cost.		
Direct coral restoration (coral gardening/transplantation)	Growing coral fragments in nurseries and transplanting them onto degraded reef structures. Used in various tropical settings to restore reef structures.	Prohibitively expensive at the scale required to deliver meaningful coastal protection benefits: cost range of USD 6,000–143,000,000 per hectare (PMC, 2025), making catchment-scale interventions financially unviable. Does not address land-based sediment and nutrient drivers of reef degradation; restoring corals onto reefs still receiving high	USD 6,000–143M/ha, 10–10,000x more expensive per hectare than EbA alternatives.	Low (at scale)	Not selected as primary approach

⁴⁸⁶ Beck, M. et al. (2026). Mangrove restoration and coastal flood adaptation: A global perspective on the potential for hybrid coastal defenses. PNAS. doi:10.1073/pnas.2510980123

⁴⁸⁷ Narayan, S. et al. (2016). The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-Based Defences. PLOS One. doi:10.1371/journal.pone.0154735

⁴⁸⁸ EESI (2019). Nature as Resilient Infrastructure: An Overview of Nature-Based Solutions. Environmental and Energy Study Institute, Washington DC.

		sediment loads would result in rapid mortality. Sedimentation must be reduced first; EbA interventions (mangroves, riparian buffers) are therefore a prerequisite for any reef restoration to be sustainable.			
Seagrass bed restoration	Replanting or transplanting seagrass in degraded coastal zones to provide habitat and some wave attenuation.	Seagrass provides lower wave attenuation than mangroves and is highly sensitive to sedimentation and water quality disturbance; restoration success is compromised if upstream sediment inputs are not first reduced. Not suitable as a primary coastal protection intervention in the high-sediment-load environments of the GSR watersheds. May be considered as a complementary measure in improved water-quality zones following upstream EbA interventions.	Variable requires water quality improvement before restoration is viable.	Low (pre-condition required)	Not selected as primary approach

Mangrove Restoration

The selection of mangrove restoration as the primary coastal EbA intervention under Output 1.1 is supported by a robust and growing body of evidence demonstrating its cost-effectiveness and adaptation benefit relative to hard infrastructure alternatives:

- Cost comparison: A global meta-analysis⁴⁸⁹ found that mangroves and salt marshes are 2–5 times cheaper than submerged breakwaters for equivalent wave height reduction on sheltered coastlines. A comparative study in the Philippines⁴⁹⁰ found seawall construction costs several hundred times higher per metre of coastline than mangrove restoration.

⁴⁸⁹ Narayan, S. et al. (2016). *The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-Based Defences*. PLOS One. doi:10.1371/journal.pone.0154735

⁴⁹⁰ Springer Nature (2026). *Do nature-based solutions deliver climate adaptation equally? Comparing mangroves and seawalls in the Global South*. Climatic Change. doi:10.1007/s10584-026-04151-2

- Wave attenuation: Mangrove belts of 100–300 m width reduce incoming wave heights by 50–70% and can reduce wave energy by up to 90%. This is directly applicable to the low-energy, sheltered embankments of the Ba, Ra, Bua, and Macuata coastlines.
- Flood protection value: During Hurricane Irma, intact mangroves were estimated to have averted USD 1.5 billion in storm surge-related property damages in Florida. A recent global assessment⁴⁹¹ confirmed that mangrove restoration as a hybrid coastal defence predominantly benefits vulnerable low-income communities, precisely the target beneficiary group of this project.
- Pacific-specific evidence: The IUCN MESCAL programme (2009–2013) demonstrated measurable improvements in coastal protection and livelihood security through community-led mangrove management in Fiji, Samoa, the Solomon Islands, Tonga, and Vanuatu. GIS-based land-cover change analysis for Fiji's Ba and Rewa deltas⁴⁹² confirms significant historical mangrove loss and high restoration potential in the project sites.
- Scalability: Mangrove restoration using natural regeneration and hydrological restoration requires minimal specialist equipment and can be implemented and maintained by trained community groups using locally available propagules and materials. This is already a demonstrated practice in Fiji's iTaukei communities.
- Self-adaptation to sea-level rise: Unlike concrete seawalls, mangrove ecosystems can accrete sediment and grow vertically in pace with sea-level rise, a critical long-term sustainability advantage for a 10-year programme with a 40-year benefit horizon.

Riparian Buffer Zone Restoration

The selection of riparian buffer restoration as the primary intervention to reduce sedimentation reaching the GSR (Output 1.1, Activity 1.1.2) is justified by the following comparative evidence:

- Sediment interception effectiveness: Research confirms that riparian buffers can stop up to 90% of sediment from entering waterways under controlled conditions⁴⁹³. A meta-analysis of 30 studies⁴⁹⁴ confirms a strong positive correlation between buffer width and pollutant retention, with a 15-metre corridor retaining approximately 67% of upland sediment inputs. Tropical forest riparian buffers achieve 45–75% effectiveness under normal conditions.⁴⁹⁵
- Nutrient and water quality co-benefits: Riparian buffers reduce not only sediment but also nitrogen concentrations - comprehensive Mid-Atlantic buffer programmes achieved 47% sediment reductions and 32% nitrogen reductions.⁴⁹⁶
- Coral reef benefit linkage: Scientific Reports (2018) demonstrated using linked land-sea modelling in a Pacific context that watershed forest conservation actions significantly promote downstream coral reef resilience, precisely the mechanism this project operationalises through InVEST-based modelling for Fiji.
- Engineered alternatives: Sediment traps and check dams are expensive to install and maintain, require specialist equipment not available locally, and fail during high-flow events, potentially releasing stored sediment in damaging pulses. Agricultural best management practices (BMPs) alone do not address bank and channel erosion or provide the continuous sediment-filtering function of vegetated riparian buffers. Dredging is a recurring cost with no long-term benefit. Riparian buffers are the only catchment-scale, self-maintaining intervention appropriate for remote communities on iTaukei lands.

Living Shorelines

The selection of living shorelines as the primary coastal flood-protection infrastructure under Output 1.2 is justified by the following evidence:

⁴⁹¹ Beck, M. et al. (2026). *Mangrove restoration and coastal flood adaptation: A global perspective on the potential for hybrid coastal defenses*. PNAS. doi:10.1073/pnas.2510980123

⁴⁹² Avtar, R., et al. 2021. *Impacts of changes in mangrove ecosystems in the Ba and Rewa deltas, Fiji using multi-temporal Landsat data and social survey*. Coastal Engineering Journal, Volume 63, Issue 3: Blue Carbon Engineering. Available at: <https://www.tandfonline.com/doi/full/10.1080/21664250.2021.1932332>

⁴⁹³ Mongabay (2021). *Restoring coastal forests can protect coral reefs against sediment runoff*. news.mongabay.com

⁴⁹⁴ ScienceDirect (2025). *Developing predictive models of riparian buffer efficacy with meta-analysis*. doi:10.1016/j.envc.2025.001775

⁴⁹⁵ Springer Nature (2025). *Mitigating riparian buffer zone degradation through policy interventions and learnings from best practices*. Discover Environment. doi:10.1007/s44274-025-00288-6

⁴⁹⁶ Ibid.

- Cost advantage: Living shorelines cost approximately USD 361 per linear foot on average, compared to USD 1,022 per linear foot for concrete bulkheads, roughly one-third the capital cost, with significantly lower maintenance requirements.⁴⁹⁷
- Comparable protective function: A University of North Carolina Chapel Hill study following Hurricane Matthew (2016) found that living shorelines prevented erosion as effectively as bulkheads. The US EPA and NOAA both recognise that living shorelines are more resilient to storms than hard structures because they dissipate wave energy rather than redirect it.
- Ecological co-benefits vs. hard structures: Unlike concrete seawalls, living shorelines maintain natural sediment dynamics, provide fish nursery habitat, reduce coastal squeeze, and support the broader reef ecosystem health that concrete seawalls would undermine. Hybrid approaches combining living shorelines with limited hard elements (where justified by wave energy exposure) are included in the project design.
- Local context: Communities in the project areas specifically requested coastal protection solutions during consultations. The GoF's hybrid seawall approach, integrating both green and hard solutions, validates the living shoreline methodology. The Feasibility Study confirms that most target shorelines are in low-to-moderate wave energy environments where living shorelines are technically optimal.
- Complementarity: Living shorelines complement mangrove restoration; mangroves provide the natural foreshore vegetation, while the living shoreline structures provide immediate protection in areas where mangrove establishment will take 3–5 years to reach full effectiveness. This sequencing is consistent with best practice.

Coral Restoration

Direct coral restoration (including coral gardening, fragment transplantation, and artificial reef structures) was considered but rejected as the primary physical intervention for the following reasons:

- Cost: Coral restoration costs range from USD 6,000 to USD 143 million per hectare⁴⁹⁸, making reef-scale restoration financially unviable within the project budget. Even at the lower boundary, restoring 10% of degraded reef area globally would require more than USD 1 billion. The project's EbA budget is far better deployed across a catchment-scale package of mangrove restoration, riparian buffers, and living shorelines that collectively protect thousands of hectares.
- Pre-condition failure: Coral restoration onto reefs still receiving high sediment and nutrient loads from unmanaged watersheds results in high transplant mortality. The sedimentation and nutrient pressure must first be reduced, which is precisely what Output 1.1 (mangrove and riparian buffer restoration) is designed to achieve. EbA interventions are therefore a necessary precondition for any future reef restoration to be sustainable.
- Scalability limitations: Academic evidence⁴⁹⁹ confirms that coral restoration 'cannot be scaled up globally to save reefs from loss and degradation' at the hectare or square-kilometre scale due to the unfavourable cost-benefit ratio. Reducing anthropogenic pressures through EbA and catchment management delivers greater reef-resilience outcomes per dollar than active coral transplantation.

Rationale for a Locally Led Adaptation Mechanism

The proposed interventions under Components 1 and 2—such as living shorelines, ecosystem restoration, and living shorelines—are designed to address key climate hazards in Fiji's coastal provinces. These interventions are informed by technical assessments and national priorities and are expected to deliver significant resilience benefits. However, consultations with communities across Ra, Ba, Macuata, and Bua provinces have revealed a critical gap: while these interventions address broad climate risks, they do not fully capture the localized, layered, and evolving vulnerabilities experienced by communities who depend directly on the Great Sea Reef (GSR) and its surrounding ecosystems for their livelihoods and wellbeing.

⁴⁹⁷ EESI (2019). *Nature as Resilient Infrastructure: An Overview of Nature-Based Solutions*. Environmental and Energy Study Institute, Washington DC

⁴⁹⁸ PMC (2025). *Restoration cannot be scaled up globally to save reefs from loss and degradation*. *Nature Ecology & Evolution*. doi:10.1038/s41559-025-02432-0

⁴⁹⁹ *Ibid.*

In early 2024, WWF conducted extensive community consultations (see section 9.3 of Annex 2) across the four provinces to better understand the climate and non-climate stressors affecting local populations and ecosystems connected to the GSR. These consultations revealed that climate risks are compounded by non-climate pressures such as poor land-use practices, waste management challenges, and declining ecosystem health. These stressors not only increase community vulnerability but also place additional pressure on the GSR and its connected coastal and terrestrial ecosystems.

One village head in Ra Province shared, *“Rainfall patterns have changed in our lifetime. The rains are more intense now, and the rivers are shallower because of all the sediment. We can’t plant the way we used to.”* This sentiment was echoed across multiple districts, where communities described how traditional agricultural cycles have been disrupted, leading to reduced food security and increased reliance on degraded land. Coastal villages reported wave penetration and land loss due to sea level rise, while mangrove ecosystems are being used as dumping grounds due to inadequate waste collection—further degrading coastal habitats.

In Ba Province, villagers described rising temperatures and more frequent wildfires, which are damaging upland forests and contributing to sedimentation in rivers. Coastal erosion and mangrove deforestation have led to reduced fish populations and declining catches of freshwater mussels and crabs. One community member noted, *“We used to fish close to shore, but now we have to go much farther. The sea is changing, and the fish are disappearing.”*

In Macuata Province, flooding, sea level rise, and droughts are increasingly common. Villages such as Nabavatu have already been relocated due to coastal inundation. Coral reef degradation and illegal fishing are widespread, with enforcement agencies lacking the resources to monitor and regulate marine areas effectively. Women and youth, who are actively involved in fishing and marine resource collection, reported declining fish stocks and changing spawning patterns. Communities are shifting toward agriculture, often clearing forests in the process, which further stresses terrestrial ecosystems and increases runoff into coastal waters.

In Bua Province, communities face tidal inundation, rapid weather changes, and increased erosion. Cyclones have destroyed crops and fishing grounds, while sedimentation from bauxite mining and sugarcane burning has compromised water quality and reef health. Mangrove destruction is a major concern, with pine chip runoff killing mangrove stands and no legislation in place to prevent further loss. Illegal fishing and poaching persist despite community-led efforts to establish protected areas.

These insights point to the need for a locally led adaptation mechanism that can:

- Provide direct financial support to communities to implement small-scale, locally relevant adaptation actions;
- Enable communities to address specific climate and non-climate stressors that impact the GSR and its connected ecosystems;
- Build local capacity for monitoring, maintaining, and championing adaptation efforts beyond the project lifecycle;
- Strengthen community ownership of adaptation outcomes and foster long-term stewardship of natural resources.

Such a mechanism would not replace the expert-led interventions under Components 1 and 2, but rather complement them by ensuring that adaptation is grounded in local realities and sustained through community leadership. It would also serve as a platform for demonstrating the value of traditional knowledge, inclusive governance, and place-based resilience strategies.

In summary, the feasibility study finds strong justification for establishing a locally led adaptation mechanism within the project. This mechanism would respond directly to community-identified needs, reduce pressure on the Great Sea Reef and its ecosystems, and build the foundation for long-term, locally driven climate resilience in Fiji’s coastal provinces. This integrated approach addresses all five barriers: it generates evidence and technical capacity for EbA/GI (Barrier 1); mainstreams these measures into national plans (Barrier 2); creates a mechanism for community financing (Barrier 3); establishes long-term operational procedures and R2R planning (Barrier 4); and provides capital and support for reef-positive businesses (Barrier 5). Targeting root causes of reef degradation makes this option more sustainable and cost-effective than grey infrastructure or policy measures alone. It aligns with the prioritisation of project areas using climate-disaster and local-threat indices, ensuring interventions are targeted where they will yield the greatest resilience benefits.

Conclusion

The options analysis indicates that a business-as-usual scenario would allow further degradation of the GSR and increased vulnerability of coastal communities. Hard infrastructure, regulatory measures, or community-led initiatives in isolation cannot effectively address the complex barriers identified above. The preferred option, an integrated nature-based solutions and R2R approach, addresses all barriers, tackles the root causes of reef degradation and provides co-benefits for biodiversity, livelihoods and climate resilience.

6.5. Proposed interventions

Fiji is characterised by its invaluable and diverse ecosystems that support fisheries, tourism, and numerous other ecological services. Despite the GSR's value, it is witnessing a rapid degradation of many of its coral reefs, mangroves and seagrass meadows. This degradation is attributed to non-climate change factors such as overfishing and nutrient pollution, as well as the impacts of climate change, including warming oceans, intensifying storms, and rapid sea level rise. Without rapid intervention, Fiji and, indeed, coral reefs elsewhere will experience a rapid loss of the world's most diverse ocean ecosystem on the planet. The proposed project will directly address the degradation of coral reefs, adjacent ecosystems (mangroves and seagrass meadows), and associated human communities.

To protect coral reefs in Fiji that are more resilient to climate change, the project should address the critical issue of poor water quality caused by land-based run-off. This run-off, which includes sedimentation from land-use changes, nutrients from fertilizers, and sewage pollution, degrades coastal water quality, leading to reduced coral reef productivity, increased mortality, and diminished marine ecosystem services, such as coastal protection and food provision from fisheries. Sedimentation can smother corals, increase their sensitivity to heat stress, and decrease the photosynthetic capabilities of symbiotic algae. Additionally, nutrient pollution can facilitate macroalgal growth, reduce coral growth areas, and drive coral disease and bleaching, while sewage pollution introduces pathogens, heavy metals, and toxins harmful to both marine life and human health.

The proposed interventions — mangrove restoration, riparian buffer restoration, and living shorelines — are informed by global and local research demonstrating that improving water quality can significantly enhance the health and resilience of coral reefs. For instance, mangroves and riparian buffers are natural filters that trap sediment and nutrients before they reach the reefs, while living shorelines help manage stormwater runoff and reduce the impact of flooding on coastal ecosystems and human populations, with secondary benefits for sediment trapping. These interventions target the root of coral reef degradation (a proactive approach) rather than the degradation itself – as opposed to interventions like coral gardening that are often expensive and ineffective if root causes are not addressed. This approach will ensure long-term benefits and increased climate adaptation from Fiji CRR from a ridge-to-reef perspective. These strategies not only protect coral reefs by mitigating sedimentation and nutrient pollution but also provide co-benefits such as soil conservation, enhanced food security, and improved human health. By focusing on these nature-based solutions, we aim to create a sustainable and adaptive approach to coral reef conservation that supports both the environment and the local communities in Fiji. These interventions were also frequently mentioned during stakeholder consultations – particularly fishing pressure and flooding.

To directly respond to these threats to the GSR in Fiji and thus reduce the vulnerability of people to climate change impacts, a suite of adaptation interventions are required, including:

- Ecosystem-based adaptation including habitat restoration and protection
- Living shoreline interventions construction

To achieve the above objectives, interventions within priority catchment areas of the four provinces of the GSR as well as within the GSR itself have been selected for the proposed project. We provide further details, rationale, and context for the proposed interventions below.

- **Fisheries management.** Integrated, climate-resilient management and planning form a crucial part of EbA in Fiji. Fisheries management plans, including seasonal closures, size limits and quotas, gear restrictions, offshore fish license caps, and fishing aggregating devices, are part of the national fisheries management

framework to ensure sustainable fisheries^{500 501}. However, there is limited capacity and integration across government agencies, limited data availability, and limited capacity to regulate and monitor fishing activities.

- **Restoration and Regeneration** EbA in Fiji involves the restoration of various ecosystems, including forests, riparian vegetation, wetlands, mangroves, and seagrass meadows⁵⁰². Restoration efforts aim to enhance the resilience of these ecosystems to climate change and contribute to the well-being of local communities. Wetland restoration is also a critical component, with efforts underway to restore and conserve wetlands for their ecological and climate benefits⁵⁰³. Revegetating buffer zones is part of the strategy to protect specific conservation areas, particularly surface waters reaching coastal areas, and enhance climate change disaster risk management. Integrated watershed management plans and regulations are being developed and enforced to manage water resources effectively⁵⁰⁴, however many of these efforts have now finished and are no longer funded at the scale necessary to drive significant change. Climate-smart development planning is also being incorporated into national development strategies to ensure climate change resilience⁵⁰⁵. Mangrove and coastal restoration are significant aspects of EbA in Fiji, with initiatives focusing on mangrove replanting and conservation to support coastal livelihoods and enhance climate resilience⁵⁰⁶. Such efforts can also assist with the landward migration of coastal ecosystems. Given that the focus of this project is the health and benefits of GSR, this project specifically focuses on mangrove and riparian buffer restoration to enhance water quality and, thus, coastal ecosystem health and coastal protection.
- **Community-based protection of ecosystems.** The community-based protected areas are another critical aspect of EbA in Fiji. Efforts are being made to support and enforce protected areas through marine and land-sea planning⁵⁰⁷. This includes the protection of forests, riparian vegetation, wetlands, mangroves, coral reefs, and seagrass meadows. These efforts aim to conserve biodiversity, enhance ecosystem services, and contribute to climate change mitigation and adaptation. While largely supported by communities, there is potential to strengthen these mechanisms by improving communication and ensuring equitable costs and benefits across communities in community-based protection establishment and enforcement.
- **Living shorelines.** In the face of flooding, storm surges, and sea level rise, living shorelines can play a crucial role in Fiji. The construction of nature-based shoreline protections are key strategies in this regard. Fiji's town councils, responsible for urban planning, are helping vulnerable settlements by strengthening both natural and built infrastructure. Natural infrastructure harnesses the benefits of ecosystems like mangrove forests, while built infrastructure refers to manmade structures like sea walls. By combining both approaches, communities usually have a better chance of building their resilience⁵⁰⁸. Early warning systems have been developed and implemented in Fiji to produce and disseminate new early warning information on coastal flooding. These systems are instrumental in saving lives and protecting property in low-lying, populated coastal areas. However, given the proximity of many rural populations to the coast, and anticipated increases in sea level rise and flooding in the future it is essential to provide solutions to reduce the intensity and extent of flooding in Fiji.

Table 0-1 An overview of nature-based solution interventions, focusing on ecosystem-based adaptation and living shorelines. However, we note that there is an overlap between these categories, and certain interventions may address multiple aspects of these categories.

INTERVENTIONS	ANTICIPATED EFFECTS ON	OTHER ANTICIPATED	POSSIBLE COSTS
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⁵⁰⁰ United Nations (2025) 'Delivering improved coastal fisheries management services in Fiji', UN SDGs. Available at: <https://sdgs.un.org/partnerships/delivering-improved-coastal-fisheries-management-services-fiji>.

⁵⁰¹ SPC (2023) 'Community-based fisheries management in Fiji', SPC. Available at: <https://cbfm.spc.int/countries/fiji>

⁵⁰² IISD (2021) How Fiji is using NAP process to scale up Ecosystem-based adaptation (EBA). Available at: <https://www.iisd.org/publications/fiji-nap-process-ecosystem-based-adaptation-eba>.

⁵⁰³ WWF Pacific (2021) 'Wetlands: The life blood of Fiji', WWF Pacific. Available at: <https://www.wwfpacific.org/?193125/Wetlands-the-life-blood-of-Fiji>.

⁵⁰⁴ Fijian Government (2022) Climate vulnerability assessment: Making Fiji climate resilient. Available at: <https://fijiclimatchangeportal.gov.fj/publication/climate-vulnerability-assessment-making-fiji-climate-resilient/>

⁵⁰⁵ Fijian Government (2022) Climate vulnerability assessment: Making Fiji climate resilient. Available at: <https://fijiclimatchangeportal.gov.fj/publication/climate-vulnerability-assessment-making-fiji-climate-resilient/>

⁵⁰⁶ Fijian Government (2022) Climate vulnerability assessment: Making Fiji climate resilient. Available at: <https://fijiclimatchangeportal.gov.fj/publication/climate-vulnerability-assessment-making-fiji-climate-resilient/>.

⁵⁰⁷ United Nations (2021) 'Integrated coastal management: Preserve ecosystems services, improve climate resilience', UN SDGs. Available at: <https://sdgs.un.org/partnerships/integrated-coastal-management-preserve-ecosystems-services-improve-climate-resilience>.

⁵⁰⁸ World Economic Forum (2019) 'From mangroves to tin roofs: Fiji uses built and natural infrastructure for climate adaptation', World Economic Forum. Available at: <https://www.weforum.org/agenda/2019/05/from-mangroves-to-tin-roofs-fiji-uses-built-and-natural-infrastructure-for-climate-adaptation/>.

	COASTAL ECOSYSTEMS	BENEFITS	
Ecosystem health assessments and monitoring	- Improved adaptive management capacity - Improved coastal ecosystem health - Enhanced biodiversity value	- Increased community resilience to storms from wave attenuation of coastal ecosystems achieved from improved management and better decision-making with better data - Increased cost-efficiency of management interventions through a strategic, coordinated and systematic approach - Improved food security - Improved livelihoods from improved management and monitoring of marine and coastal systems and informed decision-making.	Stakeholder engagement and training costs Material costs Management/monitoring costs Technology and data management costs
Mangrove restoration	- Improved water quality - Increased natural value of native ecosystems (marine and terrestrial)	- Coastal protection - Increasing sediment and nutrient retention	Stakeholder engagement and planning costs Opportunity costs - loss of other uses
Riparian vegetation restoration and fencing	- Increase in fish and invertebrate abundances and health - Reduced macroalgae and less frequent outbreaks of microalgae - Improved reef health and cover	- Reduces peak flow in watersheds and similar areas - Reduces risk of flash flooding and landslides - Increases infiltration capacity - Increases in tourism and fisheries livelihoods - Community resilience - Disease control	Restoration/Acquisition costs Management/monitoring costs
Community-based protection capacity building and enforcement			
Green seawalls	- Reduced coastal erosion - Reduced storm impacts	Create habitat and juvenile	Stakeholder engagement and planning costs

	- for coastal communities - Protection of infrastructure/livelihoods	- nursery grounds for species - Reduce soil entering coastal waters - Reduces risk of landslides	- Opportunity cost of potential loss of coastal habitat due to “squeeze” - Building material and construction costs - Maintenance costs
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One of the most important aspects of developing and implementing a project is gaining the licence to operate. There is a diversity of opportunities as well as also challenges to Fiji. Understanding how to communicate the value and intricate nature of the project is critically important for its successful implementation and achievement of benefits.

6.5.1. Quantification and spatial distribution of interventions

For each intervention, systematic spatial assessments were used to determine the most feasible and beneficial areas for implementation. Notably, the exact specifications and methods for intervention are dependent on local conditions and stakeholder engagement and might, therefore, vary from the number in the table below.

Intervention areas were identified through a systematic, spatial modelling approach using existing datasets from publicly available and government sources (provided through collaboration with the Fiji government). Suitability metrics were developed for each intervention, and combined to create a composite suitability score, similar to the site selection methodology. Criteria were based on scientific understanding and consultation with stakeholders. Once sites with suitability environmental and governance characteristics were selected, they were further refined based on aspects of cost, feasibility, and potential benefit. The final areas for each intervention represent the most suitable areas with the most significant potential benefit to communities and the GSR that are potentially feasible within the project constraints. This approach also provides some flexibility to expand or contract implementation areas based on final community engagement, budget, and feasibility considerations.

Systematic modelling was performed across each of the four priority provinces (Ba, Ra, Bua, Macuata) to represent the variation across provinces and to ensure that benefits to nature and people were distributed equitably across the areas bordering the GSR. The final suitability index for each intervention was then rescaled based on percentiles to calculate the project areas and potential benefits. From there, benefits for each intervention were calculated with increasing intervention area to create benefit-area curves and select the final intervention area for each proposed activity. The final threshold was selected based on diminishing benefit returns as well as implementation costs.

Table 0-2 Data layers and criteria used to select intervention sites within project areas. NA indicates that a layer was not included for a particular intervention. Criteria denoted with “max” refers to high values of a given metric indicating high suitability, while “min” refers to low values of a given metric indicating high suitability (e.g., high values of slope are ideal for restoration, while low values for slope are ideal for improved farming practices). “Inside” indicates that suitable pixels can only occur within valid values of the named layer, while “outside” indicates the opposite.

Interventions	Sediment export	Slope	Distance to rivers	Suitable land uses	Current mangrove extent	Potential mangrove extent	Land tenure	Distance to populated areas	Flooding hazard	River discharge	Distance to coast	Historic loss of mangroves
NbS: Riparian restoration	Max	Max	Inside buffer	Cropland/agriculture, grasslands – outside water, mangrove, bare soil/rock, urban/impermeable, shrubland,	Outside	Outside	iTaukei Land – outside freehold land and state	NA	NA	NA	NA	Outside

				trees			land					
NbS: Mangrove restoration	NA	NA	NA	Cropland/agriculture, grasslands, mangroves, water – outside bare soil/rock, urban/imperious, shrubland, trees	NA	Max	iTaukei Land – outside freehold land and state land	Min	NA	NA	Min	Inside
Green seawalls	NA	Min	NA	Cropland/agriculture, grasslands, mangroves – outside water, bare soil/rock, urban/imperious, shrubland, trees	Outside	Max	iTaukei Land – outside freehold land and state land	Min	Max	NA	Inside buffer	Outside

Table 0-3 Statistics of intervention packages for all key areas.

Interventions	Threshold	Intervention area	
Ecosystem health assessments and monitoring	Not Applicable	All provinces	
Mangrove restoration	Top 56% of suitable area equating to 22% reduction in vulnerable flooding area	Ba	339 ha
		Ra	105 ha
		Bua	332 ha
		Macuata	247 ha
Riparian vegetation restoration and fencing	Top 11% of suitable area, equating to 12.8% of riparian sediment reduction	Ba	669 ha
		Ra	476 ha
		Bua	261 ha
		Macuata	405 ha
Green seawalls	Top 50% of the suitable area, equating to a 24% reduction in vulnerable flooding area	Ba	4.6 km
		Ra	3.4 km
		Bua	2.2 km
		Macuata	2.2 km

Thresholds were selected based on benefit relative to area, given that area is a proxy of cost. Estimates of cost were also calculated for the final intervention areas based on the values in the Bill of Quantities. However, given the number of proposed interventions and the complexity of the analysis, we have endeavoured to make this flexible to allow for potential changes in the future.

6.5.2. Ecosystem-based adaptation

Effective management of ecosystems hinges on comprehensive information across various dimensions, including physical, biological, and other relevant factors. Without these critical data, making informed strategic decisions becomes challenging. For this reason, the project will implement an active health assessment monitoring program. This program will enable the Fiji government and its partners (University of Arizona, CRR partners), to understand the types of changes occurring within the ecosystem and how they might intervene to correct any negative trends.

Restoration and revegetation

Restoring degraded ecosystems, including mangrove restoration, riparian buffer restoration, and forest and natural vegetation restoration, is crucial for the health and resilience of the GSR. Mangrove restoration helps stabilize coastlines, reduce erosion, and provide vital habitats for marine species. Riparian buffer restoration enhances water quality by filtering pollutants and preventing sediment runoff into the reef, promoting a healthier marine environment, while also increasing freshwater quality (i.e., water security) and stabilising embankments. Forest and natural vegetation restoration support biodiversity and mitigate climate change impacts by sequestering carbon, reducing flood risk, and regulating local microclimates. Together, these restoration activities will bolster the ecological integrity of the GSR, ensuring its longevity and the continued support of the Fijian communities that rely on its resources.

Mangrove restoration

Mangroves are widespread across Fiji and serve many purposes including coastal protection and habitat for species and resources used by local communities. Mangrove loss and degradation have been witnessed across the GSR coastline. While several initiatives have aimed to restore mangroves, in many cases by empowering local communities to create nurseries (as witnessed during site mission visits), there is still an opportunity for mangrove restoration and rehabilitation in areas of loss and degradation.

Mangrove restoration suitability was determined based on potential mangrove extent and indications of mangrove loss or degradation. In addition, suitable land uses (open lands) and iTaukei land (outside freehold or state lands) were considered due to restoration feasibility concerns. Mangrove restoration had the smallest area out of all restoration interventions, with a total of 1023 ha identified across all priority areas and provinces.

Mangrove restoration will follow best practices, including:

1. Planting only in areas that naturally support mangroves (“reforestation”) and not in areas where mangroves are not known to have grown (“afforestation”) to avoid any adverse impacts on existing habitats, species, and communities.
2. Consider the full suite of risks of any potential planting site in terms of hazard, exposure, and vulnerability.
3. Restoration at a sufficient scale to achieve desired benefits – effective coastal protection from swell waves and wine requires hundreds of metres of mangroves, while protection from storm surges requires thousands of metres of mangroves.
4. Involve local communities through informed consent and ensuring equitable benefits and understanding.
5. Proper planning to ensure long-term success
6. Ensured monitoring and ongoing support to ensure long-term success
7. Leveraging and supporting natural regeneration (assisted natural regeneration) of mangroves where possible, and supplementing with mangrove restoration when needed.
8. Including diversity and appropriate species in restoration efforts including native Rhizophoraceae mangroves (*Bruguiera gymorrhiza* (dogo in Fijian), *Rhizophora stylosa*, *R. samoensis* (both tiri), and *Lumnitzera littorea* (sagale)). Notably, a diversity of species should be used within projects to avoid “plantation” style restoration, including mangrove associate species like swamp grass (*Paspalum distichum*), and mangrove sedge (*Scirpodendron ghaeri*), among others. Many existing guides can assist with the selection of species for certain areas and objectives (e.g., ITTO Mangrove Management Guidelines⁵⁰⁹).

Once the baseline future flood impacts are assessed, we identify potential areas for mangrove restoration. Identifying suitable areas for mangrove restoration is a complex exercise, and restoration suitability is controlled by multiple ecological factors, such as landform, sedimentary and hydrological suitability, as well as social factors such as ensuring access to the coastline for communities, and available land.⁵¹⁰ Here, we use information on the 2040 baseline flood extents, mangrove cover in Fiji for AD 2023⁵¹¹ and land-use from google earth images, we identify ~1660 hectares of potential mangrove restoration sites across the four Great Sea Reef provinces in Viti Levu and Vanua Levu.

⁵⁰⁹ https://www.itto.int/sustainable_forest_management/mangroves/

⁵¹⁰ Villarreal-Rosas, J., et al., Integrating socioeconomic and ecological data into restoration practice. *Conservation Biology*, 2024. 38(4): p. e14286. <https://onlinelibrary.wiley.com/doi/full/10.1111/cobi.14286>

⁵¹¹ de Sousa, C., D. Lagomasino, and L. Fatoyinbo, Mangroves II—Change Mapping, in *Cloud-Based Remote Sensing with Google Earth Engine: Fundamentals and Applications*. 2023, Springer. p. 1045-1060. https://link.springer.com/chapter/10.1007/978-3-031-26588-4_48#:~:text=Overview,The%20purpose%20of%20this%20chapter%20is%20to%20present%20two%20methods,are%20defined%20by%20threshold%20values.

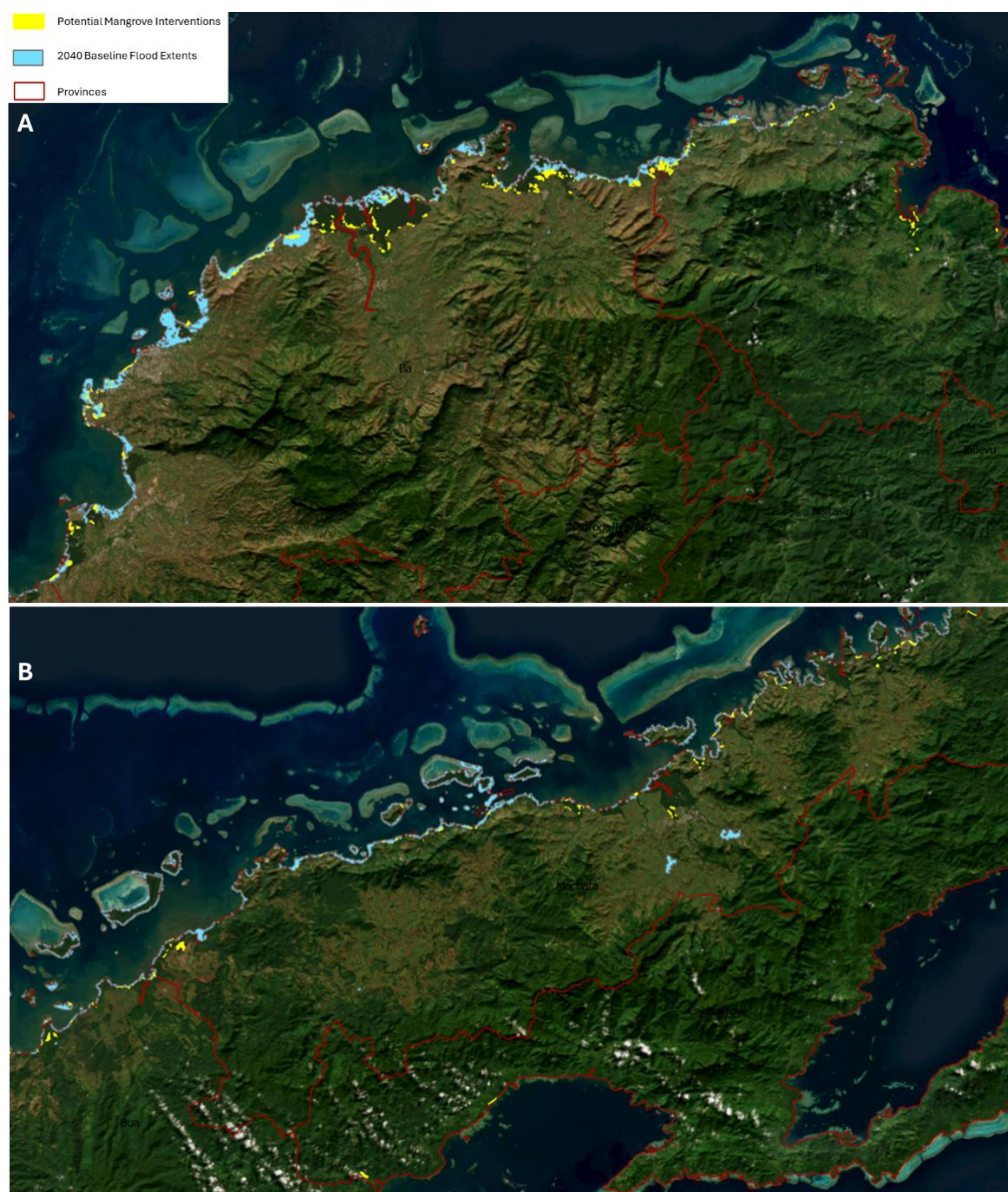


Figure 2: Potential mangrove intervention polygons (yellow) identified in Top (A): Viti Levu and Bottom (B): Vanua Levu. Baseline 2040 flood extents are shown in blue and province outlines are in red. World Imagery Basemap from ArcGIS.

Mangrove forests can reduce storm surge flooding by providing additional frictional resistance against the flow of storm surges, due to their dense vegetation. The effect of these interventions can be felt several kilometres away, depending on the size of the interventions, the location of the exposed assets, and the intervening topography of the floodplain. The flood reduction benefits from mangroves are typically higher when these forests are located close to high-density populations or high-value assets.⁵¹²

However, not all the mangrove areas identified as suitable for restoration are located close to high-density human populations or assets, due to the ecological and social constraints that determine restoration suitability.

To quantify the flood impacts of these potential mangrove interventions, we update the flood model to reflect the updated friction coefficient due to the newly restored mangroves in all interventions. We then recalculate peak flood heights for each of the 11 tracks from Winston and Evan, with the updated friction coefficients that represent the effect of these restored mangroves. The maximum flood extents from these simulations are derived using the same approach as the baseline, by estimating maximum peak flood heights across all tracks.

⁵¹² Menéndez, P., et al., Valuing the protection services of mangroves at national scale: The Philippines. *Ecosystem Services*, 2018. **34**: p. 24-36. https://www.nature.org/content/dam/tnc/nature/en/documents/Mangrove_Report_digital_FINAL.pdf

Next, we calculate the difference between the peak flood heights between the mangrove intervention and baseline scenarios to identify the specific mangroves that provide a flood reduction benefit. We then identify the mangrove intervention polygons that are within 2 kilometers of all locations where our model indicates a reduction in flooding. These interventions are assumed to be directly responsible for these reduced flood heights^{513 514}. We exclude all mangrove interventions that are greater than 2 km away from the locations of reduced flooding in our model. From our analyses of the flood reduction benefits of mangrove interventions we identify a total of ~835 hectares of mangrove restoration polygons that provide a flood reduction benefit.

⁵¹³ Del Valle, A., et al., *Mangroves protect coastal economic activity from hurricanes*. *Proceedings of the National Academy of Sciences*, 2020. 117(1): p. 265-270. <https://www.pnas.org/doi/10.1073/pnas.1911617116>

⁵¹⁴ Narayan, S., et al., *Valuing the flood risk reduction benefits of Florida's mangroves*. *The Nature Conservancy*, 2019. 11. https://www.nature.org/content/dam/tnc/nature/en/documents/Mangrove_Report_digital_FINAL.pdf

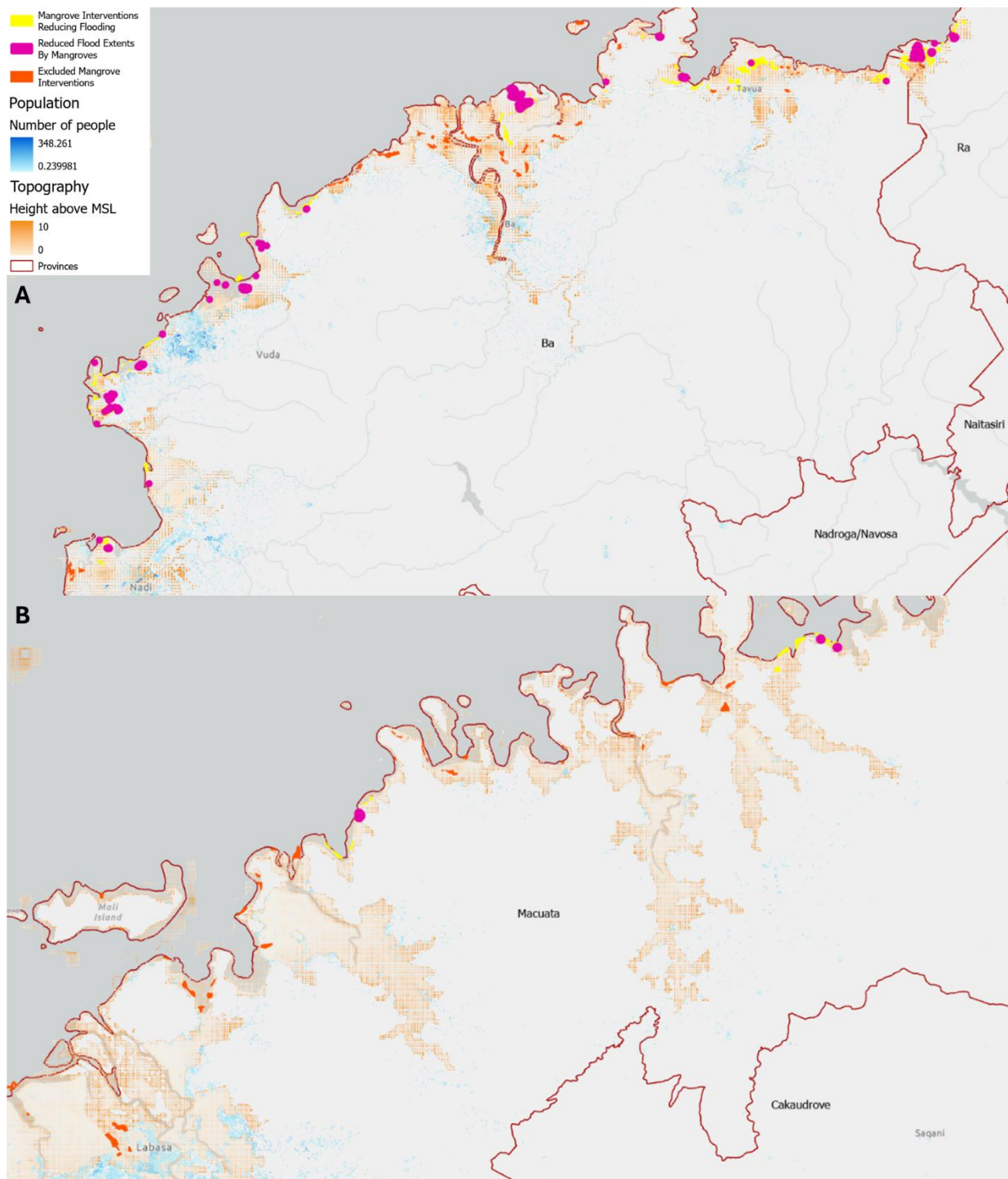


Figure 3: Map of example mangrove interventions included (yellow) and excluded (orange) based on their flood reduction benefits (pink) for Top (A): Viti Levu and Bottom (B): Vanua Levu. Topography is shown in shades of red, population in shades of blue and province outlines in red. Light Gray Basemap from ArcGIS.

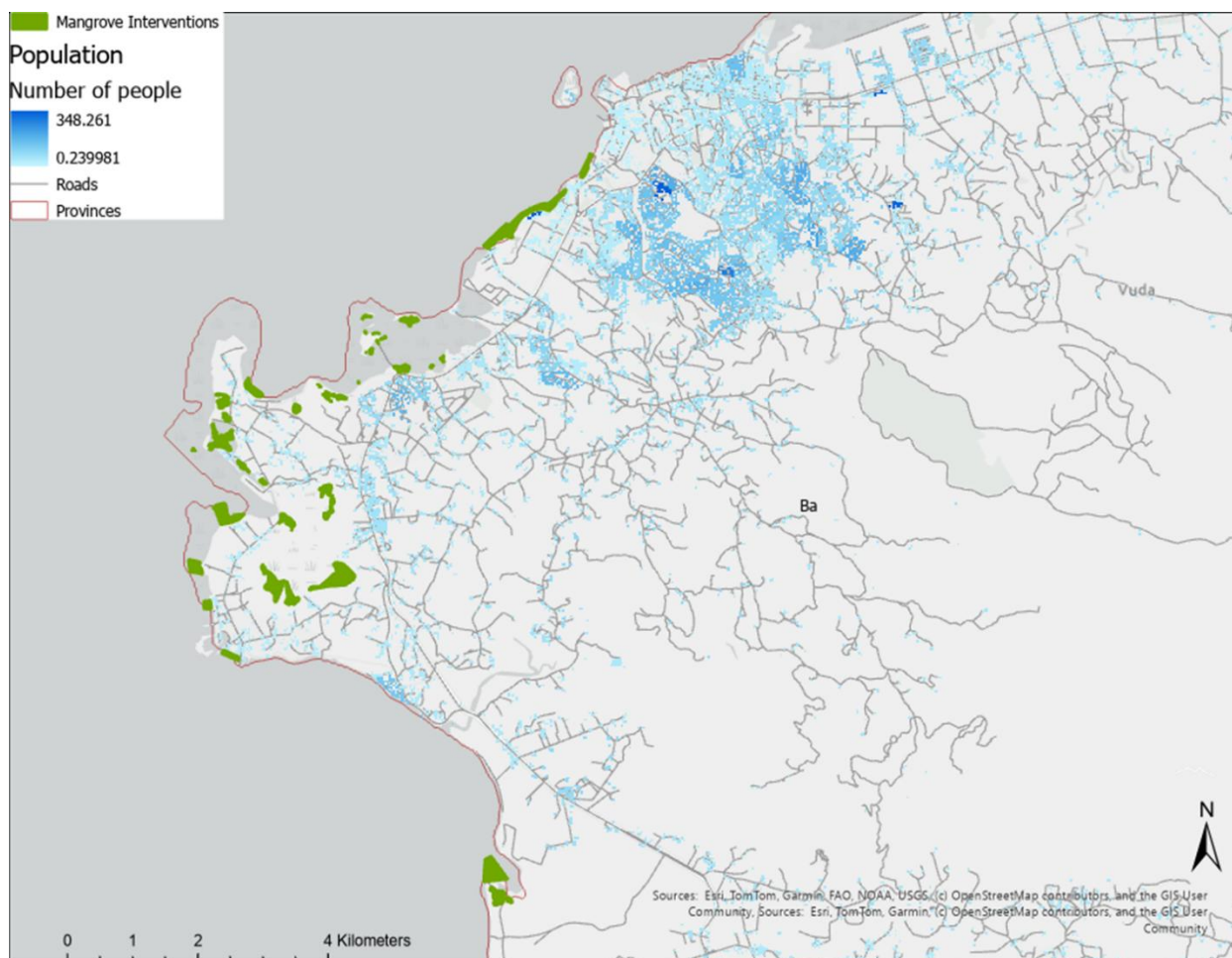


Figure 4: Zoomed-in map of example mangrove interventions (green) in Ba Province, displayed over population (blue), roads (grey) and province outlines (red). Light Gray Canvas Background from ArcGIS™.

Impacts of Mangrove Interventions for Flood Reduction

The analyses indicate that the 835 ha of mangrove interventions result in reduced flood impacts to ~42,000 direct beneficiaries and ~93,000 indirect beneficiaries in the GSR region, roughly 4.5 and 10% of the total population of Fiji (Table 4). Inside the modelled flood extents, mangrove interventions result in reduced flooding to >300 hectares of land, including urban and agricultural land.

For the future flooding scenario, our flood model predicts maximum storm surge heights of up to 5 meters above mean sea-level. Thus, to measure the full impact of mangrove interventions in avoiding future flood damages, we consider the direct beneficiaries as all people within a 3-kilometre buffer, approximating the 5 m elevation contour, of all mangrove interventions that reduce flooding.

Typically, the impacts of a flood event go beyond direct impacts, with indirect impacts to populations, transport and other infrastructure, from interruption of business activities, transportation and other metrics of socio-economic activity. To identify the indirect beneficiaries of the mangrove interventions that reduce flooding, we count the number of people within a 6 km buffer, approximating the 10 m elevation contour, of all mangrove interventions that reduce flooding. For each type of beneficiary, all buffers are spatially treated to exclude any overlaps.

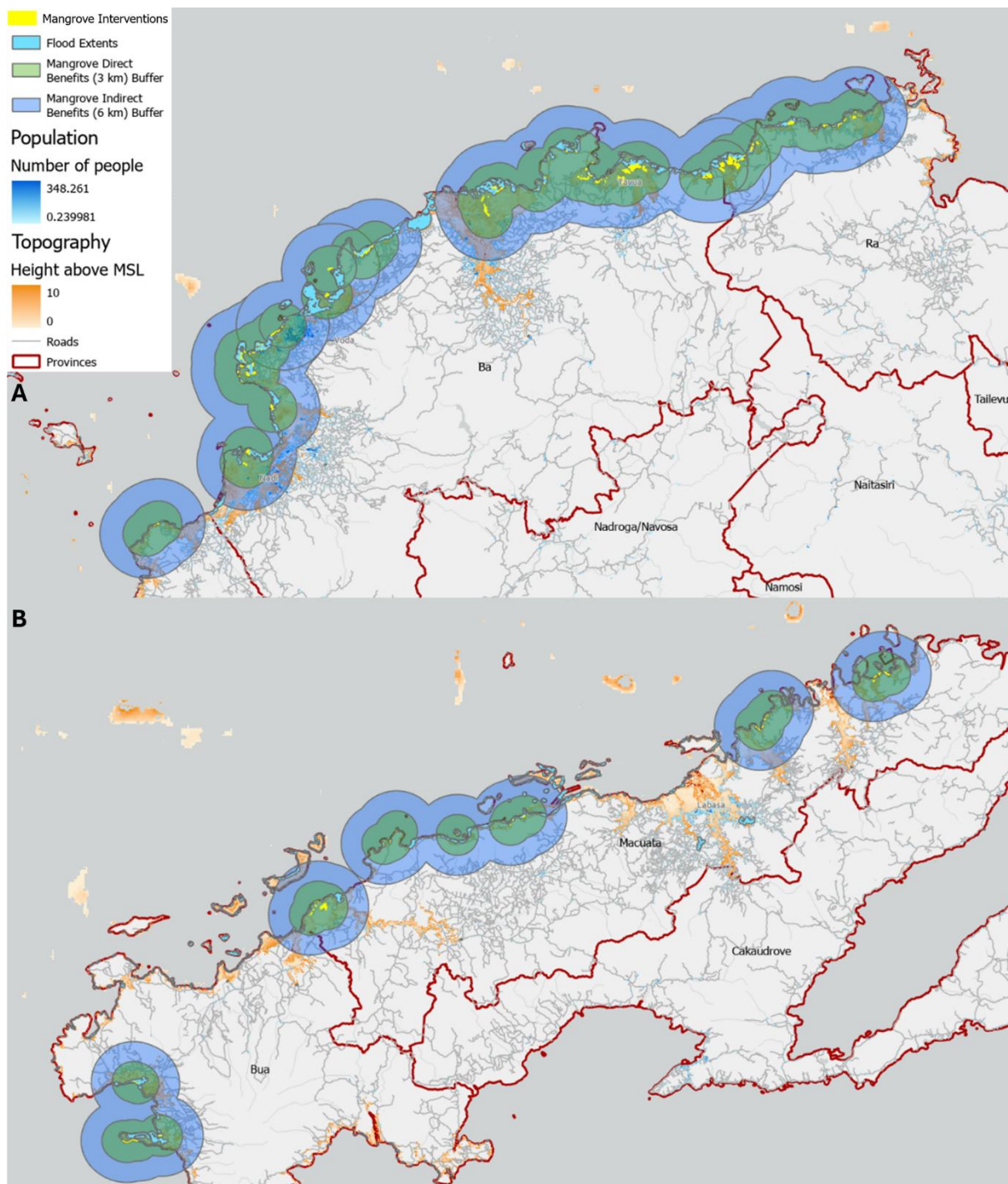


Figure 5: Example Map showing Mangrove Intervention Beneficiary Buffer Zones, Direct (3 Km) Zones in Green and Indirect (6 km) Zones in Blue for Top (A): Viti Levu and Bottom (B): Vanua Levu. Topography in orange shades, population in blue shades and provinces in red outlines. Light Gray Imagery from ArcGIS.

6.5.3. Riparian buffers and embankments

Buffers and filter strips are areas of permanent vegetation located within and between agricultural fields and the water courses to which they drain. These buffers are intended to intercept and slow runoff, thereby providing water quality benefits. In addition, in many settings, they are intended to intercept shallow groundwater moving through the root zone below the buffer. Buffer also provides shade, stabilises slopes, and can help slow down and clean stormwater runoff.

Vegetated buffer strips are sloping planted areas designed to allow stormwater to infiltrate sheet flow from adjacent impervious surfaces naturally. Buffer strips slope away from the impervious surface and are most often vegetated

with low-lying ground cover. As an integral part of a planned conservation system, buffer strips may be located at various locations within a landscape. To maintain buffer-strip performance, periodic maintenance is required. Contour buffer strips, filter strips, and grassed waterways are frequently used types of buffer strips. Buffer strips can have several different configurations of vegetation found on them varying from simple grass to combinations of grass, trees, and shrubs. Areas with diverse vegetation provide more protection from nutrient and pesticide flow and at the same time provide better biodiversity amongst plants and animals.

Vegetated buffer strips have been included in all types of proposed interventions. A provision of a between 100 and 500m wide buffer strip will be provided on the left and right banks of the interventions, across priority restoration areas. Over time these vegetated buffer strips will grow and expand and provide additional protection against floods and land-based run-off.

Livestock in Fiji are most often allowed to roam freely across landscapes. Livestock trampling is known to degrade embankments leading to habitat degradation and increased run-off. Livestock fencing is strongly suggested to accompany riparian buffers and embankment restoration within this project. Further, several communities recognised issues with livestock escapes during severe storms, contributing to the landscape degradation of feral livestock. Areas of high sediment export and steep slopes were prioritised while only considering cropland/agricultural lands and grasslands – outside water, mangrove, bare soil/rock, urban/impervious, shrubland, and trees. In addition, only iTaukei Land outside of freehold land and state land were considered, and outside of areas with mangrove cover.

Implementation of this restoration will follow best practices including appropriate selection of species, planning techniques (spacing, line-cutting, planting), buffer zones, fire management (where and if appropriate), and post-planting management – including firebreak management, livestock management, survival monitoring and weeding. The main purpose of riparian buffer restoration within this proposed project relates to a reduction in soil erosion and thus reduced sedimentation and increased water quality for the GSR. This is expected to then improve GSR health and provide climate adaptation benefits to ecosystems and people. However, secondary objectives of this intervention may vary by location and community and may include providing cleaner water, food security, increased biodiversity, improved soil fertility, fire prevention, economic gains, and medicinal and/or cultural value⁵¹⁵. Species selection will be based on environmental conditions at each site, and the level of degradation, and will take into account secondary project priorities of individual communities. Lists of native and naturalised tree species used for forest restoration in Fiji have been compiled and can assist with species selection⁵¹⁶.

Ba Province

In Ba, most selected areas are upstream in major catchments, likely transferring significant benefits for water quality for downstream communities and the GSR. Several tributaries of the Ba River, a major river in Fiji, as well as several areas near Lautoka and bordering Ra. The total intervention area for riparian restoration in Ba is 669 ha. This is the largest target area for riparian restoration across all provinces. The most riparian restoration was identified in the Ba catchment, followed by the Lautoka catchment, with smaller areas identified near Nadi.

⁵¹⁵ WCS Fiji (2021) *A guide to planting native trees for forest restoration in Fiji's watersheds*. Available at: <https://fiji.wcs.org/Portals/82/A%20Guide%20to%20Planting%20Native%20Trees%20for%20Forest%20Restoration%20in%20Watersheds%20PDF%20.pdf>.

⁵¹⁶ EPA (2021) *Handbook for developing watershed plans to restore and protect waters*. Available at: <https://www.epa.gov/nps/handbook-developing-watershed-plans-restore-and-protect-our-waters>.

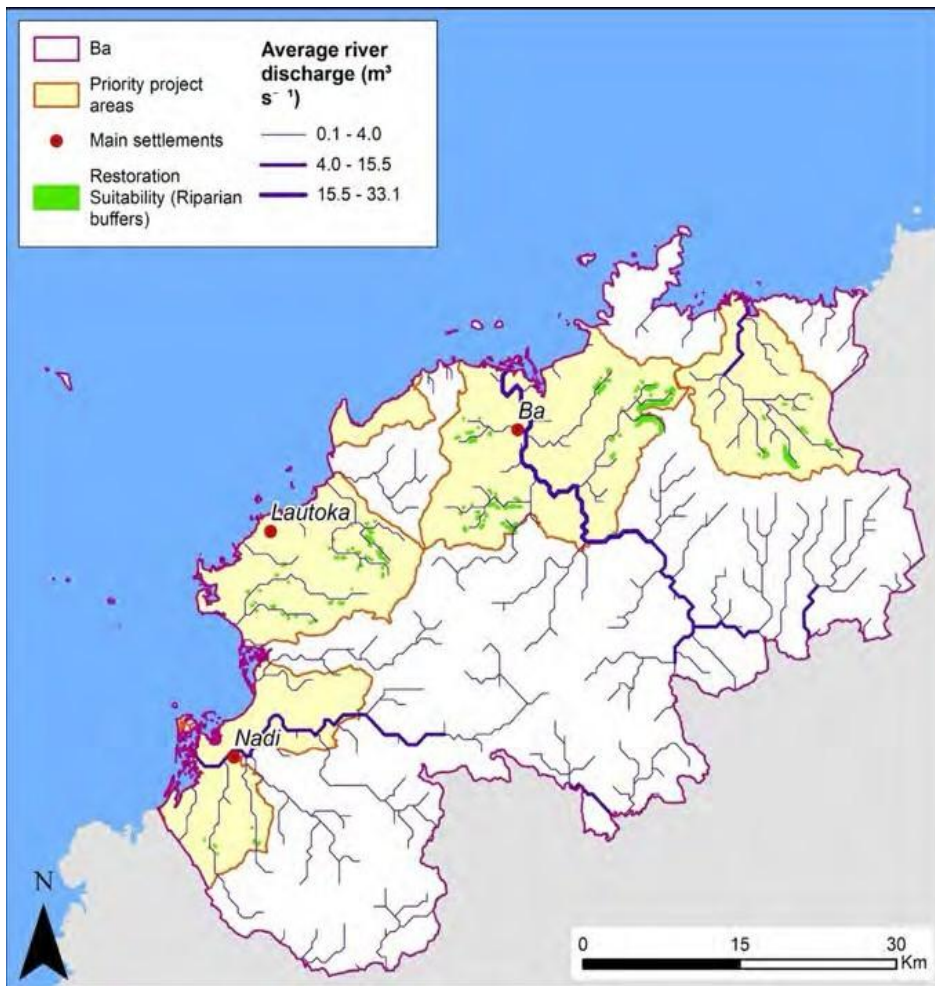


Figure 0-6 Priority pixels for restoring riparian buffers within priority project sites in the Ba Province. Project area pixels are represented in green.

Ra Province

The Ra province priority areas had the second highest amount of area identified for riparian buffer restoration at 476 ha. Identified areas largely fell along the west coast of the province and the Naindandara river. Like Ba, upstream restoration is likely to provide significant benefits downstream, particularly in combination with mangrove restoration and living shorelines along the coasts.

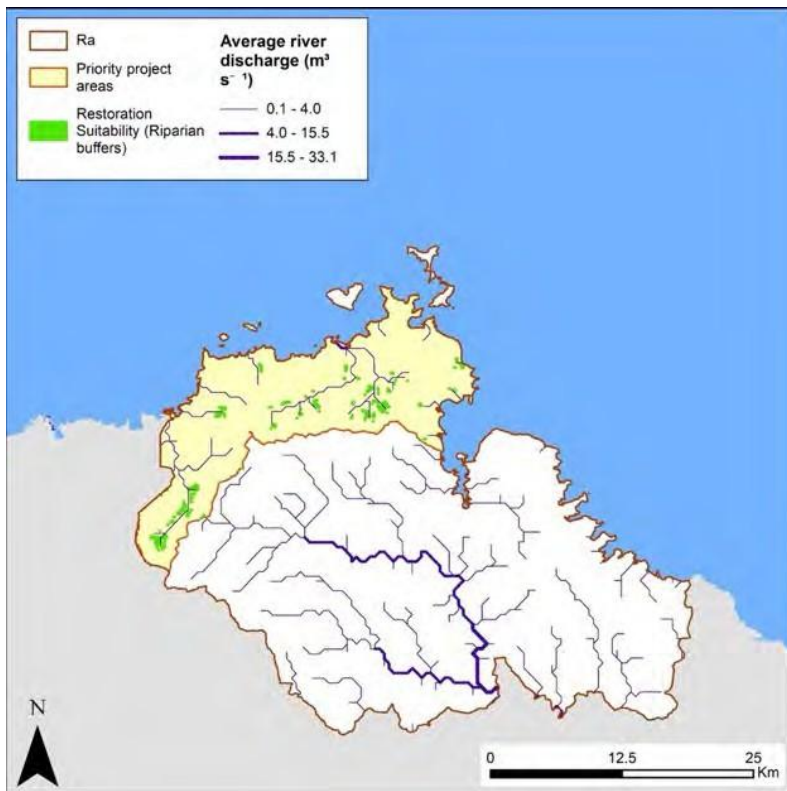


Figure 0-7 Priority pixels for the restoration of riparian buffers within priority project sites in the Ra Province. Project area pixels are represented in green.

Bua Province

Bua had the smallest area identified for riparian restoration, totalling 261 ha. While restoration areas are spread across the project area identified in Bua, a substantial amount of restoration is located upstream in the Namatatoka river, and upstream of several rivers and creeks that outlet into Bua Bay.

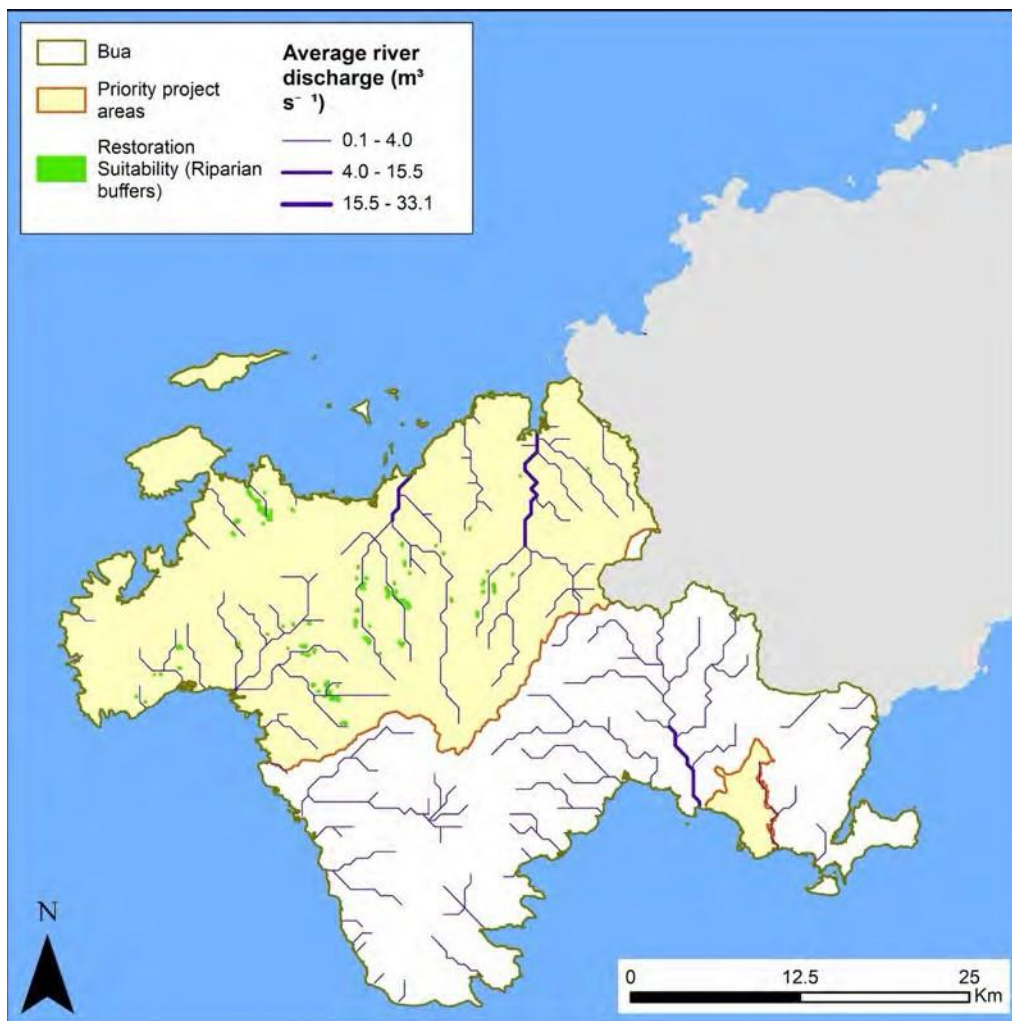


Figure 0-8 Priority pixels for the restoration of riparian buffers within priority project sites in the Bua Province. Project area pixels are represented in green.

Macuata Province

The total intervention area for riparian restoration in Macuata is 405 ha, largely in tributaries around Labasa, with some smaller areas to the west. Similar to Bua, the restoration areas identified are widespread across the priority project areas in the province. However, hotspots of restoration occur near Labasa near the Wailevu River, Labasa River, and Kumbolu Creek. The coast of Macuata directly outfalls on the GSR, thus substantial benefits are expected through riparian restoration for sediment reduction and flood and sea level rise vulnerability.

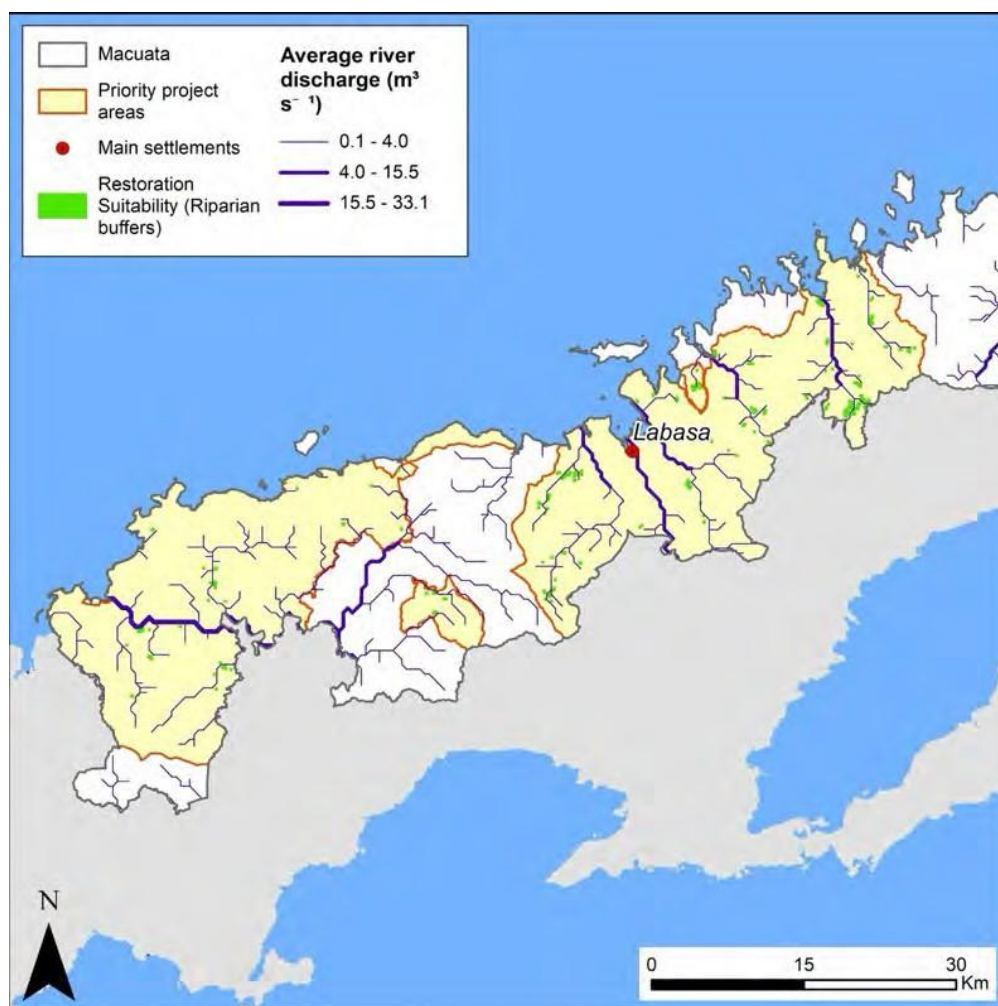


Figure 0-9 Priority pixels for the restoration of riparian buffers within priority project sites in the Macuata Province. Project area pixels are represented as green pixels.

6.5.4. Living shorelines

Living shorelines, a strategically planned set of interventions for natural and semi-natural areas, as well as other environmental features. The GI proposed here are green seawalls and retention areas.

Living Shorelines construction

Living shorelines help dissipate wave energy, reduce the impact of storm surges, and prevent shoreline erosion, thus safeguarding both the marine ecosystem and local communities. Constructed shorelines are common and were frequently requested by communities during site visits. While constructed they provide benefits, they also have some drawbacks including contributing to coastal squeeze and disrupting natural hydrological processes. In some areas, constructed seawalls may be an appropriate solution. However, in many cases, living shorelines will provide additional benefits to nature and people. Living shorelines are an innovative and eco-friendly solution designed to protect the GSR from the escalating threats of climate change and coastal erosion. These shorelines integrate natural elements like mangroves, coral reefs, and seagrasses, fostering a biodiverse environment that bolsters marine life and enhances coastal resilience. By mimicking natural processes, they offer a sustainable alternative to traditional concrete seawalls, which often disrupt marine habitats and fail to provide long-term protection. Implementing living shorelines in the GSR is essential not only for preserving its rich biodiversity but also for supporting the livelihoods of the Fijian people who depend on these coastal ecosystems.

The analysis below identifies areas for both constructed and living shorelines. Suitable areas were identified as those areas outside of areas with current mangrove cover, and outside of areas identified in this FS for mangrove restoration. Areas were selected that were near the coast and close to human settlements to maximize benefits from coastal protection. In addition, areas with high flooding hazard were prioritised. Suitable areas were selected for intervention to maximize feasibility and benefits.

Living shorelines are structures constructed parallel to the shoreline to prevent flooding during a storm and are constructed to a height that is designed to provide a desired level of protection. Typically, living shorelines are constructed along exposed coastlines in front of high-density populations or high-value assets.

First, we identify using the future baseline flood extents and google earth satellite images of land-use, areas suitable for new seawall interventions. With this exercise, we identify a total length of 12 kilometres of potential living shorelines interventions.

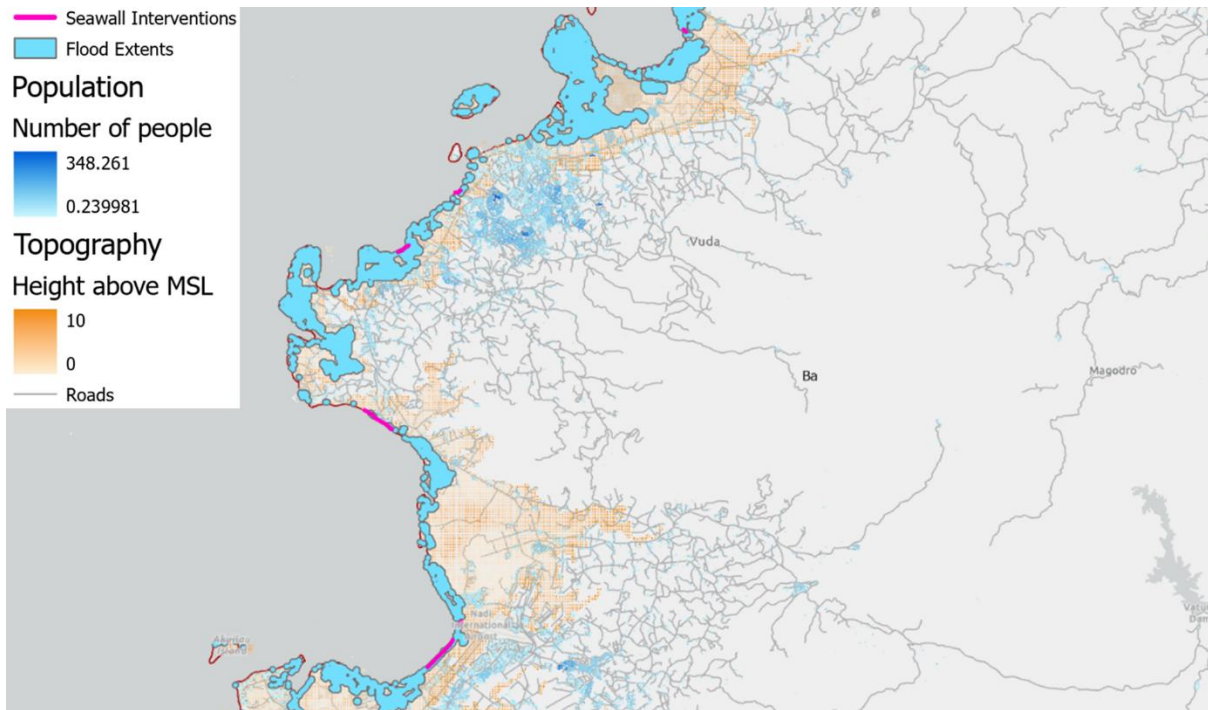


Figure 10: Example map of living shorelines intervention locations (pink) in Viti Levu. Flood extents are shown in light blue. Topography in shades of orange and population in shades of blue. Light Gray Imagery from ArcGIS.

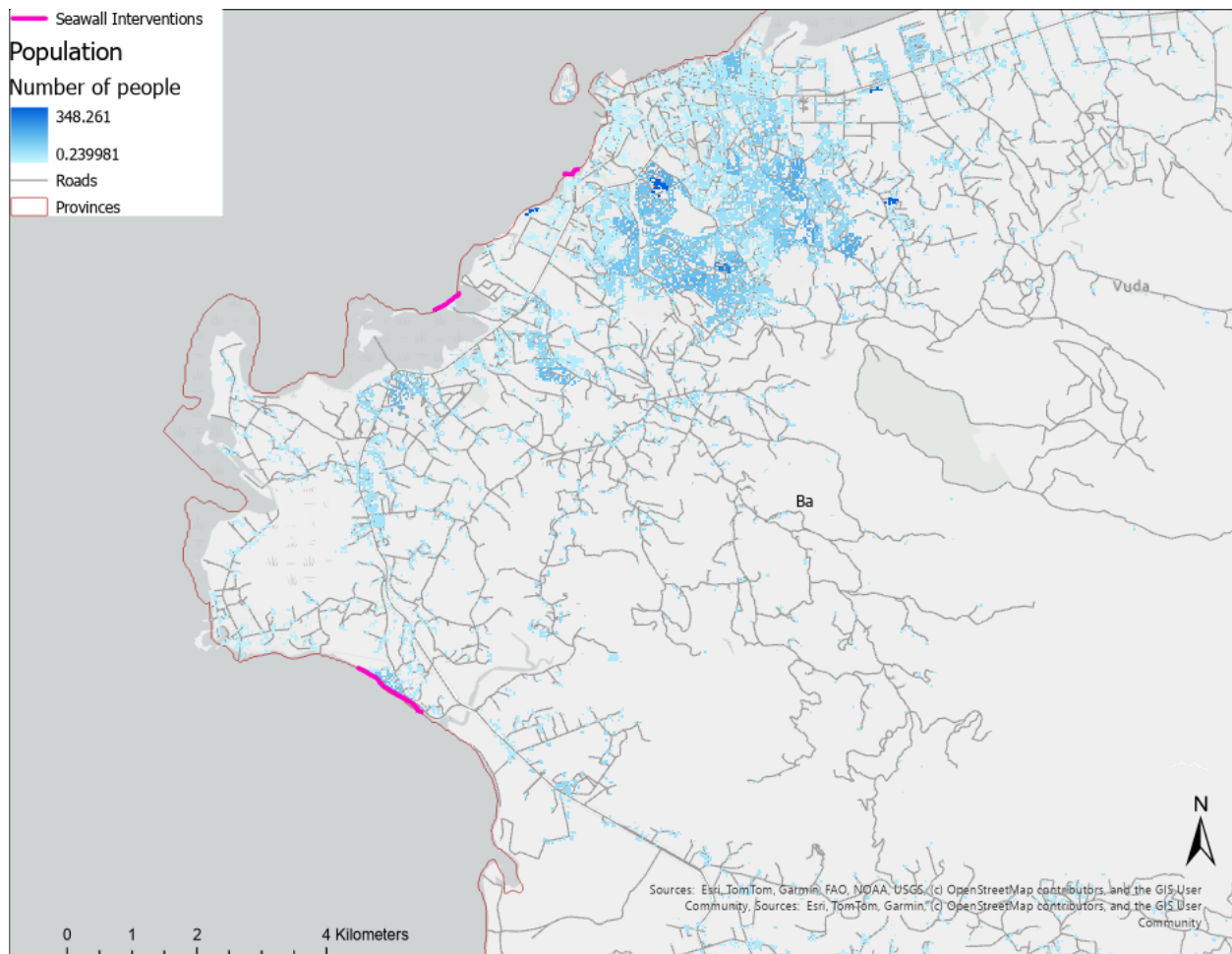


Figure 11: Zoomed-in map of example living shorelines interventions (green) in Ba Province, displayed over population (blue), roads (grey) and province outlines (red). Light Gray Canvas Background from ArcGIS™.

Since the profile, and hence, the cost of a seawall is highly dependent on its height, seawalls are typically designed for a height that corresponds to the likely expected flood height at a location, rather than the maximum flood height at that location. The design of a seawall typically follows this approach recommended by the U.S. Army Corps of Engineers' Coastal Engineering Manual⁵¹⁷:

1. Calculate extreme water levels.
2. Calculate potential wave heights on top of this water level
3. Determine the design height for the seawall and
4. Design and build the cross-section to the requirement.

The design height of a seawall is based on two considerations, extreme water level and wave heights. Seawalls are typically designed to a desired return period water level, often a 50-year, or 2%, event, plus a safety factor. Waves often add flood risks on top of extreme water levels during a storm, and studies have shown that the contribution of waves can be as high as 60%.^{518 519}

For the seawall interventions, we first identify locations where seawalls are feasible, based on the characteristics of the coastline and the presence of potentially exposed assets within the floodplain. We then estimate the median and maximum peak future flood height values from our flood model within 200 meters of each seawall.

⁵¹⁷ USACE, *Design of Coastal Revetments, Seawalls and Bulkheads*, in *Coastal Engineering Manual*, U.S.A.C.o.E. Department of the Army, Editor. 1995, USACE, Vicksburg, Mississippi. https://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_1110-2-1614.pdf

⁵¹⁸ Melet, A., et al. 2018, Under-estimated wave contribution to coastal sea-level rise. *Nature Climate Change*, 2018. 8(3): p. 234-239. <https://www.nature.com/articles/s41558-018-0088-y>

⁵¹⁹ Serafin, K.A., P. Ruggiero, and H.F. Stockdon, *The relative contribution of waves, tides, and nontidal residuals to extreme total water levels on U.S. West Coast sandy beaches*. *Geophysical Research Letters*, 2017. 44(4): p. 1839-1847.

Based on these values, we calculate the design height for each seawall conservatively, as the maximum of either of two height values:

1. The median flood height around the wall, multiplied by 1.6, which accounts at least for a 1% event, or
2. The maximum flood height around the wall, which accounts for an event higher than the 1% event.

4.4 Impacts of Seawall Interventions for Flood Reduction

Similar to the mangrove interventions, we calculate the direct beneficiaries of the seawall interventions within a 3 km buffer of each seawall, and the indirect beneficiaries within a 6 km buffer from each seawall (Figure 16). For each type of beneficiary, all buffers are spatially treated to exclude any overlaps. Also, since all seawalls are designed to avoid flooding, we do not exclude any seawalls from our final impact analyses. We measure the impacts of the seawall interventions directly within the flooded extents as the reduced exposure across all socio-economic metrics within 200 meters of each seawall.

12 km of seawall interventions result in reduced flood impacts to ~35,000 direct beneficiaries and ~82,500 indirect beneficiaries, of a similar scale as the mangrove interventions, corresponding to roughly 4% and 9% of Fiji's total populations. Inside the modelled flood extents, seawall interventions result in reduced flooding to >1500 hectares of urban, agricultural, and other land uses.

6.6. Outcomes of Proposed Interventions

EbA interventions are often combined with other (green) solutions to mitigate the effects of climate change. For successful and sustainable solutions, the problem must be clearly defined, the solutions must be supported by all stakeholders, and the project must fit within feasibility constraints (governance, biophysical, budget, etc.). A natural system analysis is required to define good management objectives and develop suitable and sustainable interventions.

The interventions that are suggested in this study are anticipated to reduce the expected effects of climate change in Fiji, i.e. the increase in magnitude and frequency of floods and droughts, improve coastal protection, and reduce local threats to the GSR to ensure ecosystem services and health are maintained to increase climate adaptation. The qualification of the interventions is challenging as many of the intervention benefits will be experienced not only at a local level in individual households and livelihoods but at regional levels through improvement in downstream habitats and coastal and marine environments that will benefit many outside of the direct project intervention areas. That being said, the benefits of the EbA and GI interventions are estimated below.

Benefits are considered both in terms of environmental benefits (i.e., sediment reduction), benefits to society (i.e., flood vulnerability reduction), and the number of people expected to benefit, both within local project sites and through indirect benefits to downstream and coastal habitats.

Riparian vegetation restoration is expected to provide benefits through sediment reduction, and thus water quality improvement in freshwater and coastal ecosystems. These sediment reduction benefits were calculated for each basin within each Tikina using the InVEST modelling framework. Values of sediment export were summed across each priority project area in a baseline scenario considering business as usual, or no intervention. The InVEST model was then performed again considering the implication of interventions and changing the land use type of identified pixels to represent restoration (i.e., from a degraded state to a restored state). The sediment export was then recalculated based on the change in land use type, and the intervention scenario sediment export was then subtracted from the sediment export of a baseline scenario (current land uses) to obtain the benefit in sediment reduction of implementing each restoration scenario within the proposed project provinces.

Mangrove restoration can also provide benefits for soil stabilisation and, thus, sediment loss reduction. However, due to their coastal nature, it is difficult to quantify this potential benefit with existing models. However, the primary purpose of mangrove restoration for climate adaptation is for coastal protection and flood/seal level rise susceptibility reduction.

6.6.1. Physical intervention benefits

EbA Benefits

EbA utilizes the natural functions of rivers and ecosystems to preserve the socio-economic services upon which communities depend. It strives to implement natural solutions based on a risk-based approach to optimize effort and

division of resources by deriving a balanced set of interventions. The evidence of the cost-effectiveness of EbA is rapidly increasing. However, the effectiveness of the interventions depends on the location where the interventions are planned. In upstream areas, for instance, water and sediment can be retained by vegetation restoration or water retention on slopes, while effective land-based run-off and flood interventions downstream are achieved through restoration.

There have been many examples of EbA implementation in Fiji and across the Pacific. Integrating ecosystem-based strategies into food security policies in the Pacific region has been important in addressing interconnected issues like climate change, sustainable development, and land use planning. A significant initiative highlighted is the Pacific Ecosystem-based Adaptation to Climate Change (PEBACC) project, launched by SPREP in 2015 with funding from Germany's BMU. This project aimed to study and enhance social-ecological systems in Fiji, Vanuatu, and the Solomon Islands.

Another key project is the REDD+ (Reducing Emissions from Deforestation and Forest Degradation) initiative, which has involved various Pacific Island countries over ten years, focusing on mitigating deforestation and forest degradation. Notable achievements in Fiji include community-led initiatives and the signing of an Emission Reductions Payment Agreement with the World Bank in 2021. In Fiji, EbA measures such as green manure usage and mangrove conservation have improved agricultural sustainability and food security. In Vanuatu and the Solomon Islands, EbA projects have included coastal vegetation restoration, home garden intensification, and agroforestry, contributing to better livelihoods and resilience to climate change.

Overall, EbA projects have positively impacted the Pacific communities by enhancing biodiversity, restoring ecosystems, and reviving traditional knowledge, leading to improved food security, livelihood options, and cultural preservation. We expect similar benefits from the proposed intervention given their holistic approach across a variety of ecosystems and services, their alignment with previous and ongoing projects, and their complementarity to government goals and initiatives.

Table 0-4 Noted case studies benefits of ecosystem-based management in Pacific Islands (from Prasad et al.)

Key EbA interventions	EbA projects in line with the intervention policies in the Pacific Islands	Identified adaptation and co-benefits
Health and extent of local forests	Fiji, Solomon Islands and Vanuatu - PEBACC project - expansion of native forest at high elevations. Papua New Guinea - Managed Forests. This ongoing project attempts to decrease deforestation and forest degradation. Samoa – UNDP Project - Adaptation in Sato'alepai and Lelepa Village where reforestation of abandoned agricultural and cleared land has taken place	Carbon sequestration Reduced flooding Decreased run-off and soil erosion Improved biodiversity Improved livelihoods Increased resilience to extreme flooding and storm events Decreased risk of land slides
Productivity of soil	Fiji, Solomon Islands and Vanuatu - PEBACC project agricultural improvement and diversification for productivity and yield associated with different soil amendments and diversified cropping systems. Fiji - Ba, Lautoka, Nadi, Nadroga, and Tavua - Government project expected to deliver environmental benefits, enhanced soil fertility, improved slope, riverbank, and flood zone stability, and conservation of forest areas. Samoa - UNDP project for Adaptation to Flooding and Sea Level Rise and enhanced soil fertility, improved slope, river bank, and flood zone stability, and conservation of forest areas for Fagamolo, Safai Community, Avao, Vaipouli, Salei'a, Sato'alepai and Lelepa Village.	Improved agricultural productivity Improved food security Reduced erosion Improved flooding resilience
Riparian function	Fiji, Solomon Islands and Vanuatu - PEBACC project - for improving and buffering ecosystem services for the terrestrial, riparian, coastal and marine environments.	Decreased run-off Riverbank stabilisation Increased biodiversity Infrastructure and coastal community risk reduction

	Fiji - Vetiver grass nursery - adaptation & use of riparian buffers. Samoa - Tafitoala Village, south coast of Upolu to protect lowland areas from extreme sea surges and coastal erosion, protected by replanting of salt-tolerant coastal plants to create natural barriers along the coastline and reforestation of riparian buffers. Samoa - UNDP project for Adaptation and protection against sea-level rise and coastline protection for Fagamolo, Safai Community, Avao, Vaipouli, and Salei'a.	from sea level rise and extreme storms
Biodiversity	Fiji, Solomon Islands and Vanuatu - PEBACC project - for reforestation, decrease in fragmentation, and diversity in agricultural systems. - Fiji - Ridge-2-Reef programme - Ridge-to-reef management of priority water catchments on the two main islands of Fiji to preserve biodiversity, and ecosystem services, sequester carbon, improve climate resilience and sustain livelihoods. - Fiji - Gau Island forest protection. Preservation of cloud forest and coastal habitat using ecosystem- based management, participatory approaches and integrated resource management. Papua New Guinea - Wanang Conservation Area. Lowland rainforest protected area. Community-led educational focus. Samoa - UNDP project where agroforestry practices are reviewed and changed to create diverse agro-ecological systems for Fagamolo, Safai Community, Avao, Vaipouli, Salei'a, Sato'alepai and Lelepa Village.	Improved watershed management Decreased land-based run-off Increased water quality Improved carbon storage Improved water security Improved livelihoods Improved capacity and education of local communities More resilient watersheds, infrastructure, and communities to extreme events Reduced risk of flooding
Protection against storm surges	Fiji, Solomon Islands and Vanuatu - PEBACC project - for catchment area with Hazard reduction through stormwater regulation and flood control, reducing sedimentation into waterways. Papua New Guinea - Mangrove Rehabilitation - Project to increase the resilience of communities to the negative effects of climate change. Samoa - UNDP project for Adaptation and protection against storm surges, sea inundation, and flooding for Fagamolo, Safai Community, Avao, Vaipouli, and Salei'a	Reduced flooding Increased resilience of infrastructure Increased resilience of livelihoods Reduced human health risks Reduced land-based run-off Improved water quality
Freshwater sustainability	Fiji, Solomon Islands and Vanuatu - PEBACC project - for protection and expansion of high-elevation forests to slow run-off and increase cloud and rainwater infiltration to groundwater supply. - Fiji- Wash Programme - Projects focused on the delivery of water, sanitation and hygiene promotion assistance. Some aspects of Wash are NbS. - Fiji and Samoa - Water and Nature Initiative - Projects focused on good governance, payments for ecosystem services and learning and leadership, to improve the quality and sustainability of water resources in the region	Improved water security Reduced flooding risk Reduced risk to infrastructure and communities Reduced human health risks Improved biodiversity
Food supply and sustainability	Fiji, Solomon Islands and Vanuatu - PEBACC project - for protection of marine resources, improvement of habitats and potential for aquaculture, and diversity of crops. Vanuatu - Community Disaster Committee (Futuna) Projects focused on nutrition, food security, working with women in agriculture, and expanding a network of village gardens	Improved food security Reduced overfishing Improved marine natural resource management Increased resilience to livelihoods Reduced human health risks
Income and independence sustainability	Fiji, Solomon Islands and Vanuatu - PEBACC project - for diversification of income from cash crops to other investments through enhanced ecosystems.	Improved livelihoods Improved resilience to extreme events

	Fiji - Kai Project - Improving livelihoods by increasing kai fishery's economic benefits by addressing food safety issues. Tokelau - solar Project - Solar power plants and coconut biofuel generators to reduce reliance on imported fuel. Vanuatu - Nakau Programme. Reducing exposure to climate-related risks, poverty, and natural disasters by helping indigenous landowners sell carbon offsets and conservation credits instead of timber as a way to deliver economic development to communities. Fiji, Samoa, Solomon Islands, Vanuatu and Tonga - MESCAL Project - An IUCN Oceania project to address the key challenges of mangrove management to increase the resilience of the Pacific people to climate change and improve livelihoods. Melanesian countries except for New Caledonia. REDD+Program - An integrated framework to reduce carbon emissions from deforestation and valuation of forest ecosystem services.	Reduced human health risks Improved natural resource management (marine, terrestrial)
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Living shorelines Benefits

Living shorelines refers to any vegetative or natural material infrastructure system which enhances the natural environment through direct or indirect means. It is the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspiration of stormwater and reduce flows to sewer systems or to surface waters. In this study, we consider the construction of new elements in the landscape using natural materials, i.e. clay, sand, and stones, which contribute to climate change adaptation as living shorelines.

Across the Pacific, there have been stronger demands from all stakeholders to focus investments in 'living shorelines'. There is growing awareness and attention paid to nature-based solutions and approaches that create synergies between climate mitigation, adaptation, and social and ecological outcomes. Nature-based solutions can be cheaper and more sustainable than engineered solutions and can benefit local communities by unlocking the potential for local economic development, often developing tourism potential. Improvements to coastal protection, for example, can often utilise plants, reefs, sand, and natural barriers to reduce erosion and flooding while maintaining natural shoreline processes. There is a range of activities that can be undertaken for communities to preserve reefs and strengthen climate resilience. Nature-based solutions are increasingly adopted for floods and storm surge management and managing drought conditions in combination with flood defences^{520, 521}

Armouring with 'hard' engineered structures, such as seawalls and breakwaters, is the current solution for coastal defence to protect against hazards⁵²². However, the financial costs of maintaining these structures under future climate change scenarios are significant.⁵²³ In parallel, this has prompted research investigating the value of natural ecosystems, such as biogenic reefs, dunes, beaches and vegetation, to protect against erosion and waves, with the benefit that these systems can adapt to changes in climate and self-repair after major storm events⁵²⁴. Recently, the restoration or creation of habitats through 'soft ecological engineering' techniques has been advocated as a tool for natural shoreline stabilization, with additional ecosystem benefits, such as biodiversity provision.⁵²⁵

GI interventions, like mangrove restoration, will result in a substantial increase in climate adaptation due to reduced risks of flooding. Green seawalls will result in a total of 169 km² which is equal to a reduction in flooding vulnerability

⁵²⁰ UNDRR (2021) *Fiji National Disaster Risk Reduction Policy*. Available at: <https://www.undrr.org/media/85938/download?startDownload=20240617>.

⁵²¹ SPREP (2020) *Coastal ecosystem-based rehabilitation guide*. Available at: <https://pacific-data.sprep.org/dataset/coastal-ecosystem-based-rehabilitation-guide>

⁵²² https://www.coastalwiki.org/wiki/Hard_coastal_protection_structures

⁵²³ Pandolfi, J. M., et al. (2020) 'Coral reefs and ecosystem services in Fiji', *Proceedings of the National Academy of Sciences*, 117(45), pp. 28048–28055. doi: 10.1073/pnas.1222469111.

⁵²⁴ https://www.researchgate.net/publication/325267001_Ecosystem-based_management_of_coral_reefs_under_climate_change

⁵²⁵ United Nations (2025) 'Delivering improved coastal fisheries management services in Fiji', UN SDGs. Available at: [https://sdgs.un.org/partnerships/delivering-improved-coastal-fisheries-management-services-fiji#:~:text=Genuine%20and%20effective%20partnerships%20are,%2DFiji\)%2C%20and%20academic%20institutions](https://sdgs.un.org/partnerships/delivering-improved-coastal-fisheries-management-services-fiji#:~:text=Genuine%20and%20effective%20partnerships%20are,%2DFiji)%2C%20and%20academic%20institutions)

across 24% of the area. Ra and Bua will experience the greatest benefits with around 43% and 31% flood-susceptible areas in each province, respectively, followed by Ba and Macuata at about 26% and 13% of the area less vulnerable to flooding.

While there may be some overlap across interventions, this equates to a substantial amount of area, and thus human populations, with higher adaptation capacity to the impacts of climate change.

In addition to flood vulnerability reduction, green seawalls will also aid in water quality improvements by entrapping sediments, particularly during extreme rainfall and storm events. In combination with riparian vegetation and mangrove restoration, substantial water quality improvements are expected in both freshwater and coastal ecosystems.

Future decision triggers for adaptive management:

For the living shorelines the decision triggers will be either a) loss of functionality, i.e., the shorelines getting overtopped during a storm surge; b) damage during a storm that leads to loss of functionality; c) [Vegetation Loss](#): Die-off of native marsh grasses due to poor planting, saltwater intrusion, or drought; d) [Structural Failure](#): Displacement or breakage of protective structures (e.g., rock sills, oyster reefs, fiber logs) leaves the shoreline exposed to wave action; e) prevalence of invasive species; f) [Human Activity](#): Dredging, improper landscaping that removes native plants, or construction nearby can destabilize the area. In these cases, the living shorelines should be rebuilt.

For mangroves, the decision triggers will be loss of 50% of mangrove extent (based on the Verra Coastal Resilience Credits methodology (Under Development) - [Methodology for Coastal Resilience Benefits from Restoration and Protection of Tidal Wetlands - Verra](#)).

For riparian restoration we modelled a range of buffer widths from 100 m to 500 m to consider how changing buffer width affected sediment retention. Our analysis, existing literature, and past project experience highlights that the optimal buffer width for riparian restoration to maximize sediment retention depends on local site characteristics. For this reason, the exact buffer width for riparian restoration will be tailored to each site based on local conditions. This also means that the decision triggers for responding to damage will also need to be optimized based on site conditions. We broadly plan to follow similar principles to the VERRA coastal resilience methodology, which prompts re-evaluation of project if 50% of the ecosystem is lost/degraded – i.e. if 50% of a riparian area was lost or degraded, we would redesign, conduct reinforcement, or conduct replanting. However, in some areas in the watershed where there is particularly high sediment input, we would plan to both increase the buffer width but also have more sensitive trigger thresholds to respond.

6.6.2. Capacity building benefits

In addition to physical intervention, the project will enhance the capacity of communities to actively manage and maintain the EbA, GI and CSA interventions and help formalise and strengthen their organisation and governance structures. Non-governmental and governmental organisations will be strengthened to implement community-based natural resource management. They will be trained and equipped with sustainable forest management practices, sustainable agricultural practices, and sustainable marine resource management to ensure the sustainability of interventions and ecosystems, e.g., maintenance of wetlands, floodplains, fisheries resources, watersheds and plantations. These organisations will be engaged in implementing and supporting EbA and GI measures, as well as the health of the ecosystems where they are located, using indigenous knowledge and skills.

6.7. Summary of Environmental Benefits

The proposed GCF project in Fiji will deliver significant benefits through a comprehensive ecosystem management strategy. This initiative, which aligns with the principles of Ecosystem-based Adaptation (EbA), incorporates multiple interventions (e.g., riparian management, mangrove restoration, green seawalls), which are designed to enhance environmental sustainability and community resilience. Below is a brief exploration of the key benefits and applicability associated with these interventions.

6.7.1. Fisheries management

To address overfishing, the project introduces measures such as license caps and stringent enforcement of fishing regulations. Additionally, it educates fishers on sustainable practices, aiming to ensure the long-term viability of fish populations, as described in the feasibility studies⁵²⁶. These efforts are expected to improve the health of coral reefs, enhance their resilience to climate change and other stressors, and contribute to the livelihoods and food security of local communities⁵²⁷.

6.7.2. Restoration of Degraded Ecosystems

Restoration and GI activities such as mangrove restoration, riparian buffer repair, and construction of living shorelines can play important roles in stabilising coastlines, reducing erosion, filtering pollutants, improving water quality, protecting habitats and supporting biodiversity. Collectively, these actions contribute to the ecological resilience of the Great Sea Reef (GSR) and the communities it supports. In addition, green seawalls provide sediment reduction and biodiversity outcomes from local populations, which will also increase water quality for communities downstream and all users of marine and coastal areas.

6.7.3. Anticipated sedimentation reduction

Why addressing sedimentation is important

Poor water quality caused by land-based run-off is a major threat to reef health in the GSR, and likely to get worse under climate change. This run-off, which includes sedimentation from land-use changes, nutrients from fertilizers, and sewage pollution, degrades coastal water quality, leading to reduced coral reef productivity, increased coral mortality, and diminished marine ecosystem services, such as coastal protection and food provision from fisheries. Sedimentation can smother corals, increase their sensitivity to heat stress, and decrease the photosynthetic capabilities of symbiotic algae. Additionally, nutrient pollution can increase macroalgal growth, reduce coral growth, and drive coral disease, while sewage pollution introduces pathogens, heavy metals, and toxins harmful to both marine life and human health.

Direct impacts of sedimentation also undermine the resilience of the GSR under climate change. Under future climate scenarios it is expected that sea surface temperatures will increase, leading to increased coral bleaching events. While bleaching will damage corals and may lead to death, reefs that have low sediment and nutrient exposure are best positioned to rapidly recover. This can be caused by several mechanisms. Coral larvae are unable to settle on sediment covered surfaces – so deposited sediment on the reefs suppress new corals colonizing and regrowing following bleaching. Coral larval settlement is also suppressed by dense algal coverage, therefore nutrient enhanced algal growth can hinder coral recovery following bleaching. Reducing land-based run-off and sedimentation is thus critical for the health of marine ecosystems and the coastal human populations that depend on them.

Proposed interventions

To protect coral reefs in Fiji that are more resilient to climate change, interventions are proposed that address the critical issue of poor water quality caused by land-based run-off. Our proposed interventions—mangrove restoration, riparian buffer restoration, and living shorelines—are informed by global and local research demonstrating that improving water quality can significantly enhance the health and resilience of coral reefs. Reduced sedimentation refers to a decrease in the amount of sediment (soil, silt, and organic matter) entering waterways compared to a baseline or reference level. It is typically measured in terms of sediment load (e.g., tons per year) or concentration (e.g., mg/L).

Mangroves and riparian buffers are natural filters that trap sediment and nutrients before they reach the reefs. These interventions target the root of local coral reef degradation (a proactive approach) rather than the degradation itself – as opposed to interventions like coral gardening that are often expensive and ineffective if root causes are not addressed. This approach will ensure long-term benefits and increased climate adaptation from Fiji CRR from a ridge-

⁵²⁶ United Nations (2025) 'Delivering improved coastal fisheries management services in Fiji', UN SDGs. Available at: [https://sdgs.un.org/partnerships/delivering-improved-coastal-fisheries-management-services-fiji#:~:text=Genuine%20and%20effective%20partnerships%20are,%2DFiji\)%2C%20and%20academic%20institutions](https://sdgs.un.org/partnerships/delivering-improved-coastal-fisheries-management-services-fiji#:~:text=Genuine%20and%20effective%20partnerships%20are,%2DFiji)%2C%20and%20academic%20institutions)

⁵²⁷ United Nations (2025) 'Delivering improved coastal fisheries management services in Fiji', UN SDGs. Available at: [https://sdgs.un.org/partnerships/delivering-improved-coastal-fisheries-management-services-fiji#:~:text=Genuine%20and%20effective%20partnerships%20are,%2DFiji\)%2C%20and%20academic%20institutions](https://sdgs.un.org/partnerships/delivering-improved-coastal-fisheries-management-services-fiji#:~:text=Genuine%20and%20effective%20partnerships%20are,%2DFiji)%2C%20and%20academic%20institutions)

to-reef perspective. These strategies not only protect coral reefs by mitigating sedimentation and nutrient pollution but also provide co-benefits such as soil conservation, enhanced food security, and improved human health.

Riparian restoration benefits for reduced sedimentation

Riparian buffers are areas of permanent vegetation located within and between agricultural fields or other lands and the water courses to which they drain. These buffers are intended to intercept and slow runoff, thereby providing water quality benefits. In addition, in many settings, they are intended to intercept shallow groundwater moving through the root zone below the buffer. Buffer also provides shade, stabilizes slopes and riverbanks, and can help slow down stormwater runoff – reducing riverbank erosion, especially during storms. In combination, this helps reduce sediment and nutrient input into rivers, which reach the reef.

Riparian buffer strips are protected by law in Fiji, but many have been degraded or lost – leading to a loss of this sediment retention capacity. Livestock in Fiji are most often allowed to roam freely across landscapes. Livestock trampling is known to degrade embankments leading to habitat degradation and increased run-off. Livestock fencing is strongly suggested to accompany riparian buffers and embankment restoration within this project. Further, several communities recognized issues with livestock escapes during severe storms, contributing to the landscape degradation of feral livestock.

Implementation of riparian restoration will follow best practice including appropriate selection of species, planning techniques (spacing, line-cutting, planting), buffer zones, fire management (where and if appropriate), and post-planting management – including firebreak management, livestock management, survival monitoring and weeding. The main purpose of riparian buffer restoration within this proposed project relates to reduction in soil erosion and thus reduced sedimentation and increased water quality for the GSR. This is expected to improve GSR health and provide climate adaptation benefits to ecosystems and people. However, secondary objectives of this intervention may vary by location and community and may include providing cleaner water, food security, increased biodiversity, improved soil fertility, fire prevention, economic gains, and medicinal and/or cultural value. Species selection will be based on environmental conditions at each site, the level of degradation, and will consider secondary project priorities of individual communities. Lists of native and naturalized tree species used for forest restoration in Fiji have been compiled and can assist with species selection.

Mangrove restoration benefits for reduced sedimentation

In addition to coastal protection, mangrove restoration also provides benefits for soil stabilization and, thus, sedimentation reduction. Sediment capture occurs when sediment is trapped within mangrove structures (i.e., root systems) that results in immediate benefits to water quality. Previous studies have shown differences in sediment capture based on mangrove location (i.e., fringing vs basin) and on state (degraded, natural, restored). Based on the classification system presented by Worthington et al., many mangrove restoration sites proposed in this analysis are considered “Open coast” or “Estuary.”

Studies suggest that mangroves can vary in their sediment trapping and erosion control properties depending on hydrological dynamics, mangrove state, and level of sediment inputs. Generally, restored mangroves can reach the same levels of benefits as natural mangrove systems once they reach natural levels of tree density and size in a given area.

Literature review of mangrove sedimentation rates by biophysical typology within priority areas (estuarine and open coast)

Biophysical typology	Sedimentation rate	Standardized sedimentation rate (kg/m²/year)	Source	Location
Estuary	2.94 (dry season)- 3.46 (wet season) g/cm ² /yr	29.4 - 34.6 kg/m ² /year	Van Santen et al. (2006) Sedimentation in an estuarine mangrove system ⁵²⁸	Vietnam

⁵²⁸ https://www.researchgate.net/publication/222421858_Sedimentation_in_an_estuarine_mangrove_system

Estuary	36 mg/cm ² /day	131.5 kg/m ² /year	Victor et al. (2006) Sedimentation in mangroves and coral reefs in a wet tropical island, Pohnpei, Micronesia ⁵²⁹	Micronesia (Pohnpei) - high rainfall
Open Coast (Fringe)	20 mg/cm ² /day	73 kg/m ² /year	Golbuu et al. (2005) ⁵³⁰	Micronesia (Palau)
Open Coast (Fringe)	2-5 mg/cm ² /day	7.3-18.3 kg/m ² /year	Furukawa et al. (1997) ⁵³¹ , Wolanski et al. (1998) ⁵³²	Australia
Open Coast (Fringe)	3.37 ± 0.49 kg m ⁻² year ⁻¹)	3.37 kg/m ² /year	Cinco-Castro, Herrera-Silveira, Comin (2022) ⁵³³ Sedimentation as a support ecosystem service in different ecological types of mangroves	Mexico
Open Coast (Fringe)	0.21 (Palau)-1.01 (Vietnam) g/cm ² /year	2.1-10.1 kg/m ² /year	MacKenzie et al. (2016) ⁵³⁴ Sedimentation and belowground carbon accumulation rates in mangrove forests that differ in diversity and land use: a tale of two mangroves	Vietnam and Palau

While sedimentation rates are highly dependent on local factors, and studies are somewhat difficult to compare due to differences in sampling design, sampling period, and indicators - a literature search revealed that estuarine mangroves have sedimentation rates ranging from 29.4-131.5 kg/m²/year while open coast (fringing) mangroves have sedimentation rates from 2.1-73 kg/m²/year. Notably, estuarine mangroves near rivers tend to have higher sediment capture rates than those on the open coast, though in many cases the open coast mangroves provide the greatest coastal protection. Given the focus on climate adaptation and the feedback from stakeholders engaged during country visits, the primary purpose of mangrove restoration for climate adaptation is for coastal protection and flood/sea level rise susceptibility reduction. A blend of open coast and estuarine mangrove areas for restoration has therefore been proposed.

7. Institutional and Policy Analysis

Understanding the effectiveness of climate change and mitigation has grown in importance as communities and nations have sought to understand the future and how to reduce the impacts in a highly dynamic interconnect world. This is a complex area of discovery, which will ultimately be extremely important for responding to the challenges of often unsustainable impacts from increasing storms, drought, and flood, as well as a whole host of issues already described in the present desktop study. The next section reviews this issue for Fiji by taking a few examples from the Fijian literature.

7.1. Introduction to Fiji's governance framework

Fiji's legal system can be described as a "dual" legal and governance system that simultaneously incorporates the English common law that arrived following cession to Britain and a traditional iTaukei system of law and governance rooted in Fiji history and customs. Fiji has a centralised government based on a liberal democracy, which includes a Parliament (known as the Parliament of the Republic of Fiji) and an independent judiciary.

Customary law is reserved for Indigenous Fijians, though the rights and interests in the traditional iTaukei system of law and governance may create rights and interests recognised by the state and enforceable against non-Indigenous Fijians and non-citizens. While customary law continues to operate locally, it is no longer explicitly recognised as a general source of law. However, customary rights and interests have been recognised in the Constitution or in

⁵²⁹ <https://www.sciencedirect.com/science/article/abs/pii/S0272771405003185>

⁵³⁰ https://www.researchgate.net/publication/241431123_The_State_of_Coral_Reef_Ecosystems_of_Palau

⁵³¹ <https://ui.adsabs.harvard.edu/abs/1997ECSS...44..301F/abstract>

⁵³² <https://link.springer.com/article/10.1023/A:1009971326046>

⁵³³ <https://www.frontiersin.org/journals/forests-and-global-change/articles/10.3389/ffgc.2022.733820/full>

⁵³⁴ <https://link.springer.com/article/10.1007/s11273-016-9481-3>

legislative enactments, including concerning matters relevant to ascertaining climate change impacts (e.g. fisheries, land, culture).

Fiji's governance structure consists of a Central Government and fourteen provincial governments spread across the four divisions (Central, Northern, Eastern and Western Divisions – see Chapter 1, Figure 1.2). Established under the iTaukei Affairs Act, these offices are crucial in local governance. They are headed by Roko Tui from the Provincial Council, who are responsible for formulating and implementing policies to ensure good governance and well-being of the iTaukei communities at the Tikina (district) and village levels. The council leader responsible for policies promoting health, peace, and welfare of the i-Taukei in the provinces, including promoting the economic, cultural, and social development of the province.

Table 7-1. Responsibilities across ministries of the Fijian Government⁵³⁵.

	Fishe ries	Waste manage ment	Maritime/ marine pollution	Touri sm	Shipp ing	Environm ental protectio n	Coastal infrastru cture	Non- living marin e resou rces	Cultural resource s
Ministry of Econom y									
Ministry of Fisheries									
Ministry of Forests									
Ministry of Environ ment									
Ministry of iTaukei Affairs									
Ministry of Commer ce, Trade, Transpo rt and Tourism									
Ministry of Local Govern ment									
Ministry of Lands and Mineral Resourc es									

⁵³⁵ https://en.wikipedia.org/wiki/Politics_of_Fiji#Constitutional_structure

Environmental and climate laws and policies exist across all levels of government in Fiji, and there are increasing moves towards incorporating more indigenous iTaukei knowledge into frameworks for the management of the environment.⁵³⁶ These efforts are driven by recognising that traditional ecological knowledge might be crucial in addressing climate challenges and promoting sustainable development. Fiji also has a rich history of successful community-based management of marine areas.⁵³⁷

7.2. Regulatory environment

The governance of coastal and marine resources in Fiji is a complex web of legislation and policies, with multiple government and non-government organisations involved in natural resource management. In addition to top-down, government-led legal approaches, Fiji also has a strong tradition of bottom-up, community-led approaches to natural resource management.⁵³⁸

To date, Fiji does not have stand-alone legislation for protected or conservation areas; therefore, management styles of areas of significance vary from site to site. Without a clear framework or plan in place for the management of the Great Sea Reef, supported by relevant agencies and stakeholders, management is likely to be complex given the overlapping laws and roles within government agencies, differences in legislative objectives and priorities, and associated challenges which led to challenges in compliance and enforcement.

In the absence of new legislation, this chapter examines the existing regulatory framework for climate change, environment, coastal and marine resources in Fiji and considers how existing laws may be harmonised to enhance the protection and management of the GSR.

7.2.1. Land and Marine Tenure

In Fiji, land tenure is distributed in three main tenure categories – iTaukei, State, and freehold. iTaukei tenure is dominant, comprising 88% of Fiji's land mass, 3.9% state, and 7.9% private freehold.³ The iTaukei Land Trust Board is empowered to issue leases and licences of iTaukei land. Inshore fisheries, although owned by the State, may be managed and used for subsistence purposes by customary resource owners under the Fisheries Act of Fiji.

7.3. Key Laws and Policies

7.3.1. The Constitution of Fiji 2013

The Constitution of Fiji is the supreme law of the State and any law inconsistent with it is invalid to the extent of the inconsistency. Chapter 2 of the Constitution contains a Bill of Rights, which includes a right to a clean and healthy environment.

Article 40 provides: 40 (1) Every person has the right to a clean and healthy environment, which includes the right to have the natural world protected for the benefit of present and future generations through legislative and other measures. The right to a clean and healthy environment imposes levels of obligation by the State to respect, protect and fulfil that right.

7.3.2. Environmental Management Act 2005

The Environmental Management Act (EMA) was passed in 2005 in response to Fiji's obligations as a party to the Convention of Biological Diversity (CBD). The EMA seeks to apply principles of sustainable use and development of natural resources and identify matters of national importance for Fiji. The preservation of the coastal environment, the relationship of the iTaukei with their ancestral lands and waters and the protection of human life and health are considered matters of national importance and require a person performing any function under the Act to recognise and have regard to matters of national importance.

The Act serves several important purposes, including a regime for environmental impact assessment of actions that may cause significant environmental or resource management impact. It also sets out a system for gaining

⁵³⁶ Pearson, J., K. E. McNamara and P. D. Nunn (2020). *iTaukei Ways of Knowing and Managing Mangroves for Ecosystem-Based Adaptation*. https://link.springer.com/chapter/10.1007/978-3-030-40552-6_6

⁵³⁷ Sievanen, L., R. L. Gruby and L. M. Campbell (2013). "Fixing marine governance in Fiji? The new scalar narrative of ecosystem-based management." *Global Environmental Change* 23(1): 206-216.

⁵³⁸ Sievanen, L., R. L. Gruby and L. M. Campbell (2013). "Fixing marine governance in Fiji? The new scalar narrative of ecosystem-based management." *Global Environmental Change* 23(1): 206-216.

permits for pollution and waste activities and a regime for offences and penalties where permits are not obtained, and EIA processes are not followed. Importantly, the Act extends out to the outer limits of national jurisdiction of the ocean, so it applies to activities on both land and in coastal waters (clause 3).

Table 7-2. Provisions of the Environmental Management Act 2005

National Environment Council	A National Environment Council is established (clause 7), which has responsibilities as listed in clause 8, including: • Approving the national report and national environment strategy; • Monitor and oversee the implementation of the national environment strategy; • Facilitate a forum for discussion of environmental issues; • Ensure that regional and international commitments on the environment are implemented, and advise the government on these issues Under clause 11 the Council may also direct the Department responsible for the environment to carry out functions including: • Coordinate the formulation and review of the national report, and formulation, review and implementation of the national environment strategy; • Implement and carry out the EIA process; • Design and implement policies and programmes on pollution and waste management, abatement and reduction; • Coordinate conservation and management of natural resources Amongst others. The Climate Change Act, which came into force on September 24, 2021 includes Clause 12(8) which requires the National Climate Change Coordination Committee to meet with the National Environment Council annually.
Environmental Impact Assessment	The Department must have a unit responsible for environmental impact assessment (EIA) (clause 12(1)). This unit must examine and process every development proposal referred to it (clause 12(3)). An approving authority must examine every development proposal received, and determine whether the activity or undertaking is likely to cause significant environmental or resource management impact (clause 27(1)). The authority must take into account, pursuant to clause 27(2): • The nature and scope of the activity or undertaking; • The significant of any environmental or resource management impact; • Whether there exist any technically or economically feasible measures that would prevent or mitigate any adverse environmental or resource management impact; or • Any public concern relating to the activity or undertaking The proposal will be subject to an EIA process if it will cause significant environmental or resource management impact (clause 27(4)). This process is governed by clause 28-31.
Resource management	The Department must have a unit responsible for environmental resource management (clause 13(1)). The unit has a number of functions and responsibilities, including coordinating resource management activities (clause 13(2)).
Environmental management	An environmental management unit may be established, with the responsibility to scope development proposals, review completed EIA reports, and other functions (clause 15). Applicable to Government agencies, statutory authorities and local authorities. Facilities, however, must establish environmental management committees if required to by the Department of Environment. EMC's facilitate cooperation between employer and employees in relation to environment management at the facility. They investigate and report on any matter at the facility that may constitute a threat to the environment, conduct awareness etc.

National State of the Environment Reports and Plan	Sets out the requirements for a National State of the Environment Report to be published at least every five years (clause 23(1)). The National Environment Strategy must then be formulated within 12 months after the approval of the report (clause 24).
Waste management and pollution control	Part 5 of the Act sets out controls on pollution and waste. In short, a facility must not discharge any waste or pollutant into the environment, amongst other things, unless issued with a permit (clause 35). Part 5 also addresses the issuing of permits
Offences and penalties	Part 6 sets out a regime of environmental offences and penalties
Regulations	Under cl 61 of the Act, the Minister may make regulations to, amongst other things: (h) prescribe procedures for EIA in respect of any class of development proposal and procedures for the preparation of, or criteria for, approval of an EIA report (i) prescribe the format or contents of any report or plan required under the Act

The Minister's power to make Regulations under the EMA is set out in s 61. Section 61(1) sets out the majority of the matters that the Minister may make regulations for and s 61(3) includes additional powers that may only be exercised after first consulting 'the relevant Minister responsible for Fijian affairs, land, mineral resources, agriculture, fisheries or forests'. For example, s 61 includes a power to prescribe procedures for EIA, a power to 'provide procedures for formulation, implementation and review of the ... National Resource Management Plan', and a power to establish enforcement mechanisms. The regulation-making power under s 61(3)(e) empowers the Minister (e) to establish guidelines, standards and procedures for the conservation, protection or rehabilitation of any land, river or marine areas. Such guidelines, standards or procedures could be used to facilitate an ecosystems-based approach and improved management of the GSR.

EMA in Fiji provides some structures to integrate traditional governance systems of natural resources, but there are also some gaps in fully incorporating customary management practices. Here are the key issues:

7.3.3. The Environment Management Act 2005 (EMA): Potential limitations.

EMA has several limitations regarding co-management and traditional systems:

- The EMA does not contain provisions that enable Marine Protected Areas (MPAs) to be established, though it does play an important role concerning MPAs.
- The Act does not require preserving all components of biological diversity in its concept of sustainable development.
- The EMA does not acknowledge the role of the Itaukei Land Trust Board (TLTB) in establishing environmental policy, guidelines, legislation, and monitoring, nor does it include the ITATB in environmental assessments on Native Lands.
- Some traditional or customary structures and activities are exempted from requiring EIAs which could lead to oversight of environmental impacts.

7.3.4. Integration of Traditional Systems and Co-Management (limitations).

While the EMA itself may not provide a comprehensive framework for co-management, other aspects of Fiji's governance system support traditional management and co-management approaches:

- The EMA does not provide a comprehensive framework for co-management between government agencies and local communities using traditional systems.
- Fiji has a dual governance system that combines customary elements and Western (or 'formal') elements.
- The Constitution of the Republic of Fiji 2013 recognises customary land ownership and the customary right to access marine resources.
- The Fiji Locally Managed Marine Areas network (FLMMA) supports communities implementing marine resource management, combining local customs and scientific knowledge.
- There is a strong policy-enabling environment for co-management arrangements between FLMMA partners and coastal communities.

7.3.5. Integration: Gaps and Potential Solutions

To enhance the framework for co-management, several steps could be taken:

- Reducing policy fragmentation: Various agencies collect information (e.g. MSME) information for different purposes, but there is a lack of data harmonization and integration across government bodies.
- Filling legislative gaps: There is a need to review and update the legislative structure and mandate for small development, including provisions for data collection. This would include the need to develop a centralised repository for MSME data. While data is available, it is scattered across ministries and does not necessarily all get shared with the Bureau of Statistics.

- Financing constraints: MSMEs face significant challenges in accessing affordable capital due to high collateral requirements, limited credit history and stringent lending criteria of commercial banks. Limited financial literacy, bureaucratic barriers and lack of alternative financing options such as crowdfunding further constrain their growth.
- Integrating coastal governance integration: There are challenges in achieving integrated coastal management and governance in Fiji; working to harmonise legislation, governance, people and the environment together.

7.3.6. Fiji National Biodiversity and Strategies Action Plan 2020 to 2025

Fiji's National Biodiversity and Strategies Action Plan (FNBSAP) 2020 to 2025 is a nationally executed Programme of Work endorsed by the NEC and required under Fiji's obligations to the CBD and is a national document recognised under the Environment Management Act. The FNBSAP is aligned with the CBD Strategic Plan for Biodiversity 2011-2020, the Aichi Biodiversity Targets and Climate Change Adaptation Goals. Implementation of the actions is undertaken through partnerships between various agencies within the government of Fiji and nationally based NGOs working collaboratively with communities and the private sector.

The goal of the strategy is to conserve and sustain Fiji's terrestrial, freshwater, and marine biodiversity and to maintain the ecological process and functioning of the ecological systems, which are the foundation of national and local development and have immense global significance. The formulation of the strategy is based on principles that include Ecosystem-based adaptation (EBA) and Eco-Disaster Risk Reduction (Eco-DRR) as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change. The following table summarises priorities of the NBSAP aimed at enhancing the climate change resilience of terrestrial, coastal and marine ecosystems⁵³⁹.

Table 7-3. Priorities/goals of Fiji's NBSAP.

Priorities/goals	Objectives
Community participation and ownership	• Promote community property rights, including traditional rights over natural resources, indigenous intellectual property rights relating to natural resources and cultural knowledge; • Encourage community decision-making structures and practices, while ensuring gender inclusivity; • Encourage active participation and ownership of resource owners in conservation and resource management initiatives; • Promote active involvement of local communities in planning, implementation, monitoring and evaluation; • Recognise the value of traditional knowledge and wise use management practices to sustainable biodiversity management.
Gender mainstreaming and equality	• Promote mainstreaming of gender perspective into all NBSAP-related policies, strategies, actions and project stages; • ensure equal rights, possibilities and obligations for both men and women in society; • ensure that stereotyped concepts of gender roles do not restrict the opportunities of individuals; • ensure equal appreciation of the values, choices, and life experiences typical of both women and men.
Biodiversity Mainstreaming and Ownership	• ensure collaboration and partnership between biodiversity and development and Cross-sector coordination; • strengthen links and action between sectors and associated public and private sector institutions that affect and/or benefit from biodiversity.
Improve knowledge, capacity and intellectual property	• ensure that intellectual property rights to biodiversity, genetic resources, and bio-derivate knowledge about biodiversity are recognised; • improve scientific knowledge of biodiversity and enhance ethnobiological understanding; • promote training, skills and international collaboration; • encourage education, public awareness and local knowledge sharing; • build effective and sustainable conservation capability and organisations through ongoing capacity development; • ensure conservation is continuously improved by recording, disseminating and incorporating lessons learned and best practices.
Biodiversity is foundation for all	• ensure that future generations of landowners and citizens, as well as today's

⁵³⁹ CBD Strategy and Action Plan - Fiji (English version)

Priorities/goals	Objectives
development and inter-generational equity	- youth and children, all have an equal opportunity to use and enjoy Fiji's biodiversity; - promote key ecosystem services through green, cheaper and low-energy infrastructure; - promote disaster risk reduction, including disaster and climate risk reduction across sectors; - promote economic diversification through habitat, species and genetic diversity; - ensure that the principle of polluter and/or user pays is adhered to when assessing responsibilities relating to conservation.
Adopting an ecosystem-based management approach	- adopt an integrated approach to ecosystem-based management; - maintain healthy, productive and resilient ecosystems; - maintain and restore connectivity between social and cultural values; - incorporate economic, social and cultural values in conservation plans; - promote participatory governance.
Managed and Protected Areas (for species protection, forest, watersheds and marine areas) should be comprehensive and representative	- promote ex-situ conservation to assist in the conservation management of threatened species or forms; - manage and conserve forest ecosystems; - conserve and sustainably manage Fiji's reefs, lagoons and mangroves; - control invasive species which threaten indigenous flora and fauna.
Ecosystem-based adaptation (EbA) and Eco-Disaster Risk Reduction	- enable people to adapt to the impacts of climate change and disasters by using opportunities created by sustainably managing, conserving and restoring ecosystems to provide ecosystem goods and services; - aim to maintain and increase resilience and reduce the vulnerability of ecosystems and people to adverse effects of climate change; - ensure that climate change adaptation is integrated into broader adaptation and development strategies; - build upon and use approaches that already exist in the practices of biodiversity and ecosystem conservation, climate change adaptation and livelihood development; - implement mangrove, forest and grasslands conservation to protect communities and settlements from erosion and sandstorms, or integrate vegetation into urban spaces, such as in green walls and green roofs, to reduce the urban heat island effect and improve air quality; - contribute to sustainable livelihoods by maintaining the ecosystem services that provide clean water, food and fibre; supporting poverty reduction; heritage conservation; and preservation of local identities.
Financial Sustainability and accountability	- conservation initiatives must be adequately supported if they are to be successful; - ensure that conservation programmes are of scale and budget appropriate to the local context; - promote long-term strategic planning and resource mobilisation that sustains conservation over time; - ensure international and national partners are accountable to the communities and other stakeholders.

The NBSAP also lists specific, unique terrestrial and marine areas of Fiji that require consideration in planning and management decisions, for example, in conducting EIAs, issuance of permits, and planning for MPAs and/or other effective area-based conservation measures. (See Annex 6 of the NBSAP).

Fiji's National Biodiversity Strategy and Action Plan (NBSAP) outlines several specific targets related to coastal, marine, and terrestrial ecosystem protection and restoration, as well as climate change adaptation. Relevant targets extracted from the NBSAP are presented below.

Protection and Conservation of Ecosystems

- Marine and Coastal Areas:* By 2030, Fiji aims to increase the proportion of marine areas under protection. This includes a goal to designate 30% of its Exclusive Economic Zone (EEZ) as marine protected areas (MPAs).
- Terrestrial Areas:* Fiji plans to expand terrestrial protected areas and strengthen the management of existing ones to protect biodiversity, particularly in critical areas like forests, wetlands, and important species habitats.

Restoration of Ecosystems

- Restoration efforts are targeted to address degraded ecosystems, including coral reefs, mangrove forests, and terrestrial forests. This includes restoring 30% of degraded lands and marine ecosystems to enhance resilience to climate change and support biodiversity.

Climate Change Adaptation

- *Climate Resilience of Ecosystems*: Protecting ecosystems as critical solutions to mitigate and adapt to climate change. The NBSAP promotes the restoration of ecosystems such as coral reefs and mangrove forests to buffer the impacts of climate change like coastal erosion and sea-level rise.
- *Ecosystem-Based Adaptation (EbA)*: Integrating EbA strategies in national and local planning processes, especially in vulnerable areas like coastal zones, to help communities adapt to climate-related risks.

Sustainable Resource Management

- Promoting sustainable management of marine and terrestrial resources, with a focus on ensuring that biodiversity conservation is integrated into agricultural and fisheries sectors. This includes reducing overfishing, promoting sustainable land-use practices, and enhancing community-managed areas.

Biodiversity in Climate Policy

- Mainstreaming biodiversity conservation into national climate change policies and strategies, including Fiji's Nationally Determined Contributions (NDCs) under the Paris Agreement. These efforts aim to ensure that climate change adaptation and biodiversity goals are aligned.

These targets reflect Fiji's commitment to addressing the dual challenges of biodiversity conservation and climate change adaptation through integrated, ecosystem-based approaches. They emphasize protecting and restoring natural systems while ensuring that local communities are equipped to manage and adapt to climate-related changes. Fiji's NBSAP aligns with the Convention on Biological Diversity's (CBD) Aichi Biodiversity Targets. It addresses the following key Aichi Targets relevant to coastal, marine, and terrestrial ecosystem protection and restoration, as well as climate change adaptation:

Aichi Target 10: By 2015, the multiple anthropogenic pressures on coral reefs and other vulnerable ecosystems impacted by climate change or ocean acidification are minimized, so as to maintain their integrity and functioning.

Aichi Target 11: By 2020, at least 17% of terrestrial and inland water areas and 10% of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative, and well-connected systems of protected areas and other effective area-based conservation measures.

Aichi Target 15: By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks have been enhanced, through conservation and restoration, including restoration of at least 15% of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification. These targets underscore Fiji's commitment to preserving its rich biodiversity and enhancing ecosystem resilience in the face of climate change.

7.3.7. Climate Change Act 2021

This act provides a framework for implementing urgent and long-term measures to promote the climate change resilience of vulnerable communities and ecosystems. It also facilitates the achievement of climate change commitments. The act also promotes the integration of climate change adaptation across all sectors and encourages implementing adaptation and climate resilience strategies such as the NAPA and NCCP. Promoting government transparency, enabling decision-making, and enhancing capacity-building are additional objectives for achieving climate change resilience. This act also aims to ensure that ocean and coastal ecosystem conservation and enhanced climate change resilience of these ecosystems are integrated into climate-related policies.

International context

The overarching framework for climate change regulation in Fiji derives from the international level. The United Nations Framework Convention on Climate Change was entered into in 1992, set out some general commitments, and established the Conference of the Parties (COP) and monitoring and reporting mechanisms through national inventories (Art 12).

The Kyoto Protocol (1997) did not apply to Fiji, but Fiji is a signatory to the 2015 Paris Agreement and was one of the first countries to ratify it. The key essence of the Paris Agreement is captured in Art 2, which states that:

- This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change in the context of sustainable development and efforts to eradicate poverty, including by:
 - (a) *Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;*
 - (b) *Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and*
 - (c) *Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.*

Parties to the Paris Agreement agree to pursue climate action as pledged in their increasingly ambitious nationally determined contributions ('NDCs').

Domestic context

As a response to the Paris Agreement, in 2021 the Fijian government passed the Climate Change Act 2021, which aimed to comprehensively enshrine the Fijian response to climate change.⁵⁴⁰ However, the Act has not yet come into effect and is scheduled to come into effect at a date gazetted by the Minister.

The Act included a Climate Emergency Declaration, recognising and declaring that the world faces a climate emergency and proportionately swift adoption of sustainable practices is required. Other important provisions include:

Table 7-4 Climate Act - Provisions of the Paris Agreement, in 2021.

Paris Agreement	Implementation of the Paris Agreement via various measures, including a mechanism for preparing and reporting Fiji's Nationally Determined Contribution ('NDC') (clauses 7-8)
Minister's powers	Powers of the Minister, including powers to oversee the implementation of and promote compliance with the Act, and formulate guidelines related to climate change (clause 9)
State entity obligations	Obligations of State entities, including ensuring that decisions and policies etc are consistent with any guidelines published by the Minister (clause 18)
National Climate Change Policy (NCCP)	Development and implementation of a National Climate Change Policy (NCCP) by the Minister, with the assistance of a Committee (clause 27)
GHG inventory	Development of a Fijian GHG inventory (clause 29)
Net zero target	Climate target of net zero emissions by 2050 (clause 38). Corresponding Carbon budgets must be prepared to support this (clause 39).
Carbon sequestration rights	Carbon sequestration rights rules, such as the exclusive and distinct legal right to carbon sequestration and carbon stocks (clause 45)
REDD+	REDD+ Policy to be formulated by the Minister for Forests (clause 48)
Climate adaptation	Recognition that climate change will impinge on human rights, including rights to a healthy environment, adequate food and water, health, rights of children, housing and sanitation, and transport (clause 65). To this end, the Act establishes a National Adaptation Plan Steering Committee (clause 66) to prepare successive National Adaptation Plans (NAP). Requires new infrastructure to be subject to climate risk and resilience assessments (clause 71).
Climate displacement and relocation	Taskforce establishment (Clause 75) and development of corresponding guidelines (clause 76).
Oceans and climate change	Recognition of the importance of oceans to Fijian people (clause 79). Sets a long-term sustainability target, for 100% of Fiji's oceans to be sustainably and effectively managed (clause 81). Sets target for 30% of Fiji's marine areas to be protected by 2030. Establishes a National Ocean Policy Steering Committee (clause 82) to prepare successive National Ocean Policies (clause 83).

The current National Climate Change Policy is in effect from 2018-2030. This policy sets out an overarching vision, objectives and strategies for climate change adaptation and mitigation as well as an implementation plan.

⁵⁴⁰<https://leap.unep.org/en/countries/fj/national-legislation/climate-change-act-no-43-2021>

The REDD+ framework is also relevant in the Fiji context. REDD+ developed as a mechanism to involve developing countries in forest management, both as a measure to reduce deforestation and to assist with the realisation of the myriad other benefits and ecosystem services associated with protecting and managing forests. One of the potential benefits of REDD+ over schemes focused solely on addressing afforestation and reforestation is that the latter favours monoculture plantings, whereas REDD+ is intended to incentivise the protection of much more biodiverse forests.⁵⁴¹

Fiji has a REDD+ Policy that was entered into in 2011. It sets out how REDD+ initiatives will be developed in Fiji. Forest and catchment management is strongly linked to water quality and carbon capture, hence their mention here.

7.3.8. National Climate Change Policy (NCCP; 2018-2030)

The NCCP prioritises climate change adaptation of vulnerable communities and ecosystems. The following climate change adaptation objectives are proposed with ecosystem-based adaptation (EbA) being a means to achieving enhanced resilience⁵⁴².

- promote flexible ecosystem-based adaptation solutions which protect biodiversity, increase carbon sequestration potential and reduce human vulnerability to climate impacts;
- revise existing environmental policies and planning regulations where required to improve consideration of the implications of climate change projections and risks;
- enhanced collaboration of ministries with environmental oversight to promote uptake of EbA practices across sectors;
- improve policy coherence recognising the need to better represent the inter-relations between environments, human behaviours, economic interests, and human development needs in response to increasing climate change-related stressors and risks;
- formalise methods for assessing and quantifying the adaptation and mitigation co-benefits resulting from environmental conservation activities;
- use full cost accounting methods to evaluate infrastructure proposals and the benefits of EbA interventions;
- promote the integrated management of freshwater resources by ensuring that infrastructure is adapted to climate change impacts;
- promote sustainable and resilient infrastructure and adaptation investments; and
- ensure that the objectives of international frameworks such as the Convention on Biodiversity, Aichi Targets, and UN Convention to Combat Desertification are supported and progressed through implementation of ecosystem-based adaptation solutions.

7.3.9. National Adaptation Plan (NAP)

It should be noted that the NAP is currently undergoing review. The current NAP prioritises climate change adaptation of vulnerable communities and ecosystems. Special emphasis is placed on using nature-based solutions to achieve this goal. Fiji's NAP incorporates several strategies that emphasize the protection and restoration of coastal, marine, and terrestrial ecosystems as integral components of climate change adaptation. Key aspects include:

1. **Marine and Coastal Ecosystem Management:**
 - The NAP supports sustainable management and protection of marine and coastal ecosystems, aiming to enhance their resilience and facilitate restoration when degraded. This involves promoting conservation areas and sustainable fisheries management to reduce overfishing and restore fish stocks.
2. **Ecosystem-Based Adaptation (EbA):**
 - EbA is recognized as an approach that utilizes biodiversity and ecosystem services to help communities adapt to climate change. By focusing on maintaining and enhancing the resilience of ecosystems, EbA contributes to reducing vulnerability to climate-related hazards.
3. **Integration of Ecosystem Values into Development Planning:**
 - The NAP emphasizes the integration of ecosystem and biodiversity values into development processes. This includes implementing the National Biodiversity Strategy and Action Plan and promoting protected areas through improved management and financing.
4. **Addressing Land Degradation and Desertification:**
 - Through its agriculture sector, the NAP focuses on sustainable land management practices to combat desertification and land degradation. This includes tackling challenges posed by droughts and floods, aiming to restore and protect terrestrial ecosystems.

⁵⁴¹ Ministry of Waterways and Environment, 2020. Strategic Plan 2020-2024. Available at: <https://leap.unep.org/en/countries/fj/national-legislation/ministry-waterways-and-environment-strategic-plan-2020-2024>.

⁵⁴² FIJI-NCCP-2018-2030_0.pdf

These strategies underscore Fiji's commitment to leveraging ecosystem-based approaches for climate change adaptation, recognizing the critical role of healthy ecosystems in building resilience against climate impacts.

Additional specific details related to EbA and living shorelines mention in the NAP include⁵⁴³:

- equip youth and vulnerable communities with the knowledge and skills needed to promote sustainable development. Particular focus will be given to contextually relevant ecosystem-based as well as gender and human rights-based approaches to adaptation;
- improve awareness of ecosystem-based adaptation among private sector entities and non-governmental and community-based organisations to support the integration of ecosystem-based approaches into programme design;
- enhance focus on the potential of green, nature-based, or hybrid infrastructure solutions in reducing vulnerability to environmental and climate risk;
- adopt an 'ecosystem approach' which uses as a strategy the integrated management of land, water and living resources to support the delivery of ecosystem services equitably;
- conserve and restore flora, fauna, and habitats as a basis to enhance adaptive capacity or reduce the adverse socioeconomic impacts associated with environmental and climate events;
- promote horizontal integration of ecosystem-based approaches to adaptation as well as participatory and inclusive processes into the development of Strategic Development Plans and other relevant processes of Government Ministries and other entities;
- implement riverbank protection activities that integrate ecosystem-based approaches with hard infrastructure, such as riparian buffers;
- integrate ecosystem-based adaptation (EbA) measures into the planning and construction of seawalls and riverbanks, including mangrove planting; and
- implement ecosystem-based approaches to adaptation to protect, maintain, and restore degraded habitats with active community, NGO and private sector engagement in restoring watersheds, riparian and coastal zones.

7.3.10. Nationally Determined Contribution (NDC)

The updated NDC submitted to the UNFCCC indicates revised measures for improving the climate change resilience of vulnerable ecosystems and communities. This includes implementing nature-based solutions to promote climate change adaptation across sectors. The following priorities relevant to EbA are mentioned in this NDC⁵⁴⁴:

- enhance climate change resilience by upgrading, repairing and relocating existing critical public infrastructure;
- enhance resilience by upgrading, repairing and relocating existing critical public infrastructure;
- develop simplified and standardised early warning and monitoring systems, and prioritise nature-based solutions to mitigate the impact of flooding and cyclones;
- conserve the natural environment and biodiversity, enabling the sustainable long-term provision of ecosystem services, including carbon sequestration; and
- prioritise measures to ensure that public infrastructure is resilient to cyclones and floods, prioritizing nature-based economically viable solutions, and developing future infrastructure and building projects.

7.3.11. National Oceans Policy 2020-2030

One of the main goals of the National Oceans Policy (NOP) is to provide a holistic framework for integrated action and partnerships on all of Fiji's national, regional and global ocean-related commitments. The NOP is an umbrella that sets out processes and principles to encourage coordinated management of stakeholders. It recognises and aligns itself to ongoing approaches in various ocean management and provides overarching support and integration across these sectors. The governance structure established by the Climate Change Act indicates a coordinated approach to environmental management and monitoring. The Minister responsible for climate change has significant authority to implement and oversee various aspects of environmental policy, including ocean management.

The NOP consists of a series of goals accompanied by strategies for implementation. These goals and strategies include:

- Cooperation – including through the development of a governance framework including a National Oceans Policy Steering Committee (NOPSC) and subsidiary working groups, and mapping and analysis of laws and policies to identify gaps.

⁵⁴³ [NAP Fiji.pdf](#)

⁵⁴⁴ [NDC Proceedings](#)

- Sustainability, including a goal that by 2030 100% of the ocean under national jurisdiction will be under sustainable management, and 30% will be designated as MPAs. Strategies to achieve this include building awareness of ecosystem services, strengthening existing policies and processes, revising legislation where necessary, assembling area-based management tools, and implementing area-based management.
- Security, including reduction of illegal fishing – through better coordination and stronger regulations.
- People, including diversification of livelihoods, through strategies including cross-sectoral resource management, policy measures to achieve gender equality, and increased equity of ocean benefits across society.
- Development, but through strategies to mitigate or reduce the impacts of development on the ocean;
- Knowledge, including the incorporation of traditional knowledge into ocean decision-making through free, prior and informed consent; and
- Advocacy through regional and global policy advocacy on oceans.

These goals are accompanied by a section on implementation, which sets out responsibilities for implementing each goal across sectors.

The NOP is managed and administered by the Climate Change and International Cooperation Division (CCICD) of the current Ministry of Climate Change and Environment. Oversight responsibilities ensuring general support of the NOP and providing insight into policy reform processes, will fall under the purview of the NOPSC. The NOPSC will carry out its role in an advisory capacity with the final decision vested in the responsible line Minister.

Regulation of coral reefs and marine and coastal ecosystems

Coral reefs and marine ecosystems are a crucial part of Fiji's natural environment and natural capital, with fishing and aquaculture responsible for 1.6% of Fiji's GDP (as reported in 2016).⁵⁴⁵

7.3.12. The National Integrated Coastal Management Framework

The National Integrated Coastal Management ('ICM') Framework 2011⁵⁴⁶ manages and preserves coastal and marine environments. It was created under the Environment Management Act 2005⁵⁴⁷ and involves a 'ridge-to- reef' strategy connecting marine ecosystems with inland, freshwater, and coastal ecosystems to ensure a holistic approach to sustainability and climate change. The ICM Framework was implemented using a model Integrated Coastal Management Plan (ICMP) in Ra Province in 2018, alongside national guidelines for ICM processes. Generally, ICMPs create overarching frameworks for development opportunities while considering province- specific threats and issues.

Furthermore, during our province-level stakeholder consultation, a representative from the Ministry of Rural and Maritime Development (Provincial Administrator) stated that under the National Environment Council (NEC), Integrated Coastal Management (ICM) Committees are established. In Ra, a province-level ICM committee convenes on an ad-hoc basis subject to funding availability. These provincial committees directly contribute to the National ICMS under NEC. At the district level (Tikina), ICM involves department heads from provincial levels and representatives from Qoliqoli communities. Ra's ICM initiatives have included efforts towards sustainable finance, such as establishing a trust fund for reef management. However, ICM encounters challenges related to funding and staff turnover, impacting its effectiveness.

The National ICM Committee ('ICMC') was established under the Environment Management Act (EMA) to oversee the ICM Framework and assist with implementation. A review of the ICM framework is planned to inform its updating, an opportunity to integrate the ambitions of the proposed GCF project.

7.3.13. Fisheries Act⁵⁴⁸

The Fisheries Act was passed in 1941 and entered into force in 1942 and has been amended subsequent times. While fishing in Fiji pre-war was very low intensity with little environmental impact, post-war Fiji saw the introduction of larger-scale commercial fisheries practices with more significant environmental impacts.⁵⁴⁹ The Fisheries Act serves several important purposes.

⁵⁴⁵ Government of Fiji, n.d. Fiji's REDD+ Policy. Available at: https://www.un-redd.org/sites/default/files/2021-10/Fiji%20REDD%20Policy_final.pdf

⁵⁴⁶ <https://macbio-pacific.info/wp-content/uploads/2017/08/Integrated-Coastal-Management-Plan-Framework-for-the-Republic-of-Fiji-2011.pdf>

⁵⁴⁷ <https://macbio-pacific.info/wp-content/uploads/2017/08/Integrated-Coastal-Management-Plan-Framework-for-the-Republic-of-Fiji-2011.pdf>

⁵⁴⁸ <https://www.laws.gov.fj/Acts/DisplayAct/628>

⁵⁴⁹ DeMers, A. and V. Kahui (2012). "An overview of Fiji's fisheries development." *Marine Policy* 36(1): 174-179.

First, it sets out a regime of licences for fishing activities. A licencing officer has the discretion to grant licences to take fish in Fijian waters (clause 4(1)). No person can take fish for trade or business without having a licence (clause 4(3)). However, an exception applies to a person who takes fish with a line from the shore or with a spear (clause 4(3)(a)) or when an exemption is granted by the Minister (clause 4(3)(b)). There are also requirements for registration of fishing vessels (clause 6), and offences may apply for fishing without the relevant licence (clause 10).

Second, the Act provides for the protection of native customary rights. Clause 13(1) states:

...it shall be an offence for any person to take fish on any reef or on any kai (cockle) or other shellfish bed in any area in respect of which the rights of any mataqali or other division or subdivision of the Fijian people have been registered by the Native Fisheries Commission in the Register of Native Customary Fishing Rights unless he shall be a member of such mataqali, division or subdivision of the Fijian people who do not require a licence under section 5 to take such fish or shall first have obtained a permit to do so from the Commissioner of the Division in which such area is situated: Provided that-

- a) such permits shall not be necessary in the case of persons taking fish (other than by way of trade or business or as the employee of a person carrying on the trade or business of a fisherman) with hook and line or with a spear or portable fish trap which can be handled by one person; and
- b) any such permit may exclude fishing for particular species of fish, or may exclude fishing in any particular areas, or may exclude fishing by any particular methods, or may contain any combination of such exclusions.

If there is a registered mataqali (Fijian clan) claim, clan members do not need a licence to fish for subsistence purposes within their customary fishing grounds (I qoliqoli). If they engage in commercial fishing, they will require a licence. Other persons can apply for a permit unless they take fish with a hook, line, spear or portable trap. Furthermore, a permit may contain exclusions that will be necessary to protect customary interests. Under clause 13(2), the grant of a permit is at the discretion of the Commissioner, but they must consult the Fisheries officer and the subdivision of the Fijian people whose fishing rights may be affected before granting the permit.

From the stakeholder community consultations (Annexes 13.1 and 13.6), it was noted that several issues of concern related to fisheries and coastal management were highlighted during the discussion. Firstly, it was noted by the Nadi Town Council (NTC) representative that overfishing is rampant due to a lack of monitoring and enforcement, compounded by jurisdictional complexities. The Commissioner of the Western Province said that he issues a large number of fishing licenses monthly, further raising concerns about the sustainability of the harvest of these reefs. The community representatives from SASA village mentioned that illegal fishing, often involving fishers from other provinces and even neighbouring countries, is prevalent in the area, contributing to the depletion of resources. Night fishing has become a common practice, further complicating efforts to regulate fishing activities. Additionally, fishers frequently change their fishing locations, making it increasingly challenging to predict fish habitats. The diversity and abundance of fish have decreased, as has the average size of fish, and the spooning/ maturity times have changed.

The Ministry of Maritime Affairs provincial representative noted that fish wardens lack sufficient resources to effectively manage and monitor extensive fishing grounds, contributing to overfishing. While a national strategy exists, a provincial-level strategy is lacking to comprehensively address fisheries management.

In 2017, FELA highlighted a key issue with the Fisheries regime is that the same Department is responsible for both the resource allocation and conservation functions. To this end, FELA recommended that resource allocation and conservation functions be separated and managed by different groups.⁵⁵⁰

It should be noted that the Act also has a broad regulation-making power. Under cl 9, the Minister may make regulations:

- Prohibiting any practices or methods, or employment of equipment or devices or materials, which are likely to be injurious to the maintenance and development of a stock of fish
- Prescribing areas and seasons within which taking is restricted or prohibited
- Prescribing limits to the size of fish, and size of nets
- Regulating the procedure relating to the issue and cancellation of licences
- Prescribing fees
- Regulating any other matter relating to the conservation, protection and maintenance of a stock of fish which may be deemed requisite

⁵⁵⁰ FELA and EDO NSW, *Regulating Fiji's Coastal Fisheries: policy and law discussion paper (2017)*. <https://catalogue.nla.gov.au/catalog/7504808>

The objective of the Offshore Fisheries Management Decree 2012 (Offshore Decree) is to “conserve, manage and develop Fiji fisheries to ensure long-term sustainable use for the benefit of the people of Fiji”. The Offshore Decree explicitly provides for establishing MPAs and empowers the Director of Fisheries to ‘identify and recommend’ the designation of MPAs and the Permanent Secretary to designate MPAs. The Offshore Fisheries Management Regulations 2014 (Offshore Regulations) allows for the scheduling of restricted and prohibited areas. Schedule 1 to the Offshore Regulations includes some prohibited and restricted areas, but these areas do not prohibit or restrict all types of fishing in all circumstances. Instead, the restrictions and prohibitions apply only to vessels (foreign fishing vessels and Fiji fishing vessels) and only in some circumstances. Other relevant features of the Offshore Decree and Regulations include:

- The ability of the Permanent Secretary to “appoint such committees as he or she determines necessary to advise or make recommendations on any areas under his or her authority”, which includes advising the Minister on any matter relating to the conservation, management, development and sustainable use of fisheries resources and designating MPAs;
- Provisions for establishing seasonal and species restrictions; a prohibition on killing, taking, landing, and selling endangered or listed species; and a prohibition on the use of certain types of fishing methods or gear; and
- The ability to declare that an international conservation or management measure is applicable to Fiji fishing vessels and foreign fishing vessels in Fiji fisheries waters, and to Fiji fishing vessels beyond Fiji fisheries waters.

The Minister also has a broad power to make further regulations (under cl 104), including to:

- Prescribe measures for the conservation, management, development and regulation of fisheries or any particular fishery
- Licensing, authorisation or registration of vessels, fishermen, etc
- Other matters related to the fishing industry

Importantly, the Offshore Decree states that it applies to inshore and offshore areas and is to prevail in the event of inconsistency with any other law. This creates the potential for any decisions under the Offshore Decree to override any decisions under the Fisheries Act.⁵⁵²

7.3.14. State Lands Act 1946

The *State Lands Act 1946* (SLA) regulates the ‘control, administration and disposal of Crown land’. ‘Crown land’ refers to: “... all public lands in Fiji, including foreshores and the soil under the waters of Fiji, which are for the time being subject to the control of Her Majesty by virtue of any treaty, cession or agreement, and all lands which have been or may be hereafter acquired by or on behalf of Her Majesty for any public purpose.”⁵⁵³ Foreshores are the area between the mean high-water mark and the mean low-water mark, including mangroves, beachfront and sand or mud flats areas. Foreshores are therefore important for the integrated management of the marine environment.

The Ministry of Lands and Mineral Resources is responsible for the administration and oversight of all development on State Land in Fiji mostly undertaken through a lease or licence under the SLA. A lease gives the lessee, in addition to a positive right to occupy and use the land for the agreed purpose, a temporary negative right to exclude others from the lease area. A licence is a governmental permission to perform a particular act, conduct a particular business or activity (e.g. logging or fishing), or use property for a certain purpose.

Development for which the Ministry of Lands and Mineral Resources issues leases and licences includes jetties, marinas, integrated tourism development, gravel or sand extraction, MPAs, aquaculture, mangrove harvesting;⁵⁵⁴ agriculture, logging and residence. SLA mechanisms include the conferral of a statutory right on the CFROs as lessee or licensee where SLA leases or licenses are granted, public notification and consultation requirements before the grant of a foreshore lease, and the practice of compensating CFROs for the loss of customary fishing rights when foreshore leases and licences are granted.

7.3.15. The Fiji Locally Managed Marine Area Network (FLMMA)

Community-based management is an important part of environmental management in Fiji, and FLMMA is a key part

⁵⁵¹ <https://www.laws.gov.fj/Acts/DisplayAct/2286>

⁵⁵² <https://www.marineecologyfiji.com/towards-an-effective-legal-framework-for-marine-protected-areas-in-fiji-policy-and-law-discussion-paper>

⁵⁵³ https://www.paclii.org/fj/legis/consol_act_OK/c134/

⁵⁵⁴ <https://www.parliament.gov.fj/wp-content/uploads/2020/08/Ministry-of-Lands-and-Mineral-Resources-2013-Annual-Report.pdf>

of this approach.⁵⁵⁵ FLMMA is a not-for-profit charitable association founded in 2000. It is part of the broader global Locally Management Marine Area network, which has the aim of implementing more effective projects and improving the capacity of countries in the network to achieve adaptative management of natural resources.⁵⁵⁶ The aims of FLMMA, according to its constitution, include:

- Encouraging collaboration among government ministries and departments, NGOs, businesses, communities and individuals, to better manage the 'i qoliqolis' (local fishing areas) of Fiji;
- The use of adaptive management;
- Using participatory techniques to empower people and communities.^{557,558}

In essence, FLMMA was established 'to bring together community members, conservation practitioners, researchers, and government officials to learn more about how community-based conservation can best be achieved'.⁵⁵⁹ FLMMA operates as a form of a community-led network of marine protected areas (MPA), but with governance coming from the bottom-up rather than the top-down.⁵⁶⁰ The objectives for FLMMA are set by the local community, and different community groups have experimented with different approaches to conserve marine resources, including the establishment of no-take areas.⁵⁶¹ The FLMMA network covers more than 20% of Fiji's inshore fishing areas and has resulted in improved environmental outcomes in these areas, including increased biodiversity, restored habitat, and increased fish abundance.⁵⁶²

The FLMMA constitution specifically refers to adaptive management, a natural resource management approach that involves learning by doing and adjusting management techniques in response to the outcomes of management actions. To implement this, some FLMMA boundaries and activities have been amended throughout their history.⁵⁶³ The members are appointed from the FLMMA AGM by their respective provinces.

They have some funding allocated under the FLMMA Secretariat as well as support from the NGO that is working on their site, e.g., WCS - Kubulau, Bua. Traditional fishing practices are seen as a tool in their management plans and are revived in some areas as a way to restrict effort but keep catches sustainable.

According to FELA, 'LMMA go some way to bridging the gap between customary and 'modern' law as they, among other things, combine traditional knowledge and practices with modern scientific and technical expertise in MPA management'.⁵⁶⁴ There are limitations to bridging that gap under the formal law. The Inshore Fisheries Draft Decree provided a means through which LMMA would be formally recognised; however, this has always been a sensitive and controversial issue. The recognition of voluntary conservation without government acquisition of rights would be ideal but any issue relating to customary fishing grounds and formal recognition of customary or LMMA management will require extensive consultation.

7.3.16. Inland watershed management

All four provinces have land use practises that contribute to coastal impacts, including agricultural runoff, industrial discharge, sewerage, land clearing and coastal development.

This is a recognised issue across Fiji. According to Fiji's National Ocean Policy:

Prime coastal land traditionally used for agriculture has increasingly faced demand from housing, tourism and infrastructure development sectors, pushing agricultural production onto marginal lands which require chemical fertilizer, pesticides and other inputs and increase soil erosion. Improved planning, coordination and implementation of urban and coastal development and other land use practices are required. Environment Impact Assessment (EIA) will be used as one of the key tools to address this issue (p 14).

⁵⁵⁵ Fiji Environmental Law Association and EDO NSW. (2017). Towards an Effective Framework for Marine Protected Areas in Fiji. Available at: https://www.sprep.org/attachments/VirLib/Fiji/effective-framework-marine-protected_area-fiji.pdf.

⁵⁵⁶ https://www.sprep.org/attachments/pipap/flmma_operations_guide_1.pdf.

⁵⁵⁷ https://www.sprep.org/attachments/pipap/flmma_operations_guide_1.pdf.

⁵⁵⁸ https://www.equatorinitiative.org/wp-content/uploads/2017/05/case_1348160544.pdf

⁵⁵⁹ https://www.sprep.org/attachments/pipap/flmma_operations_guide_1.pdf.

⁵⁶⁰ https://www.sprep.org/attachments/pipap/flmma_operations_guide_1.pdf.

⁵⁶¹ https://www.sprep.org/attachments/pipap/flmma_operations_guide_1.pdf.

⁵⁶² https://www.equatorinitiative.org/wp-content/uploads/2017/05/case_1348160544.pdf

⁵⁶³ Environmental Protection Agency (EPA), n.d. Effects of Ocean and Coastal Acidification on Marine Life. Available at: <https://www.epa.gov/ocean-acidification/effects-ocean-and-coastal-acidification-marine-life>

⁵⁶⁴ Fiji Environmental Law Association and EDO NSW. (2017). Towards an Effective Framework for Marine Protected Areas in Fiji. Available at: https://www.sprep.org/attachments/VirLib/Fiji/effective-framework-marine-protected_area-fiji.pdf.

Thus, the EIA scheme set out under the Environmental Protection Act 2005 (see 4.2) is relevant to inland catchment management. The Former Fiji Minister of Water and the Environment also emphasise the importance of watershed management for protection of waterways.

Management of Ba River catchment: There is no overarching catchment management strategy for the Ba River. Under Fiji's Reef to Ridge initiative there have been a range of activities implemented in the Ba River catchment, including tree planting and establishment of a biodiversity park. A draft Watershed Management Plan for Ba was developed under the GEF R2R.

7.4. Analysis of Gaps in Fiji's Environmental Governance

Fiji faces critical gaps in governance and management, affecting its ability to achieve sustainable use of natural resources. These challenges span inter-agency coordination, ecosystem governance, fisheries management, integration of traditional knowledge, data availability, and financial resources. The key identified gaps, in no particular order, are presented in the table below.

Key Gap	Description
Non-existent inter-agency coordination and cooperation for the sustainable management of the GSR	Fiji's environmental and infrastructural governance set-up struggles with efficient inter-agency coordination. There are several reasons which contribute to the siloed approach of government agency mandates as it relates to environmental conservation and climate adaptation. Jurisdictional overlaps, minimal inter-agency knowledge transfer, lack of an oversight planning body, fragmented environmental management policies, and lack of recognition of ridge to reef approach are some of the key issues contributing to inefficient coordination between planning agencies. Additionally, consultation among departments is inconsistent, often treated as a procedural formality rather than a substantive effort to coordinate policy or action. Some of the key ecosystems, such as mangrove forests, are managed and governed by several agencies, each with their own mandates and jurisdictions. The Lands and Survey Department oversees mangrove resources and foreshore reclamation, while the Forestry Department regulates commercial mangrove cutting under the Forestry Act but lacks laws for illegal or subsistence use. The Fisheries Department issues coastal fishing licenses via the Fisheries Act, and the Department of Environment protects mangroves and biodiversity through the Environment Management Act, 2005. This leads to maladaptive practices where, despite efforts to promote sustainable resource management, conflicting mandates and lack of coordination between different departments could result in activities that harm the health and resilience of ecosystems. Such contradictions can undermine overall environmental goals and lead to practices that are counterproductive to long-term sustainability. The 2022 Audit Report on the Infrastructure Sector by the Auditor-General of Fiji highlights significant governance inefficiencies stemming from inadequate information sharing between agencies. The lack of cross-agency information sharing systems due to fragmented communication channels results in agencies operating in silos. This isolation has prevented the timely exchange of critical information necessary for coordinated decision-making and project implementation. Delays in project timelines and resource misallocation have often occurred because agencies do not have access to up-to-date information from their counterparts. This lack of information sharing not only hampers the efficiency of national level priority projects but also leads to suboptimal achievement of outcomes and targets. Additionally, the acts and policies responsible for ecosystem management aren't well aligned and coordinated. The Great Sea Reef is governed by a patch work of multiple laws, such as the Fisheries Act, the Environmental Management Act (EMA), provincial regulations, and QoliQoli traditions. This disjointed framework undermines holistic conservation, leaving critical habitats unprotected and managed in silos. The Fisheries Management Act dates back to the colonial period and does not incorporate climate change vulnerabilities and risk considerations even though the Climate Change Act mandates all sectoral policies to incorporate future climate scenarios. This is currently a barrier to climate-resilient planning in the fisheries sector. Although the EMA addresses environmental protection broadly, it does not explicitly incorporate climate change adaptation measures. This omission means that the Act does not fully account for the increasing impacts of climate change on Fiji's ecosystems and communities.

Key Gap	Description
	Further, coastal management lacks comprehensive compliance and enforcement framework, as well as necessary finances to address the interconnected nature of terrestrial, estuarine, and marine ecosystems. This gap is exacerbated by cultural and behavioural challenges, with government officials acknowledging the need for efficient cross-sectoral coordination but facing structural barriers and resource constraints. The most critical issue is the lack of financial resources, which impedes meaningful integration and development. Without adequate financing, compliance and enforcement efforts are undermined, making it difficult to establish long-term governance mechanisms capable of hosting projects that address issues holistically. Consequently, the absence of sufficient funding hinders the ability to implement sustainable solutions and achieve comprehensive coastal management.
Lack of long-term planning across national level projects and programs	Although, the Fiji's National Adaptation Plan (NAP), provides for approximately 160 cross-sectoral adaptation measures to reduce vulnerabilities of the communities and ecosystems they rely on, they have one thing in common—they lack longer timescales which can enable sustained management of the ecosystems. Most measures are restricted to a 5-year time scale which is not enough to implement large scale solutions at the GSR level. Lack of funding, focus on pilot projects, and lack of resources to incubate sustained technical capacity are some of the primary reasons for short term planning of priority projects. Also, there is a lack of long-term vision to incubate frameworks and mechanisms which would allow projects to self-sustain after the designated completion date. For instance, many locally managed marine areas are reliant on external donor funding, which is typically short-term and project-specific, leaving communities vulnerable to financial instability once projects end. Furthermore, technical capacity deficits within communities, such as inadequate training and equipment for monitoring fish stocks or assessing reef health, hinder their ability to develop and sustain projects with a long-term focus.
Low availability of reliable data and technical resources	Reliable and up-to-date data is essential for evidence-based policymaking and information sharing, yet Fiji faces critical gaps in data availability, particularly in fisheries and biodiversity. There is a lack of baseline data for coral cover, fish stocks, and water quality, which hampers the ability to assess conservation outcomes, inform decision making and plan for the long term in alignment with the country's global climate commitments. This is primarily the result of a lack of investment in research to gather the necessary data and evidence. Government agencies often lack the budgets needed for this work. The WWF Report on the Great Sea Reef highlights that data collection is fragmented across NGOs, academic institutions, and government agencies, with no centralized database to ensure accessibility or standardization. Similarly, limited technical capacity is a significant barrier to systematic monitoring and evaluation. There are deficiencies in resource assessments, such as incomplete surveys of fish stocks in traditional fishing grounds (qoliqoli). Monitoring compliance with licensing and tracking environmental conditions are also underdeveloped, reducing the government's ability to adapt programs and projects based on changing climate conditions or emerging challenges. Integrating traditional ecological knowledge with scientific data is a practical solution, empowering communities to collect data and share observations which can improve monitoring while fostering local ownership of conservation efforts. Several national level programs and acts, such as the national climate change act, NAP, provide for improving data management and sharing systems, collection of baseline data, and increasing funding for data management related projects. The Fiji CRR project will directly address this through several activities in Component 2 in section B3 of the Funding Proposal.
The national government strategies and mandates are not always aligned with community governance structure and approaches	Traditional governance systems, such as qoliqoli and mataqali, have historically contributed to sustainable resource management in Fiji but remain underutilized in formal governance structures. This regulatory gap arises from the highly centralized structure of government and the highly decentralized governance of environmental resources by customary landowners. The organizational structures of these two stakeholders -- government and customary landowners—create a disconnect that requires deliberate efforts to ensure alignment. A dedicated coordination unit is needed to bridge this divide by integrating local actors into national planning processes, fostering vertical coherence in environmental resource management. Also, Indo-Fijian minorities are ignored between these two governance systems, given that most lands are managed and owned by native Fijians.

Key Gap	Description
	The Protecting Fiji's Great Sea Reef report highlights that traditional practices often outperform centralized approaches in biodiversity conservation, yet they lack formal legal recognition. This has led to conflicts between community-driven conservation efforts and industrial fishing operations. The Analysis of International Law and Indigenous Territories underscores the challenges faced by communities enforcing tabu areas, who frequently encounter resistance from commercial operators due to inadequate legal protections. The Fiji Review of Natural Resource Legislation and the Policy and Law Discussion Paper recommend formalizing co-management agreements that respect indigenous governance systems while aligning them with national objectives. This dual approach would strengthen the ecological and social outcomes of conservation policies. The implementation of indigenous governance to support the co-management of ecosystems and natural resources, is however, ultimately constrained by the lack of financing mechanism. Communities currently do not receive any financial support for the management of ecosystems and natural resources, while at the same time, the Ministry of Fisheries will prioritise based on its annual budget allocations.
Local Fisheries Management Plans exist in isolation	The Qoliqoli Fisheries Management Plans (FMPs) are documents with community-driven strategies designed to manage and sustain traditional fishing grounds (iQoliqoli) in Fiji. These plans aim to balance resource use with conservation efforts to ensure long-term benefits for local communities. The main component of the FMP is the action plans that provide policy guidance and direction on management measures for the fishery resources. These actions are determined through challenges that are identified at the community level with inputs from stakeholders on applicable strategies to mitigate and alleviate these issues. LMPs in Fiji, particularly those implemented under the LMMA framework, face significant challenges. These plans often lack standardized guidelines consistent with national planning strategies and other fisheries management plans, leading to variable outcomes across communities. Additionally, enforcement remains a critical issue, with communities struggling to prevent illegal fishing activities due to insufficient resources and unclear legal protections. WWF has undertaken efforts in the past, in collaboration with the government and communities to synergize the plans under a single document. The local FMPs often operate independently of national frameworks, creating conflicts between community conservation goals and government priorities. For example, overlapping zones of tabu areas and commercial fishing licenses have led to disputes and weakened compliance. These conflicts create tension between communities and commercial operators, as customary landowners often lack the legal authority (they need to be licensed fish wardens to apprehend poachers, for example) and financial support to enforce <i>tabu</i> restrictions against licensed fishers. Moreover, this further undermines the trust and cooperation required for effective co-management of natural resources connected to reef ecosystems. Also, the government's licensing system prioritizes economic objectives, such as revenue from commercial fishing, without considering the ecological and cultural significance of customary practices. This results in unsustainable exploitation of marine resources, threatening the long-term viability of both ecosystems and the livelihoods of local communities.
National environmental regulations governing business practices aren't robust and suffer from enforcement challenges	Fiji has several environmental regulations governing business practices, including the Environment Management Act 2005 (pollution control, waste management), EIA Process Regulations 2007 (mandatory Environmental Impact Assessments), and the Climate Change Act 2021 (climate adaptation and mitigation measures). The Endangered and Protected Species Act 2002 regulates trade in endangered species. Recently, the Fiji Commerce & Employers Federation (FCEF) and IFC introduced ESG standards for businesses. However, these regulations are not always robust enough, as enforcement mechanisms are weak, and businesses often find ways to bypass compliance requirements. Enforcement remains a challenge due to limited resources, bureaucratic inefficiencies, and weak compliance monitoring. Many businesses, especially MSMEs, struggle with the costs of regulatory compliance. This issue is especially critical for the Great Sea Reef (GSR), which faces growing threats from business activities. Industries such as tourism, fishing, and agriculture contribute

Key Gap	Description
	to some of the biggest drivers of reef degradation, including overfishing, unsustainable coastal development, and sedimentation. Overfishing by commercial enterprises disrupts marine biodiversity, while unregulated coastal development—often linked to tourism and real estate—destroys critical habitats like mangroves, which act as natural buffers against erosion. Additionally, poor land-use practices in agriculture and construction lead to excessive sediment runoff, smothering coral reefs and reducing their ability to recover. There is thus a need for robust environmental guidelines for businesses to minimize their impact on the Great Sea Reef (GSR). By strengthening oversight and compliance, the reef’s ecological health can be preserved, ensuring that it continues to support local economies, enhance climate resilience, and sustain biodiversity.

7.5. Opportunities for Regulatory Harmonization

Enhancing the resilience of the GSR and its reliant communities requires a comprehensive approach that integrates terrestrial, estuarine, and marine ecosystem management. By adopting holistic management strategies and harmonizing regulations, it is possible to address the interconnected challenges and create sustainable solutions that benefit both the environment and local communities. We have detailed potential approaches that could help management and monitoring of the GSR:

To address the lack of effective coordination between national and subnational agencies with several competing and overlapping mandates to manage the Great Sea Reef (GSR), it is recommended to develop a comprehensive GSR-wide management framework. This framework should include the establishment of a dedicated unit within the federal government responsible for the development, implementation, and monitoring of a 10-Year Ridge to Reef (R2R) Land and Marine Use Management Plan. This dedicated unit would be tasked with defining permissible seascape and landscape uses to mitigate pressures on coral reefs from overfishing, sedimentation, pollution, and coastal development. Additionally, the unit would coordinate management functions across national agencies, provincial governments, communities, and civil society to ensure all stakeholders are aligned towards a common goal. By integrating provincial and community priorities into national planning processes, this unit would ensure that on-ground realities, data, and feedback are incorporated into the management of the GSR. The responsibilities of this unit could be, but not limited to:

- Ensuring that GSR planning and management efforts are aligned with the National Development Plan (NDP) and community development plans.
- Facilitating engagement with District Councils in planning and management efforts.
- Reviewing and providing feedback on agency development and conservation plans as they relate to the GSR and its connected communities and ecosystems.

The GSR MU should facilitate the development of the 10-Year Ridge to Reef (R2R) Land and Marine Use Management Plan, which would include:

- Prioritization of sites for enhancing the management of designated landscapes and seascapes with high potential for climate change adaptation and community resilience benefits.
- Zoning for various sectors, including fisheries, forestry, tourism, and others.
- Guidelines for businesses to minimize harmful impacts on the GSR.
- Gather necessary data and information to set baselines for land and seascape uses.

If incubated within an existing ministry such as the Ministry of Environment and Climate Change, this Management Unit could play a crucial role in ensuring long-term sustainability by collaborating with various agencies and NGO partners to secure necessary financial resources including future budget allocations from the government and additional resources from international donors and foundations to continue to support its proposed planning and management mandates. This collaboration could provide district governments and communities with the resources needed to implement the provisions of the 10-Year Plan for the GSR and future planning beyond this period.

To effectively address the capacity gaps identified in the feasibility study, it is recommended that the project team focus on a comprehensive capacity-building strategy targeting both national and community levels. This strategy should include tailored training programs for national and divisional technical staff on the design, implementation, operation, and maintenance of Ecosystem-based Adaptation (EbA) and living shorelines interventions. By equipping staff with the necessary skills and resources, the project will ensure the sustainability of these interventions and facilitate future planning and implementation of similar initiatives beyond the project's scope. Additionally, training

on the 10-Year Ridge to Reef (R2R) Land and Marine Use Management Plan and best practices in R2R ecosystem planning will enable government planners to design and implement similar frameworks in other regions of Fiji. At the community level, it is suggested that the project team identify capacity development needs for community leaders and local Community-Based Organizations (CBOs) within the project area. Training programs should be developed and delivered to educate community leaders on the impacts of climate change, the benefits of EbA and GI interventions, and the operation and maintenance of these interventions. This approach will foster community buy-in and ownership, ensuring the sustainable adoption and use of these approaches. The project team should also implement community ecosystem management training to align with the project goals.

Furthermore, it is recommended that the project team embed staff within key agencies responsible for ecosystem management to provide ongoing support and expertise. This will facilitate the integration of project activities into existing agency workflows and enhance the agencies' capacity to lead and sustain these efforts. By addressing the specific needs of national and divisional planners, the project will build long-term institutional capacity, ensuring that the work initiated by the project continues beyond its performance period. This comprehensive approach will enhance the resilience of coastal ecosystems and communities in Fiji, contributing to long-term climate adaptation and ecosystem health.

To effectively address the issue that Local Fisheries Management Plans (FMPs) exist in isolation, it is recommended that the project team focus on integrating FMPs into a cohesive framework that aligns with broader ecosystem management strategies. This initiative should involve engaging local communities to improve the management of traditional fishing areas, thereby sustaining local fisheries and preserving coral reef ecosystems. By expanding community roles beyond resource users to ecosystem stewards and managers, the project could enhance the resilience benefits provided to these communities. Furthermore, it is recommended that the project team develop and deliver training programs for communities on the impacts of climate change, the benefits of EbA and GI interventions, and the operation and maintenance of these interventions.

The project team should conduct a thorough review and establish appropriate fisheries management plan template and guide by collaborating with partners to agree on a common methodology, stakeholder engagement strategy, and integration process for the FMPs. Consultations with coastal communities and provincial government fisheries officers to map existing FMPs, identify goals and objectives, and select areas for detailed biological assessments would be necessary. These assessments will help identify key species, levels of threat, and areas where benefits can be achieved, ensuring that the FMPs address the most significant climate and non-climate threats to Fiji's GSR.

To effectively address the gap in strengthening national climate and environmental commitments, it is recommended to update key national and provincial plans to integrate the GSR as a priority seascape and landscape for implementing Ecosystem-based Adaptation (EbA) and living shoreline interventions. This process should involve a review of the National Adaptation Plan (NAP), National Biodiversity Strategy and Action Plan (NBSAP), Provincial Adaptation Plans, and community plans to identify entry points for integrating the GSR. This would include drafting updated procedures for EbA and living shorelines, ensuring alignment with Fiji's key regulations and policies for coral reefs and climate change. Additionally, organizing consultative sessions with stakeholders to validate the updated documents will provide necessary feedback and adjustments before final endorsement and adoption.

Furthermore, it is essential to establish a robust evidence base to support the strengthening of national plans. This could involve conducting an economic valuation of these interventions to demonstrate their cost-effectiveness and efficiency in reducing the impacts of climate change-induced extreme events, coastal flooding, overfishing, coastal development, and sedimentation. Engaging communities throughout this process will ensure that the analysis captures their experiences and addresses their needs. This evidence will be used to develop updated procedures for the National Adaptation Plan (NAP), National Biodiversity Strategy and Action Plan (NBSAP), and Provincial and community plans, ensuring that these interventions are implemented at scale to enhance the resilience of Fiji's coastal ecosystems and communities.

To enhance coral reef ecosystem and community resilience in the GSR, it is recommended to fund community-driven projects that align with global locally led adaptation principles. These projects should empower communities in Ba, Ra, Bua, and Macuata Provinces to address their climate vulnerabilities and needs. By implementing Ecosystem-based Adaptation (EbA), ecosystem restoration, small-scale living shoreline interventions, and community capacity development, these initiatives will ensure that adaptation solutions are feasible, culturally relevant, and aligned with community governance, economic, and environmental goals. Integrating these measures within Community Plans will reflect each community's development path based on their customs and shared vision.

7.6. Stakeholders

Given the fragmented nature of Fiji's laws, there are many key stakeholders at both the central and local government levels. The local communities, and indigenous groups as a people also have a key role to play in the decision-making processes relevant to the use of their natural resources.

Table 7-6 Key stakeholders to government and policy process

Stakeholder	Responsibilities	Legislation / policy / initiative administered
Government of Fiji, including the ministries of finance, strategic planning, Justice, Itaukei Affairs, and national Planning and development.	- Recognises need for protection and management of coastal and marine ecosystems - Constitution of Fiji 2013 (supreme law) - Under the preamble it recognises the indigenous people (iTaukei, Rotuman and Banaban) their ownership of customary land and their commitment to protecting their environment.	- The Constitution of Fiji 2013 - Fiji Coral Reef Resilience (CRR) Project with WWF - Green Growth Framework - Fiji was ceded to the British Crown colony in 1874 (English common law) & traditional iTaukei system of law and governance
Office of general Counsel	- Overseeing legal matters and providing legal advice to the government. - Provides legal advice to government ministries, departments, and agencies, including those responsible for environmental management and regulation. - Ensures legal soundness of environmental policies, legislation, and enforcement actions - Contributes to effective environmental governance and the protection of Fiji's natural resources and ecosystems.	- People's Charter for Change, Peace and Progress - Constitution of Fiji 2013 - Roadmap for Democracy and Sustainable Socio-Economic Development (RDSSSED) - Constitution 2013 5 year – 20 years National Development Plan - Climate Change Policy 2018- 2030 - Fiji National Adaptation Plan (under National Climate Change Policy) - Fiji Low Emission Development Strategy (2018-2050) - National Climate Finance Strategy - Fiji Coral Reef Resilience (CRR) Project - Integrated Coastal Management Plans - National Biodiversity Strategy and Action Plan (NBSAP) (2020-2025) - Green Growth Framework - National Development Plan (currently in Consultation across the country) : 3 yr, 5 yrs and 20 yr plan - Fiji Water Policy - Rural Water Supply and Sanitation Policy - Fiji Community Development Program (FCDP) - Fiji National Adaptation Plan (under National Climate Change Policy) - National Biodiversity Strategy and Action Plan (NBSAP) (2020-2025)
Ministry of Environment and Climate Change (MECC)	Department of Environment - Responsible for implementing the Environment Management Act (EMA) 2005, Endangered Protected Species Act (EPS), Litter Act, Ozone Depleting Substances Act 1998 and its related regulations Department of Climate Change - Will implement the Climate Change Act 2021 (once commenced)	Both departments - Climate Change Policy 2018- 2030 - National Biodiversity Strategy and Action Plan (NBSAP) (2020-2025) on Protected Areas (2011) (PoWPA) Department of Environment

	- Oversees Climate Change and International Cooperation Division (responsible for coordinating Fiji's response to climate change, including water management issues) - Strategic Plan 2020-2024⁴⁴¹ - Climate-related policies for conserving coral reefs and coastal ecosystems - Improve climate change resilience - Improve drainage, flood control, riverbank, coastal protection for waterways- related hazards.	- National Biodiversity Strategic and Action Plan (NBSAP) - Fiji Coral Reef Resilience (CRR) Project - Integrated Coastal Management Plans - National Environment Strategy 1993 - National Environment Management Strategy - Clean Environment Policy 2019 - Environmental Emergency Declaration - National Air Pollution Control Strategy (2007) - Implementation Framework (NBSAP) - Yaubula Management Support Teams - Marine Resource Recovery - SREP and WWF Partnership - CITES Department of Climate Change - National Ocean Policy 2020- 2030 - National Adaptation Plan - National Climate Finance Strategy - Roadmap for Democracy and Sustainable Socio-Economic Development (RDSSED) - Green Growth Framework
Ministry of Forestry and Fisheries	Fisheries - Enforces the Offshore Fisheries Management Act 2012 and Fisheries Act 1942 - Strategic Development Plan (2019- 2029)⁴⁴² - Fisheries Strategy - Management of qoliqoli - Sustainable fisheries management, regulation of commercial fishing enterprises via licensing (Offshore Fisheries Management Act 2012)⁴⁴³ - Considerations of climate change on marine ecosystems and fisheries resources (Fiji's National Ocean Policy) Forests - Implementing the Forest Decree 1992 - Fiji Forest Harvesting Code of Practice - Management of the forestry industry in a sustainable manner (assists with soil health, biodiversity and water resource management. - Facilitates the development of community-based initiatives for forest-based projects, providing advisory services and raising awareness.	Fisheries - Fiji Coral Reef Resilience (CRR) Project - Marine Conservation Agreements - Integrated Coastal Management Plans - National Biodiversity Strategy and Action Plan (NBSAP) (2020-2025) - Marine Resource Recovery - SREP and WWF Partnership - FLMMA membership - National Fisheries Policy draft - draft Aquaculture Decree 2016 - Action Plan for Implementing the Convention on Biological Diversity's Programme of Work on Protected Areas (2011) - Inshore Fisheries Management Decree (draft) - Appoints Fish wardens Forests - Community-based natural resource management projects with Ministry of iTaukei Affairs

		• Fiji Sustainable Economic and Empowerment Development Strategy (SEEDS), • Emissions from Deforestation and forest Degradation (REDD+) program • National Biodiversity Strategy and Action Plan (NBSAP) • Climate Change Policy 2012 • Climate Change Policy Framework 2007. • (2020-2025) • Fiji REDD+ policy • Forest Bill 2016 • Fiji Forest Policy Statement⁴⁴⁴
Minister of Lands and Mineral Resources (Department of Lands & Department of Mineral Resources)	• Surveying, administration of state-owned land. • Managing land and mineral resources sustainably - affects different sectors including water management, climate change, disaster risk reduction, and environmental conservation. • Oversees the development of groundwater resources (sustainable water supply) • Water resource management approach under the Paris Agreement • Community-based natural resource management projects with Ministry of iTaukei Affairs • Supporting initiatives aimed at maintaining forest carbon stocks and promoting reforestation, afforestation, and enrichment planting.	• Regulation of Surfing Areas Act 2010 • International Seabed Mineral Management Act 2013 • Land Development Act 1961 • Land Use Act 2010 • Petroleum (Exploration and Exploitation) Act 1978 • Rivers and Streams Act 1880 • Rotuma Act 1914 • Rotuma Lands Act 1959 • Rural Land Use Policy for Fiji (2002) • Mangrove Management Plan 2013
Ministry of iTaukei Affairs	• Governance and well-being of the iTaukei (indigenous Fijian) people • iTaukei Land and Fisheries Commission under the Ministry assists with confirming traditional ownership across different structures e.g customary titles, landownership and traditional fishing boundaries. • Involved in consultation and compilation of land and fisheries management plans • iTaukei Affairs Board- Conservation Unit is responsible for spearheading iTaukei Affairs Board's (TAB) effort in the conservation and sustainable management of the natural resources (appointment of Conservation Officers)	• iTaukei Affairs Act. • iTaukei Lands Act 1940 • iTaukei Development Fund Act 1965 • iTaukei Trust Fund Act 2004 • Community-based natural resource management projects⁴⁴⁵ • Climate Change Act • National Biodiversity Strategy and Action Plan (NBSAP) (2020-2025) • National Strategic Plan (2020- 2025)⁴⁴⁶
Ministry of Health	• May provide advice / health-related data and disease prevention methods for watershed management • Water quality, availability, conservation, management • Heatwaves, climate-induced health- risks • Improving disaster preparedness and response nationwide	• Public Health Act • Quarantine Act 1965 • Food and Safety Act 2003 • Watershed Interventions for Systems Health (WISH Fiji) • National Health Emergencies and Disaster Management Plan (HEADMAP) • Ministry of Health Strategic Plan 2020-2025
Ministry of Rural and	• Manage and coordinate government	• Integrated Rural

Maritime development and disaster management	development efforts in rural and maritime communities to support socio-economic development, improve living standards and quality of life, and empower the rural populace to achieve sustainable development livelihoods ● Raise resilience levels for all Fijians and adopt Disaster Risk reduction measures at community level.	Development Framework (IRDF) ● 10-Year Strategic Development Plan (SDP) ● National Development Plan (NDP) ● National Disaster Risk Reduction Policy for 2018-2030 (National Disaster Management Office)
Ministry of Agriculture and Waterways	Agriculture ● Support the sustainable development of the agricultural sector including addressing climatic viability, food and nutrition security for all Fijians. Waterways ● responsible for the management of water resources, including water supply, drainage, irrigation and flood control ● Responsible for water supply and wastewater services	● Water Authority of Fiji Act 2007 ● National Biodiversity Strategy and Action Plan (NBSAP) (2020-2025) ● National Development Plan (NDP) 2017-2036 ● 2020 Agriculture Sector Policy Agenda ● Strategic Plan 2020-2024 ● Green Growth Framework ● Strategic Development Plan (SDP) for the Ministry of Agriculture and Waterways 2024-2028 ● Watershed Interventions for Systems Health (WISH Fiji) ● Ministry of Waterways and Environment Strategic Plan 2020-2024
Fiji Revenue and customs department	Spearheads the Coastal Watch Program	● Customs & Border Act 1986
Maritime Safety Authority of Fiji (MSAF)	● Providing safety within the maritime infrastructure and ensuring the protection of Fiji's marine environment. ● Enforces Sea Port Management Act 2005 and Sea Port Management Regulation ● Facilitates international cooperation regarding animal and plant diseases and for other related matters. ● Enforces Biosecurity Act 2008 ● Provides and promotes maritime safety, and marine environment protection.	● Maritime (Ballast Water Management) Regulations 2014 ● Maritime Carriage of Dangerous Goods Regulations 2014 ● Marine Pollution Levy Regulations 2014 ● Maritime Anti fouling on Ship Regulation 2014 ● Marine Ballast Water Management Regulations 2014 ● Marine Pollution Prevention Management Regulations 2014 ● Providing safety within the maritime infrastructure and ensuring the protection of Fiji's marine environment. ● Enforces Sea Port Management Act 2005 and Sea Port Management Regulation
WWF Pacific	● Conducting scientific assessments, working with local communities, leading conservation efforts ● Managing, recovering, protecting and conserving water, reefs, coastal areas, and marine areas ● Managing qoliqoli support resources	● WWF Pacific 2020-2025 Strategic Plan ● National Climate Finance Strategy ● Great Sea Reef Programme

	● Establishment of Marine Protected Areas (MPAs) ● Land-based activities e.g. river catchment to strengthen environmental planning and management ● Implementing Nature-based Solutions and Ecosystem-based Adaptation measures	● Biodiversity Protection and Marine Resource Recovery ● Informal collaboration with SPREP ● Fiji Coral Reef Resilience (CRR) Project ● Integrated Coastal Management Plans ● Biodiversity Protection and Marine Resource Recovery ● Secretariat of the Pacific Regional Environment Programme (SPREP) partnership for the Pacific Ecosystem-based Adaptation to Climate Change Project (PEBACC) ● Fiji Coral Reef Resilience (CRR) Project
IUCN	Conservation of coastal areas	● Integrated Coastal Management Plans ● Support regional projects. E.g. MACBIO
Wildlife Conservation Society	● Implementing and integrating systems between communities, government, and commercial sectors ● Working with qoliqoli owners in Bua and Ra to support conservation efforts	● Integrated Coastal Management Plans ● Watershed Interventions for Systems Health (WISH Fiji) ● Ecosystem-based management plans ● The Great Sea Reef Programme
WHO	● Expertise in public health, water, sanitation, and hygiene (WASH), and disease prevention.	● Watershed Interventions for Systems Health (WISH Fiji)
South Pacific Regional Environment Programme	● Promoting Pacific Island cooperation and in support of rehabilitation, protection and sustainable use of both terrestrial and marine environments.	● ICMP ● NBSAP ● NAP ● Blue Carbon
Secretariat of the Pacific Community	● Primary objective is to develop the technical, professional, scientific, research, planning and management capability of its members.	● NAP ● Blue Carbon ● RESCCUE - Project helped to develop integrated coastal management plans.
Pacific Islands Forum	● Mandate includes coordinating the implementation of the Pacific Plan, a regional strategy to strengthen regional cooperation and integration	
FLMMA Network	● To advance the practice of community-based marine resource management and conservation by providing a forum for practitioners (communities, traditional leaders, individuals, organisations, and researchers) to share experiences and information.	● EMA ● Fisheries Act
German Agency for International Cooperation (GIZ)	● Aims to strengthen the sustainable management of marine and coastal biodiversity ● sustainable financing mechanisms in maintaining the MPA network	MACBIO project
Fiji Environmental and	● Providing environmental legal analysis	● FELA (Marine Protected

Law Association (FELA)	review on policies and laws.	Areas (MPA) Scoping Paper) FELA (Towards an integrated oceans management policy for Fiji (IOMP Policy and Law Scoping Paper)
Western and central pacific fisheries commission (WCPFC)	- Address problems in the management of high seas fisheries resulting from unregulated fishing, over-capitalization, excessive fleet capacity, vessel re-flagging to escape controls, insufficiently selective gear, unreliable databases and insufficient multilateral cooperation in respect to conservation and management of highly migratory fish stocks - Convention for the Conservation and Management of Highly Migratory Fish Stocks in the Western and Central Pacific Ocean (WCPF Convention)	- UN Fish Stocks Agreement [UNFSA] - WCPFC Convention
Forum Fisheries Agency (FFA)	- Help countries to sustainably manage fishery resources that fall within their 200-mile Exclusive Economic Zones (EEZs) - Provide expertise, technical assistance and other support to its members who make sovereign decisions about their tuna resources and participate in regional decision making on tuna management through agencies such as the Western and Central Pacific Fisheries Commission (WCPFC).	Provided legal expertise for drafting Fiji's inshore, offshore and aquaculture decrees⁴⁴⁸
Conservation International	Promotes a balanced approach to sustainable fisheries management, focusing on both preserving fish stocks and addressing the social dynamics of fishing communities.	Biodiversity Protection and Marine Resource Recovery

8. Beneficiaries

8.1. Calculation of Beneficiaries

The proposed project will contribute to the GCF's fund-level adaptation objective of increased climate-resilient sustainable development by facilitating a shift towards integrated GSR watershed management in Fiji. This shift will be achieved by improving practices through EbA and GI solutions and mainstreaming these solutions into policy and planning to catalyse their uptake as key approaches for integrated watershed and marine resource management and strengthening the climate resilience of the most vulnerable rural communities in Fiji. These interventions will contribute to the GCF Adaptation Result Areas (ARAs):

ARA1.0 – Increased resilience and enhanced livelihoods of the most vulnerable people, communities, and regions; and ARA4.0 – Improved resilience of ecosystems and ecosystem services, as described below.

ARA3.1 - Change in expected losses of economic assets due to the impact of extreme climate-related disasters in the geographic area of the GCF intervention

Details of Beneficiary calculations and methodology and assumptions are noted in Annex 2d

Project interventions will directly benefit a total of 122,363 people (13% of the population), including 62,405 men and 59,958 women, as well as indirectly benefit a total of 359,589 people (39% of the population), including 183,390 men and 176,199 women across Fiji (see annex 2d for calculations). The Project lifespan is 10 years as this is the period over which the adaptation benefits below, particularly the EbA interventions, are expected to mature and continue delivering adaptation benefits to the project beneficiaries.

EbA interventions are expected to generate benefits across multiple facets of ecosystem services and climate adaptation. Direct beneficiaries near the coast will benefit from reduced coastal flooding, increased biodiversity resilience, and reduced riverine flooding vulnerability which will in turn improve water quality and health of the GSR, improve livelihoods, reduce vulnerability from extreme events, improve natural resource management, and improve biodiversity at a regional scale. These benefits were based on population data within the impact areas.

Living shoreline interventions will result in both direct and indirect benefits to communities and nature in the GSR provinces. Direct beneficiaries close to living shorelines will benefit from reduced flooding and inundation, reduced risk to infrastructure and livelihoods, and thus increased adaptation to climate change. Indirect beneficiaries downstream will benefit from improved water quality and reduced debris in flood waters to damage infrastructure and livelihoods.

Direct beneficiaries were calculated using selected “proximity to intervention” thresholds for each intervention, as summarised per output in the table below.

Indirect beneficiaries were calculated based on the priority project areas overlapping the total population by wards, as these populations are expected to receive downstream and coastal benefits in terms of improved ecosystem services, livelihood, food security, and climate adaptation due to all proposed interventions.

The table below summarises all the project’s anticipated direct and indirect benefits and associated calculation methodologies. This table is also presented in Annex 2d.

Outputs	Definition of direct and indirect beneficiaries per output	Direct beneficiaries (sex-disaggregated)	Indirect beneficiaries (sex-disaggregated)
Output 1.1: Reef-reliant communities and provincial governments engaged in the implementation of EbA interventions.	Direct beneficiaries: These are calculated as the number of people living within 3 km of the EbA interventions. This includes those people near the interventions and downstream who will experience a direct change in flood and sedimentation character because of improved coral and coastal ecosystem functioning. Indirect beneficiaries: These are people living between 3 and 6 km near and downstream from to the EbA intervention locations who will benefit from reduced effects of floods and sedimentation on the direct beneficiaries described above (e.g., this would be the people who would buy food at local markets from fishers who are a subset of the direct beneficiaries described above).	77,497 people (39,523 men and 37,974 women)	128,958 people (65,769 men and 63,189 women)
Output 1.2: Living shorelines constructed and operational.	Direct beneficiaries: These are calculated as the number of people living within 3 km of the living shoreline intervention locations who will directly experience a change in flood character from the interventions. Indirect beneficiaries: These are people living between 3 and 6 km from the living shoreline interventions that will benefit from reduced disruption to the direct beneficiaries described above, as well as the co-benefit of infrastructure damage tied to the delivery of key services such as transportation.	35,341 people (18,024 men and 17,317 women)	82,530 people (42,090 men and 40,440 women)

Outputs	Definition of direct and indirect beneficiaries per output	Direct beneficiaries (sex-disaggregated)	Indirect beneficiaries (sex-disaggregated)
Output 1.3: Locally Led Adaptation initiatives are supported and implemented to enhance climate resilience of reef-reliant communities in the GSR.	Direct beneficiaries: These are calculated as the number of people receiving direct benefits from the community led adaptation solutions. This target assumes the average community size is 150 people and that each project would provide benefits to approximately 4 communities. Indirect beneficiaries: Beneficiary calculations for Output 1.3 consider the benefits of Output 2.1, which will benefit from improved ecosystem service as a result of the GSR and its community fisheries being under improved management. As a result, indirect beneficiary numbers have not been included for Output 1.3 to avoid double counting.	6,000 people (39,523 men and 37,974 women)	-
Output 2.1. New management arrangements to reduce climate change vulnerability developed for the GSR.	Direct beneficiaries: These have been calculated estimating the number of government and community participants who will participate in and be responsible for overseeing the execution of the 1-Year GSR Management Plan and FMPs. This assumes that 150 people will be trained in each province annually. We have only included the annual figures as beneficiaries as a majority of these are expected to be reoccurring annual participants and want to avoid double counting. Indirect beneficiaries: The total population of the four project target sites will indirectly benefit from this project output, through the provision of improved ecosystem services from coral reefs resulting from the improved management of the GSR's near-shore fisheries and connected coastal ecosystems.	600 people (163 men and 131 women)	238,231 people (121,497 men and 116,734 women)
Output 2.2: Evidence base to support the adoption of EbA and living shoreline interventions by GoF.	Direct Beneficiaries: The evidence base will be disseminated to national-level stakeholders, provincial line departments, and academic and/or research organizations. These recipients who will directly use the information were calculated as direct beneficiaries. Indirect beneficiaries: Beneficiary calculations for Output 2.2 considers the benefits of Output 2.1, which will generate the economic case for EbA and living shorelines to inform current and future planning and capacity development. As a result, indirect beneficiary numbers have not been included for Output 2.1 to avoid double counting.	100 people	-
Output 2.3: Updated procedures for implementing EbA, living shorelines, and R2R ecosystem planning in Fiji will	Direct Beneficiaries: The direct beneficiaries for Output 2.3 include the direct beneficiaries identified for the other project outputs. As a result, direct beneficiary numbers have not been included for Output 2.3 to avoid double counting. Indirect beneficiaries: The total population of the four project target sites will indirectly benefit from this project output, which involves enhancing the regulatory and planning environment for coral reef and integrated coastal ecosystem management in Fiji. The indirect beneficiaries for Output 2.3 include	-	238,231 people (121,497 men and 116,734 women)

Outputs	Definition of direct and indirect beneficiaries per output	Direct beneficiaries (sex-disaggregated)	Indirect beneficiaries (sex-disaggregated)
	the same indirect beneficiaries identified for Output 2.1. The total number of indirect beneficiaries for this output will therefore also be the total number of indirect beneficiaries. Ba Province: 247,708 people Ra Province: 30,432 people Bua Province: 15,466 people Macuata Province: 65,983 people		
Output 3.1: Business development support providers and relevant national and provincial institutions have enhanced capacity to support reef-positive businesses the GSR.	Direct Beneficiaries: The direct beneficiaries for this output include the businesses supported, their employees and the families of the employees. Given that Output 3.1 targets to support 40 businesses, assuming 5 employees per business and an average household size of 5.3, the number of direct beneficiaries amount to 1060. Indirect beneficiaries: The estimated indirect beneficiaries of the project include customers, suppliers, small producers, local vendors, and community members impacted by the economic effect. Each of the 40 supported businesses is assumed to serve an average of 50 regular customers, leading to approximately 2000 indirect beneficiaries. Additionally, each business is estimated to rely on 5 suppliers or service providers, contributing another 200 beneficiaries. Market linkages further extend the impact, as each business is expected to source products from 3 additional small producers, reaching 120 people, and interact with 3 local vendors or retailers, impacting another 120 individuals. Knowledge spillover, where supported businesses influence at least 2 other businesses through shared learnings and sectoral growth, is estimated to affect 80 more people. Lastly, the household multiplier effect, where improved business activity increases local spending and benefits small shops and service providers, is estimated at 200 beneficiaries. In total, the indirect beneficiaries are estimated to be around 2720 people, amplifying the project's impact beyond direct participants.	1,060 people (540 men and 520 women)	2,720 people (1387 men and 1333 women)
Output 3.2: Enhanced coordination, transparency and resources to support reef-positive enterprises	Direct Beneficiaries: The direct beneficiaries of this output include stakeholders who actively participate in multistakeholder working groups, capacity-building sessions, and the development and use of key resources that enhance support for reef-positive enterprises. With 16 working groups held twice a year, and each session engaging around 20 stakeholders, a significant number of participants will directly benefit from improved coordination and collaboration. Additionally, 16 capacity-building sessions will provide targeted learning opportunities for approximately 25 stakeholders per session, strengthening their ability to support reef-positive enterprises. Furthermore,	760 people (387 men and 373 women)	1,500 people (765 men and 735 women)

Outputs	Definition of direct and indirect beneficiaries per output	Direct beneficiaries (sex-disaggregated)	Indirect beneficiaries (sex-disaggregated)
	the development of eight key resources, such as assessment frameworks and monitoring tools, will directly benefit financial institutions, business development service providers, and policymakers who rely on these tools to enable access to capital and support sustainable businesses. In total, this output is expected to directly benefit around 760 individuals annually. Indirect beneficiaries: The indirect beneficiaries include those who benefit from improved coordination, knowledge sharing, and resources without directly participating in the sessions or working groups. The strengthened collaboration among stakeholders will lead to better support for reef-positive enterprises, which in turn will benefit others within their networks. Each direct participant is likely to influence at least two additional people within their organizations or communities, extending the impact of the project. Additionally, improved access to financial resources and business development support will help reef-positive enterprises expand, leading to job creation and economic benefits for local communities. As these businesses grow, they will generate additional opportunities for employees, suppliers, and service providers. Overall, the number of indirect beneficiaries is estimated to be around 1500 people.		

The figures below show the GIS mapping and modelling undertaken to determine project beneficiaries from the EbA and NbS interventions.

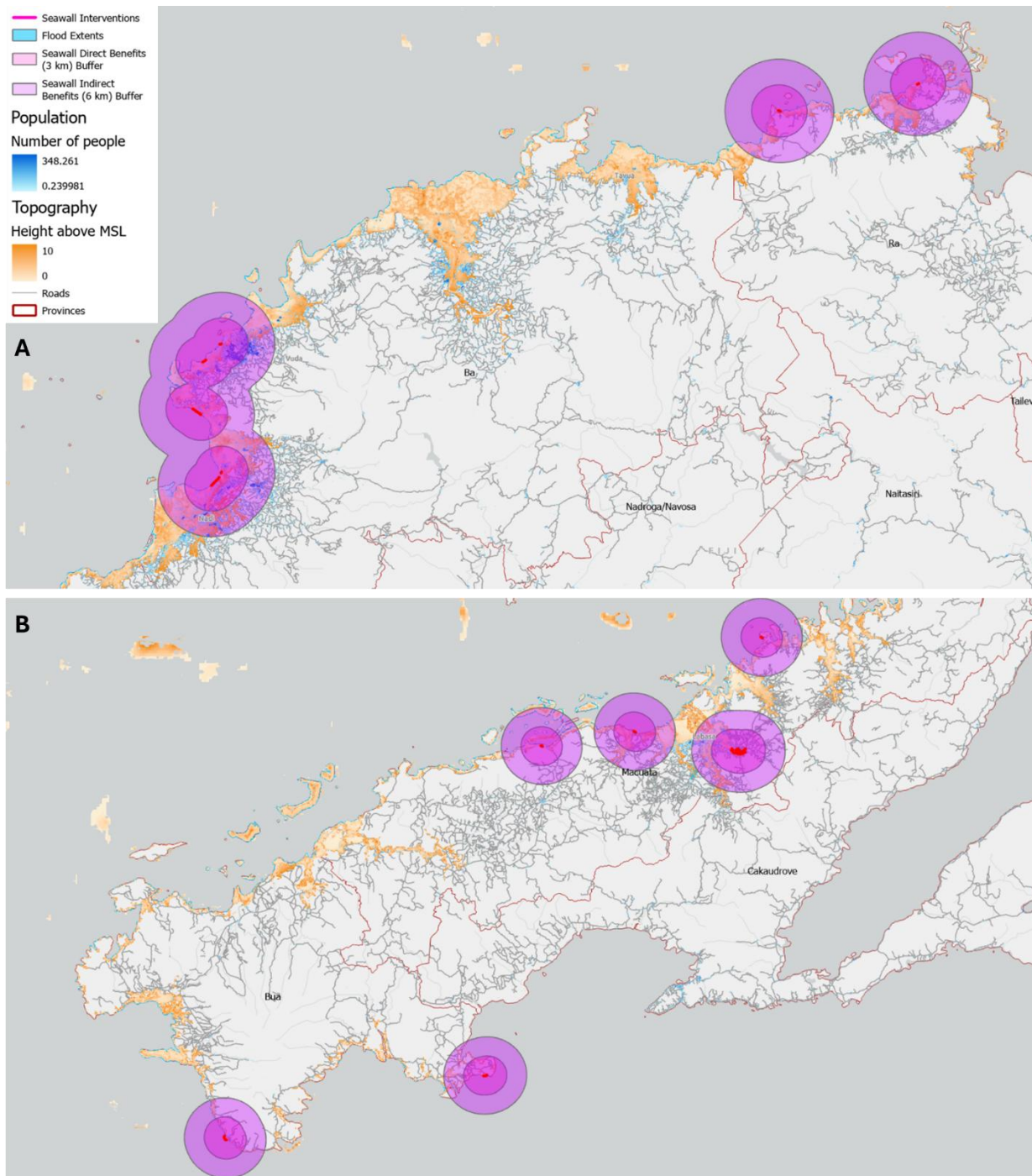


Figure 12: Map of Seawall Impact Buffer Zones for Top (A): Viti Levu and Bottom (B): Vanua Levu. Direct Impacts (3 km) in pink and Indirect Impacts (6 km) in purple. Flood extents in light blue, topography in shades of orange and population in shades of blue. Province outlines are shown in red. Light grey base map from ArcGIS.

Table 5: Estimated Population Beneficiaries from Mangrove and Seawall Interventions in Fiji's Great Sea Reef (GSR) Region. Total Fiji Population Data based on the World Bank (<https://data.worldbank.org/indicator/SP.POP.TOTL?locations=FJ>; Accessed March 19, 2025).

REGION	POPULATION					MANGROVES					SEAWALLS					CUMULATIVE			
	Total Pop	GSR Pop Under 10 m (Baseline)	GSR Pop Under 5 m	% of Pop under 5 m	% of Pop under 10 m	Mangrove Area (Ha)	Direct Beneficiaries (Pop Within 3km)	Indirect Beneficiaries (Pop Within 6km)	% Direct Benefits	% Indirect Benefits	Seawall Length (Km)	Direct Beneficiaries (Pop Within 3km)	Indirect Beneficiaries (Pop Within 6km)	% Direct Benefits	% Indirect Benefits	Direct Beneficiaries (Pop Within 3km)	Indirect Beneficiaries (Pop Within 6km)	% Direct Benefits	% Indirect Benefits
Fiji Total	924145 (UN, 2024)	NA	--	--	--	835	42156	93617	4.6%	10.1%	12.0	35341	82530	3.8%	8.9%	74330	133731	8.0%	14.5%
All GSR Provinces	357017	151557	58462	16.4%	42.5%	835	42156	93617	27.8%	61.8%	12.0	35341	82530	23.3%	54.5%	74330	133731	49.0%	88.2%
Ba	247423	95521	32627	13.2%	38.6%	541	34580	80549	36.2%	84.3%	3.3	24014	51048	25.1%	53.4%	57177	96647	59.9%	101.2%
Ra	27855	9816	3275	11.8%	35.2%	192	5521	7189	56.2%	73.2%	0.6	1913	6913	19.5%	70.4%	6046	7820	61.6%	79.7%
Bua	13568	7760	2662	19.6%	57.2%	-	-	-	-	-	1.5	725	1634	9.3%	21.1%	725	1634	9.3%	21.1%
Macuata	68170	38459	19899	29.2%	56.4%	102	2056	5879	5.3%	15.3%	6.7	8689	22935	22.6%	59.6%	10382	27630	27.0%	71.8%

Table 6: Impacts of All Interventions Inside Modelled Flood Extents. Population Inside Flooded Extent Based on Population Dataset Used in Model Analyses

Item	Unit	Province	Baseline (2040 MSL)	Mangrove s	Mangrove Benefits	Mangrove Benefits as % of Baseline Flooded Extents	Area of Mangrove Interventions By Province	Seawall Benefits Within Modelled Flood Extents	% Seawall Benefits on Baseline Flooded Totals	Seawall Length (Km) By Province	Cumulative Benefits Within Modelled Flood Extents	% Cumulative Benefits on Flooded Extent Baseline
Total Flooded Land Area	Hectares	All	16773	13,370	300	1.79%	835	1544.12	9.2%	11.99	1,844.12	11%
Total Flooded Land Area	Hectares	Ba	6909	6748	161	2.33%	541	994.72	14.4%	3.29	1,155.72	17%
Total Flooded Land Area	Hectares	Ra	1215	1119	96	7.90%	192	38.71	3.2%	0.57	134.71	11%
Total Flooded Land Area	Hectares	Bua	3103	-	-	-	-	65.01	2.1%	1.46	65.01	2%
Total Flooded Land Area	Hectares	Macuata	5546	5503	43	0.78%	102	445.68	8.0%	6.67	488.68	9%
Number of People	Count	All	6067	5332	160	2.64%	-	2439	40.2%	-	2,598.60	43%
Number of People	Count	Ba	4039	3948	91	2.25%	-	1734	42.9%	-	1,824.55	45%
Number of People	Count	Ra	331	273	58	17.52%	-	42	12.7%	-	100.06	30%
Number of People	Count	Bua	575	-	-	-	-	64	11.1%	-	63.78	11%
Number of People	Count	Macuata	1122	1111	11	0.98%	-	599	53.4%	-	610.21	54%
Flooded Urban/Impervious	Hectares	All	181.39	163.16	6.99	3.85%	-	16.22	8.9%	-	23.21	13%
Flooded Urban/Impervious	Hectares	Ba	145.63	140.4	5.23	3.59%	-	6.77	4.6%	-	12.00	8%
Flooded Urban/Impervious	Hectares	Ra	7.08	6.31	0.77	10.88%	-	1.37	19.4%	-	2.14	30%
Flooded Urban/Impervious	Hectares	Bua	11.24	-	-	-	-	2.22	19.8%	-	2.22	20%
Flooded Urban/Impervious	Hectares	Macuata	17.44	16.45	0.99	5.68%	-	5.86	33.6%	-	6.85	39%
Flooded Cropland/Agriculture	Hectares	All	1252.12	1146.31	70.14	5.60%	-	79.85	6.4%	-	149.99	12%
Flooded Cropland/Agriculture	Hectares	Ba	1073.59	1017.69	55.9	5.21%	-	21.51	2.0%	-	77.41	7%
Flooded Cropland/Agriculture	Hectares	Ra	34.28	33.99	0.29	0.85%	-	19.20	56.0%	-	19.49	57%
Flooded Cropland/Agriculture	Hectares	Bua	35.67	-	-	-	-	0.93	2.6%	-	0.93	3%
Flooded Cropland/Agriculture	Hectares	Macuata	108.58	94.63	13.95	12.85%	-	38.21	35.2%	-	52.16	48%
Flooded Buildings	Count	All	2870	2418	80	2.79%	-	481.00	16.8%	-	561.00	20%
Flooded Buildings	Count	Ba	1634	1599	35	2.14%	-	181.00	11.1%	-	216.00	13%
Flooded Buildings	Count	Ra	288	254	34	11.81%	-	56.00	19.4%	-	90.00	31%
Flooded Buildings	Count	Bua	372	-	-	-	-	55.00	14.8%	-	55.00	15%
Flooded Buildings	Count	Macuata	576	565	11	1.91%	-	189.00	32.8%	-	200.00	35%
Length of Roads Flooded	Kilometers	All	124.3	117	4.39	3.53%	-	18.59	15.0%	-	22.98	18%
Length of Roads Flooded	Kilometers	Ba	90.38	88.21	2.17	2.40%	-	4.90	5.4%	-	7.07	8%
Length of Roads Flooded	Kilometers	Ra	9.26	8.22	1.04	11.23%	-	1.12	12.1%	-	2.16	23%
Length of Roads Flooded	Kilometers	Bua	2.91	-	-	-	-	1.46	50.2%	-	1.46	50%
Length of Roads Flooded	Kilometers	Macuata	21.75	20.57	1.18	5.43%	-	11.11	51.1%	-	12.29	57%

Under the 2040 business as usual climate scenario, storm surge flooding associated with tropical cyclones is modelled to inundate 16,773ha of coastal land across Fiji. This flooding is estimated to affect 6,067 people and inundate 181.39ha of coastal urban areas, disrupting settlements and economic activity. The model also indicates that 1,252.12ha of coastal agricultural land would be flooded, increasing the risk of crop losses and impacts on rural livelihoods. In addition, approximately 2,870 coastal buildings and 124.3km of coastal roads are projected to be exposed to storm surge flooding, increasing damage to housing, public infrastructure, and transport networks.

The implementation of mangrove restoration and protection measures is modelled to reduce the area affected by storm surge flooding by approximately 300ha. The number of people exposed to flooding is projected to decrease by around 160 people. Flooding of coastal urban land is estimated to decline by 6.99ha, while inundation of coastal agricultural land is reduced by 70.14ha. The intervention is also projected to reduce exposure of approximately 80 coastal buildings and 4.39km of coastal roads. These results indicate that mangrove restoration provides localised protection by reducing wave energy and storm surge impacts, particularly along vulnerable sections of the coastline.

The construction of seawalls is modelled to further provide reductions in storm surge impacts. When implementing sea wall interventions, coastal flooded area is projected to decrease by 1,544.12ha, while the number of people exposed to flooding is reduced by approximately 2,439. Flooded urban land is reduced by 16.22ha and flooded agricultural land by 79.85ha. The intervention is also projected to prevent flooding of approximately 481 coastal

buildings and reduce affected coastal roads by 18.59km. These results suggest that strategically located seawalls can provide significant protection for densely populated and developed coastal areas.

The combined implementation of mangrove restoration and seawall interventions produces the greatest reduction in storm surge impacts. Coastal flooded area is projected to decrease by 1,844.12ha, representing an 11% reduction compared with the business-as-usual scenario. The number of people affected is reduced by 2,599, equivalent to a 43% reduction. Flooded coastal urban areas decline by 23.21 ha (13%), while flooded agricultural land is reduced by 149.99 ha (12%). Exposure of coastal buildings decreases by approximately 561 buildings (20%), and the length of flooded coastal roads is reduced by 22.98km (18%).

Table 25: Business as usual impacts and associated benefits of interventions

	Coastal flooding 2040 without interventions (BAU)	Benefits as a result of Mangrove interventions		Benefits as a result of Seawall interventions		Cumulative Benefits	
		Additional Benefits	% of baseline BAU	Additional Benefits	% of baseline BAU	Additional Benefits	% of baseline BAU
Total Land Area Within 100 m of Peak Flood Heights > 10 cm	16 773	300	1.79%	1 544	9.21%	1 844	10.99%
Number of People	6 067	160	2.64%	2 439	40.20%	2 599	42.84%
Flooded Urban/Impervious	181	7	3.85%	16	8.94%	23	12.80%
Flooded Cropland/Agriculture	1 252	70	5.60%	80	6.38%	150	11.98%
Flooded Buildings	2 870	80	2.79%	481	16.76%	561	19.55%
Length of Roads Flooded	124	4	3.53%	19	14.96%	23	18.49%

8.2. Mitigation co-benefits

While the proposed project is adaptation-only, the EbA interventions will provide mitigation co- benefits, such as carbon (C) storage and sequestration. We have estimated potential co-benefits for EbA solutions by applying values from the published literature to the proposed project area for each intervention type.

Methods: To estimate the annual CO₂ removal from assisted natural regeneration (restoration interventions), the activity area was multiplied by removal factors for upland and riparian forests. The removal factors for each forest type were obtained from the Forest Emission Reference Level reports developed under the National REDD+Project in Fiji. The development of removal factors followed the IPCC recommended approach and methodologies using a combination of field data (e.g., National Forest Inventory, Permanent Sample Plot Inventory), allometric equations for biomass estimation, and conversion factors to arrive at the carbon stock and removal estimates for each forest type. A brief summary of the removal factor methodology is outlined in bullets below.

Natural Forests (Afforestation and Reforestation): For afforestation and reforestation of natural forest species, data on mean annual increment (MAI) provided by Fiji Hardwood Corporation Limited (FHCL) were used. The MAI, reported in volume increments, was converted to carbon increments using a biomass expansion factor (1.1), root-to-shoot ratio (0.37), and carbon fraction (0.47). The calculated mean annual carbon increment for these areas was 2.63 tC ha⁻¹ yr⁻¹.

To estimate the total lifetime CO₂ removals, the annual removals were multiplied by 20 and 40 years to account for the number of years the activity is expected to continue to sequester carbon.

Fiji FREL removal factors sources

- <https://docs.google.com/document/d/1R2gcqeFYqLeQDUADqRd5fCY8vIHc7XaX/edit>
- <https://docs.google.com/document/d/13d9WBCTr0vK3W7UT4a5kEPyCuvNPUf4y/edit>

Interventions	Location	Area (ha)	Removal Factor	Total annual removals (tCO ₂)	Project Performance	Total lifetime removals	Total lifetime removals (tCO ₂)	Total lifetime removals (tCO ₂)
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			(tCO ₂ yr ⁻¹)	[area*removal factor]	Total lifetime removals (tCO ₂) [Total annual removal* 10 years]	(tCO ₂) [Total annual removal* 20 years]	[Total annual removal* 30 years]	[Total annual removal* 40 years]
Riparian vegetation restoration and fencing (500 m buffer) – all areas	Ba	896	9.65	8648.28	86482.82	172965.63	259448.45	345931.26
	Ra	424	9.65	4092.49	40924.90	81849.81	122774.71	163699.62
	Bua	483	9.65	4661.96	46619.64	93239.29	139858.93	186478.57
	Macuata	721	9.65	6959.16	69591.64	139183.28	208774.923	278366.56

Mangrove forests: To estimate the annual CO₂ removal from assisted natural regeneration (restoration interventions), the activity area was multiplied by carbon gains from revegetation or planting by taking into account survival rate (assumed to be about 10% in Fiji based on this [resource](#)) and biomass growth rate (4.7) and gains from soil carbon accumulation (using IPCC default of 1.62). IPCC source: [IPCC Coastal wetlands Supplement Table 4.12 and 4.4](#)

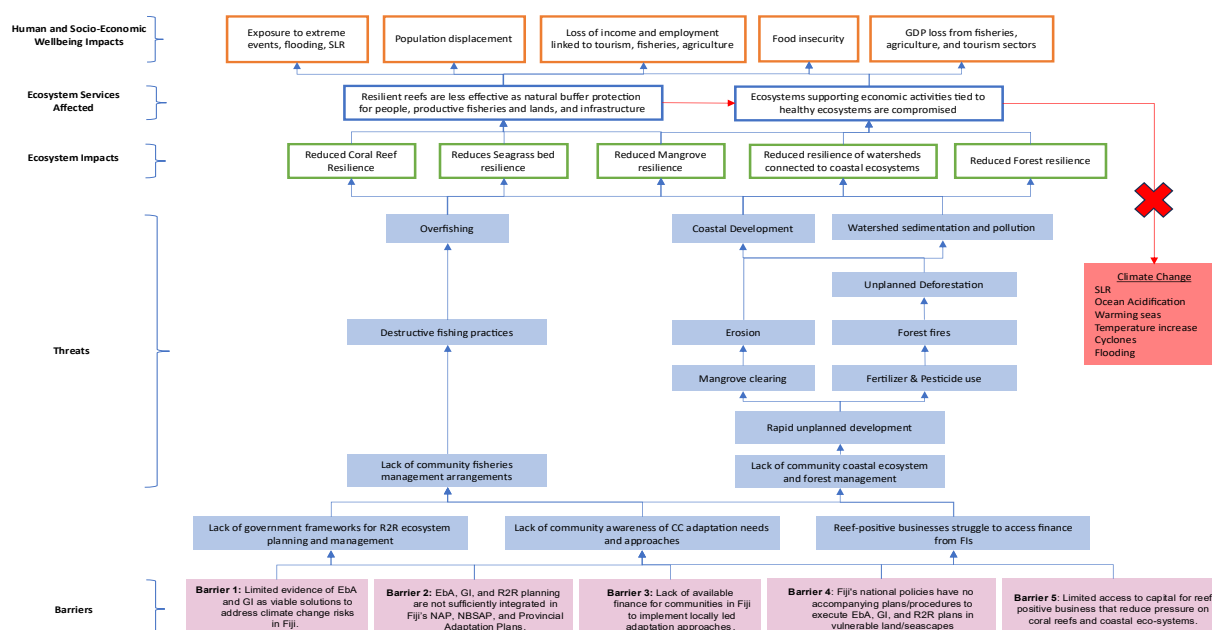
To estimate the total lifetime CO₂ removals, the annual removals were multiplied by 20 and 40 years to account for the number of years the activity is expected to continue to sequester carbon.

Interventions	Location	Area (ha)	Gains from revegetation tC yr ⁻¹	SOC gain tC yr ⁻¹	Total Carbon tC yr ⁻¹	Total annual removals (tCO ₂ yr ⁻¹)	Project Performance Total lifetime removals (tCO ₂)	Net removals tCO ₂ /Total annual removal* 20 years]	Net removals tCO ₂ /Total annual removal* 30 years]	Net removals tCO ₂ /Total annual removal* 40 years]
Mangrove restoration	Ba	541	254.27	876.42	1130.69	4149.63	41496.32	82992.65	124488.97	165985.3
	Ra	192	90.24	311.04	401.28	1472.7	14726.98	29453.95	44180.93	58907.90
	Macuata	102	47.94	165.24	213.18	782.37	7823.71	15647.41	76396.19	101861.58

9. Supplementary Information to the Funding Proposal

9.1. Section B2(a) Theory of Change

Project situation model



Project outputs, activities and sub-activities mapped against the barriers they are designed to address and potential risks associated with implementation.

Barrier	Output	Project activity	Project sub-activity	Project Risks
Barrier 1: Limited evidence of EbA and living shorelines as viable solutions to address climate change risks on vulnerable landscapes and seascapes in Fiji.	Output 1.1: Reef-reliant communities and provincial governments engaged in the implementation of EbA interventions.	Activity 1.1.1: Restore coastal mangroves to reduce flooding risk and increase sediment capture	Sub-Activity 1.1.1.1: Validate proposed mangrove restoration sites and baseline conditions Sub-Activity 1.1.1.2: Restore mangroves in the Ba province. Sub-Activity 1.1.1.3: Restore mangroves in the Ra province. Sub-Activity 1.1.1.4: Restore mangroves in the Macuata province.	Risk Factor (ii) extreme climate events, such as cyclones, could disrupt implementation, limit site access for extended periods, and shift government priorities toward disaster response. *
		Activity 1.1.2: Restore GSR watershed riparian buffers to increase sediment capture	Sub-Activity 1.1.2.1: Validate proposed riparian buffer restoration sites and baseline conditions Sub-Activity 1.1.2.2: Restore riparian forests in the Ba province. Sub-Activity 1.1.2.3: Restore riparian forests in the Ra province. Sub-Activity 1.1.2.4: Restore riparian forests in the Bua province. Sub-Activity 1.1.2.5: Restore riparian forests in the Bua province.	
	Output 1.2: Living shorelines constructed and operational.	Activity 1.2.1: Design and construction shorelines to reduce coastal flooding	Sub-Activity 1.2.1.1: Validate proposed living shorelines and baseline conditions Sub-Activity 1.2.1.2: Design and implement pre-construction measures Sub-Activity 1.2.1.3: Construction of living shorelines	
	Output 1.3: Locally Led Adaptation initiatives are supported and implemented to enhance climate resilience of reef-	Activity 1.3.1: Operationalize the LLAF	Sub-Activity 1.3.1.1: Develop the LLAF operational framework	
			Sub-Activity 1.3.1.2: Establish the Technical Advisory Board (TAB) responsible for project selection	

	reliant communities in the GSR.	Activity 1.3.2: Source and select LLAF projects	Sub-Activity 1.3.2.1: LLAF marketing and awareness raising Sub-Activity 1.3.2.2: Training and capacity building workshops Sub-Activity 1.3.2.3: Project review and selection Sub-Activity 1.3.2.4: Fund Disbursement and Financial Management Sub-Activity 1.3.2.5: Project M&E and Learning across the LLAF portfolio Sub-Activity 1.3.2.6: Stakeholder Engagement and Feedback	withdraw participation if sustained engagement is not maintained. *
Barrier 2: EbA, living shorelines, and R2R planning are not sufficiently integrated in Fiji's National Adaptation Plan (NAP), National Biodiversity Strategy (NBSAP), and Provincial Adaptation Plans.	Output 2.1. New management arrangements developed for the GSR	Activity 2.1.1: Develop a GSR Management Unit and the required operational procedures for implementing a GSR Management Plan	Sub-Activity 2.1.1.1: Establish the GSR Management Unit (MU). Sub-Activity 2.1.1.2: Establish community advisory boards to ensure local involvement in decision-making processes of the GSR MU. Sub-Activity 2.1.1.3: Develop operating agreements with communities, provincial governments, and national agencies to define roles and responsibilities under the GSR Management Plan related to management, enforcement, and monitoring. Sub-Activity 2.1.1.4: Develop arrangements for long-term sustainability the GSR MU	Risk Factor (i) establishing new coordination mechanisms across national and provincial agencies may lead to delays or reduced effectiveness if mandates are not fulfilled, potentially impacting the development of the GSR Management Plan and related policy amendments; and Risk Factor (ii); Risk Factor (iii). *
		Activity 2.1.2: Develop the GSR Management Plan.	Sub-Activity 2.1.2.1: Gather necessary data and information to set baselines for current land and seascape uses. Sub-Activity 2.1.2.2: Develop the GSR Management Plan which includes targets and indicators for climate change adaptation Sub-Activity 2.1.2.3: Hold national and sub-national	

			validation workshops with GSR communities, provincial governments, the expert consultative group and scientific and technical advisory Taskforce of NAP to validate the management plans developed under Sub-activity 2.1.2.2. Sub-activity 2.1.2.4: Launch the GSR Management Plan	
		Activity 2.1.3: Support for national and divisional staff, as well as community leaders/representatives, to implement the GSR Management Plan, EbA, and living shorelines interventions.	Sub-Activity 2.1.3.1: Support for national and divisional staff to implement the GSR Management Plan, EbA, and living shoreline interventions. Sub-Activity 2.1.3.2: Support for community leaders/representatives to implement the GSR Management Plan, EbA, and living shoreline interventions.	
		Activity 2.1.4: Develop and implement FMPs in 20 Qoliqolis in the GSR	Sub-Activity 2.1.4.1 Review and establish the most applicable fisheries management plan template and guide to suit the Governance structures and information needs Sub-Activity 2.1.4.2 Conduct a desktop review and consultations with communities and provincial governments to establish the status of FMPs in each of the provinces covered by the Project. Sub-Activity 2.1.4.3 Conduct a biological assessment of the 20 selected qoliqolis Sub-Activity 2.1.4.4: Develop FMPs and implementation plans for the 20 qoliqolis Sub-Activity 2.1.4.5: Provide TA and training for communities for FMP enforcement and monitoring Sub-Activity 2.1.4.6: Launch communications and awareness campaigns targeting the Qoliqoli to ensure the	Risk Factor (i); Risk Factor (ii); Risk Factor (iii) *

			provisions of the plans are well understood.	
Barrier 3: Lack of available finance for communities in Fiji to implement locally led adaptation approaches.	Output 2.2: Evidence base to support the adoption of EbA and living shoreline interventions by the GoF.	Activity 2.2.1: Develop an evidence-based case of the climate change adaptation benefits of EbA and living shorelines in Fiji.	Sub-Activity 2.2.1.1: Prepare baselines and indicators for the biophysical benefits of EbA on ecosystems and their flood attenuation and water resource-related services. Sub-Activity 2.2.1.2: Monitor the biophysical benefits of EbA and living shorelines on ecosystems and their flood attenuation and climate buffering services using the baselines and indicators prepared under Sub-activity 2.1.1.1. Sub-Activity 2.2.1.3: Conduct an economic valuation of the benefits of EbA and living shorelines on ecosystems and their coastal flood and extreme event impact attenuation services. Sub-Activity 2.2.1.4: Identify additional opportunities and sites at the national level across Fiji for scaling up and replicating the project's EbA and living shoreline interventions for coastal flood risk and marine and coastal ecosystem management. Sub-Activity 2.2.1.5: Collate and store the data and information generated under 2.2.1.1–2.2.1.4	Risk Factor (iii) *
		Activity 2.2.2: Develop and disseminate an evidence report to national and provincial government agencies for implementing EbA and living shoreline interventions in response to extreme events, coastal flooding, and sea level rise in Fiji.	Sub-activity 2.2.2.1: Prepare an evidence report on the use and benefits of EbA and living shoreline interventions in response to extreme events, coastal flooding, and sea level rise in Fiji. Sub-activity 2.2.2.2: Disseminate the evidence report developed under Sub-activity 2.2.2.1 to national and provincial planners and	Risk Factor (i); and Risk Factor (ii) *

			regulators as well as academic and research institutions.	
	Output 2.3: Updated procedures for implementing EbA and living shoreline in Fiji.	Activity 2.3.1: Update the National Adaptation (NAP), Provincial Adaptation Plans in Ba, Ra, Bua, and Macuata, the National Biodiversity Strategy and Action Plan (NBSAP) to integrate the GSR as a priority seascape and landscape for implementing EbA and living shoreline interventions in Fiji.	Sub-Activity 2.3.1.1: Establish a National Working Group to develop and adopt Assemble working groups responsible for developing recommendations which should include communities directly connected to the GSR and identified as vulnerable Sub-Activity 2.3.1.2: Review of the NAP, NBSAP, Provincial plans, and community plans to identify entry points for improved management of the GSR Sub-Activity 2.3.1.3: Draft recommendations for amendments to the NAP, NBSAP, Provincial plans, and community plans Sub-Activity 2.3.1.4: Validate the updated documents Sub-Activity 2.1.4.5: Strengthen the technical and institutional capacity of government staff, communities to implement the updated procedures.	Risk Factor (i) *
Barrier 4: Fiji's national policies have no accompanying plans and long-term operational procedures to execute EbA, living shorelines, and R2R plans in vulnerable landscapes and seascapes.		Activity 2.1.3: Support for national and divisional staff, as well as community leaders/representatives, to implement the GSR Management Plan, EbA, and living shoreline interventions.	Sub-Activity 2.1.3.1: Support for national and divisional staff to implement the GSR Management Plan, EbA, and living shoreline interventions. Sub-Activity 2.1.3.2: Support for community leaders/representatives to implement the GSR Management Plan, EbA, and living shoreline interventions.	Risk Factor (i); Risk Factor (ii); Risk Factor (iii) *
Barrier 5: Limited access to capital for reef-positive businesses that reduce pressure on coral reefs	Output 3.1: Business development support providers and relevant national and provincial	Activity 3.1.1: Improve institutional capacity of existing BDS providers in Fiji to support reef-positive businesses	Sub-Activity 3.1.1.1: Shortlist BDS providers who can be supported through the project to enhance BDS support for reef-positive enterprises Sub-Activity 3.1.1.2: Support identified BDS providers to	Risk Factor (iv) limited recognition by financial institutions of the investment value of reef-positive businesses-combined with a thin pipeline of investment-

and coastal ecosystems.	institutions have enhanced capacity to support reef-positive businesses the GSR.		develop tailored incubation and acceleration programs for reef-positive enterprises Sub-Activity 3.1.1.3: Monitor the progress of supported BDS providers using relevant key performance indicators (KPIs) Sub-Activity 3.1.1.4: Provide ongoing support including technical assistance (TA) to the identified BDS providers Sub-Activity 3.1.1.5: Facilitate knowledge exchange and peer learning among BDS providers	ready businesses- may constrain access to financing and hinder the scaling of these interventions.*
		Activity 3.1.2: Empowering relevant national and provincial government institutions to encourage entrepreneurship and identify reef-positive enterprises	Sub-Activity 3.1.2.1: Develop tailored capacity development plans for key national and provincial government institutions Sub-Activity 3.1.2.2: Embed new staff within the identified government institutions to address capacity and other gaps Sub-Activity 3.1.2.3: Provide ongoing training and capacity building	Risk Factor (i); and Risk Factor (iv) *
	Output 3.2: Enhanced coordination, transparency and resources to support reef-positive enterprises	Activity 3.2.1: Enable effective coordination between various stakeholders	Sub-Activity 3.2.1.1: Set up a multi-stakeholder working group to streamline support for reef-positive enterprises Sub-Activity 3.2.1.2: Facilitate periodic stakeholder engagement forums to engage the wider stakeholder network	Risk Factor (ii); and Risk Factor (iv) *
		Activity 3.2.2: Develop shared resources and deliver capacity-building programs to support stakeholders to deliver effective support to reef-positive enterprises	Sub-Activity 3.2.2.1: Develop and implement a comprehensive communication strategy to educate and engage stakeholders Sub-Activity 3.2.2.2: Create a framework to identify, and assess reef-positive enterprises Sub-Activity 3.2.2.3: Provide training and capacity building for the relevant stakeholders	Risk Factor (i); Risk Factor (ii); Risk Factor (iii); and Risk Factor (iv) *

			Sub-Activity 3.2.2.4: Develop a comprehensive monitoring and evaluation framework to assess impacts on the GSR ecosystem Sub-Activity 3.2.2.5: Develop a sustainability strategy to ensure ongoing support to reef-positive enterprises beyond the duration of the project	
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* For details and risk mitigation measures, see FP Table XX. Risks to Project Implementation and Outcomes.

9.2. Section B3 Project Description Detail

Component 1: EbA and living shoreline solutions to enhance community resilience and reduce threats to the GSR

Outcome 1: The resilience of reef-reliant communities in Fiji's GSR is enhanced through EbA and NbS solutions.

Output 1.1: Reef-reliant communities and provincial governments engaged in the implementation of EbA interventions.

Activity 1.1.1: Restore coastal mangroves to reduce flooding risk and increase sediment capture

This activity makes use of both assisted natural regeneration restoration methods and direct planting restoration methods to restore 835 hectares of coastal mangroves across Ba, Ra, and Macuata. This activity will be executed by WWF-Fiji who will work with the Divisional Forest Departments of Ba, Ra, and Macuata through which planting and propagule stock will be sourced and planted. WWF-Fiji will provide funding to the Provincial Forest Departments for restoration and cover the necessary excavation equipment, labor, materials, and plant/propagule stock for this activity. Restoration suitability has been determined based on potential mangrove extent, indications of loss or degradation, and the feasibility of restoration on suitable land uses, including open and community lands. Assisted natural regeneration (e.g. reconnection of hydrology, broadcast seeding on high tides) will be leveraged as much as possible to naturally regenerate mangrove stands, supplemented by direct seedling/sapling planting as needed. Direct planting/seeding activities will use native mangrove tree species which have close association with native biodiversity and are adapted to local conditions. These include a diverse array of locally-appropriate mangrove species, including several native *Rhizophora* species (*R. stylosa*, *R. samoensis* – both known as 'tiri' in Fijian), *Bruguiera gymnorhiza* ('dogo' in Fijian), and *Lumnitzera littorea* ('sagale' in Fijian), as well as mangrove-associated native wild fruit trees valued by local communities. This combination of species will be used to avoid "plantation" style restoration and promote ecological resilience. For smaller sites requiring planting, when available saplings will be sourced from and planted by community owned and managed nurseries. Revegetation of native species at this scale will help reduce flooding, coastal erosion, flow and wave velocities, and increase infiltration by enhancing soil porosity, ultimately increasing the climate resilience of surrounding communities. The benefits provided by mangrove restoration will result in a total of 300 ha being less vulnerable to flooding, representing a decrease of approximately 2% in flooded area against the business-as-usual scenario. These targeted benefits are significant as approximately 76% of Fiji's population, or roughly 683,000 people, live within 5 km of the coast. This focused activity alone will directly benefit over 42,000 people (28% of people living in the GSR along the coast and over 93,000 coastal people (62% of people living in the GSR indirectly).

The GCF-funded sub-grants for the Provincial Forestry Departments will be managed by WWF-Fiji's Divisional Implementation Unit (DIU) where the technical staff will coordinate with the Department staff in each province on the project planning, development, and reporting. The Government of Fiji is providing co-finance for the implementation of this activity.

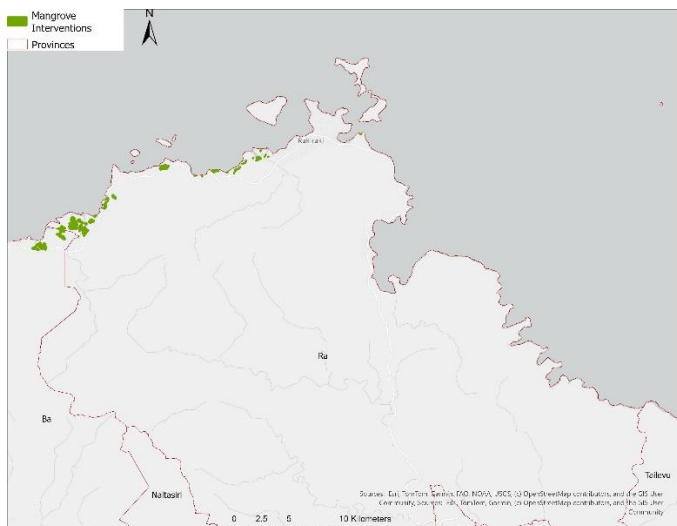
Sub-Activity 1.1.1.1: Validate proposed mangrove restoration sites and baseline conditions

Coastal ecosystems are highly dynamic, and mangrove restoration approaches must be highly tailored to local conditions that can only be evaluated through in-depth individual site assessments. In year 1 WWF-Fiji will conduct rapid validation of baselines conditions and feasibility of the proposed interventions in the sites identified in Annex 2a. This will include but not be limited to: (a) an assessment of any land use, vegetation, and ecosystem health changes including shifts in species distribution driven by climate change, (b) validation of soil salinity to confirm suitability for mangrove restoration, (c) measurement of water quality, flow patterns, baseline setting of sediment loads in adjacent intertidal areas, (d) documenting existing flora and fauna to establish a baseline for biodiversity in natural ecosystems, (e) confirming climate change threats identified in Annex 2 including sea-level rise and increased storm frequency to the site and nearby communities, (f) identification of site specific needs for restoration including O&M activities, (f) validating climate change benefit targets in Section E and setting targets for sedimentation reduction benefits from mangrove restoration, (g) socio-economic and cultural considerations to ensure the benefits of proposed species and sites extend beyond their immediate environmental benefits, with cultural practices, traditions and beliefs of local communities, when possible and (h) conducting stakeholder consultations with local communities, provincial governments, and local partners to confirm validation exercise findings and securing their approval for restoration execution. This will include consultations with the NDA, the MoFF, and FAO to confirm final sites for both projects to ensure complementarity. The findings of the validation reports conducted for each province will be used to confirm or adjust proposed mangrove restoration sites. As part of the Sub-Activity, protocols for assessing the efficiency and effectiveness of the project restoration activities benchmarked against localized site conditions will also be developed.

This sub-activity will involve restoring 541 ha of mangroves in Ba, which will avoid flooding across 161 ha representing a reduction of 2% against the business-as-usual scenario. Because so much of Fiji's population lives within 5km of the coast and Ba is the most densely populated province in Fiji, targeted investments such as these have significant impact for vulnerable communities. Mangrove restoration in these locations will provide coastal protection benefits to both people, infrastructure, community assets including agricultural lands, aid in stabilizing and restoring embankments near river mouths, restore habitat for inshore fisheries communities depend on, and increase GHG capture. This sub-activity will benefit 34,580 directly and 80,549 people indirectly along the coast of Ba province.

Identified mangrove restoration areas in Ba province

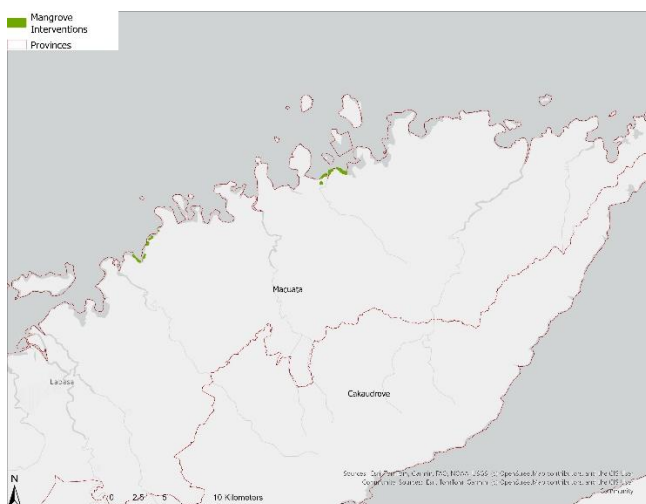
This sub-activity will involve restoring 192 ha of mangroves in Ra, which will avoid flooding across 96 ha representing a reduction of 8% against the business-as-usual scenario. Mangrove restoration in these locations will provide coastal protection benefits to both people, infrastructure, community assets including agricultural lands, aid in stabilizing and restoring embankments near river mouths, restore habitat for inshore fisheries communities depend on, and increase GHG capture. This sub-activity will benefit 5,521 people directly and 7,189 people indirectly along the coast of Ra province.



Identified mangrove restoration areas in Ra province

Sub-Activity 1.1.1.4: Restore mangroves in the Macuata province.

This sub-activity will involve restoring 247 ha of mangroves in Macuata, which will avoid flooding across 43 ha, representing a reduction of 1% against the business-as-usual scenario. Macuata is a largely agricultural area and these targeted interventions will reduce flooding across approximately 13% of the total agricultural area essential to the livelihoods of its residents. This sub-activity will benefit 2,056 people directly and 5,879 people indirectly along the coast of Ra province.



Identified mangrove restoration areas in Macuata province

Activity 1.1.2: Restore GSR watershed riparian buffers to increase sediment capture

Through this activity vegetation cover will be restored (natural regeneration and direct planting) across 2,524 hectares of riparian buffers in GSR watersheds. This activity will be executed by WWF-Fiji who will work with the Divisional Forest Departments of Ba, Ra, Bua, and Macuata through which planting stock will be sourced and planted. The Provincial Forest Departments will also provide the necessary excavation equipment and labor for this activity. Seeds and saplings will be provided by the Provincial Departments. For smaller sites and when available, saplings will be sourced from and planted by community owned and managed nurseries. Buffers areas are areas of permanent vegetation located within and between agricultural fields and the water courses to which they drain. These buffers are intended to intercept and slow runoff, reducing sediment transport, thereby providing water quality benefits. Vegetated buffer strips have been included in all types of proposed interventions. A provision of a between 500 m wide buffer strip will be provided on the left and right banks of the interventions, across priority restoration areas. Over time these vegetated buffer strips will grow and expand and provide additional protection against floods and land-based run-off. Restoration suitability has been determined based on potential riparian buffer strip extent, indications of loss or degradation, and the feasibility of restoration on suitable land uses, including open and

community lands. Assisted natural regeneration will be leveraged where possible, supplemented by active restoration as needed. Direct planting activities will include the planting of native tree species which have close association with native biodiversity and adapted to local conditions. Native tree species to be included will be assessed under Sub-Activity 1.1.2.1 and selected for their benefit and potentially include - beach cabbage (Vevedu), Beauty Leaf (Dilo), Beach Cordia (Nawanawa), Beach Hibiscus (Vau), Vetiver Grass, Mango Trees, and Fijian Longan Tree. A mix of species will be used that are valued by local communities, to avoid “plantation” style restoration and promote ecological resilience. Revegetation of native species at this scale will help reduce sedimentation of GSR watersheds, erosion, and increase infiltration through enhancing soil porosity, ultimately increasing the climate resilience of surrounding communities. The reduction in sediment exports from areas will enhance soil quality, benefiting over 68,000 people who live in these areas. Riparian restoration also provides significant downstream benefits to coastal ecosystems – particularly the coral reefs.

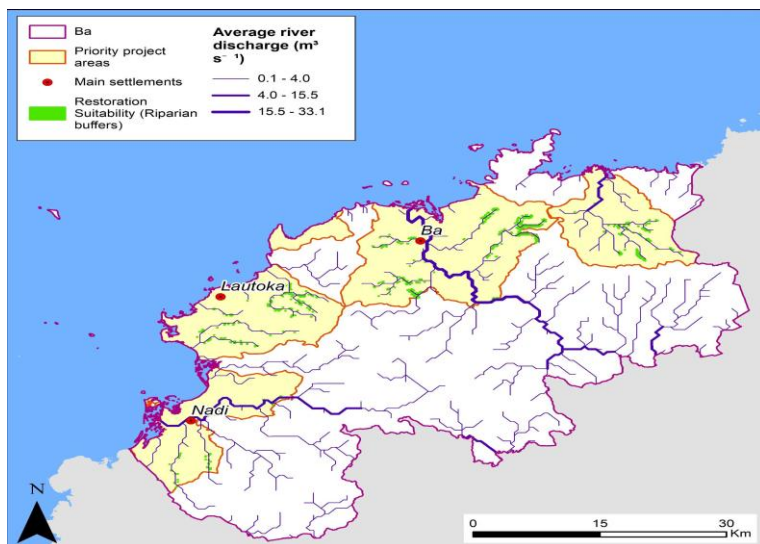
The GCF-funded sub-grants for the Provincial Forestry Departments will be managed by WWF-Fiji’s Divisional Implementation Units (DIU) where the technical staff will coordinate with the Department staff in each province on the project planning, development and reporting. The Government of Fiji is providing co-finance for the implementation of this activity.

Sub-Activity 1.1.2.1: Validate proposed riparian buffer restoration sites and baseline conditions

Considering conditions in the proposed sites for riparian buffer restoration could vary between GCF’s approval and project start, in year 1 WWF-Fiji will conduct rapid validation of baselines conditions and feasibility of the proposed interventions in the sites identified in Annex 2. This will include but not be limited to: (a) an assessment of any land use, vegetation, and ecosystem health changes including shifts in species distribution driven by climate change, (b) validation of soil health and composition to confirm suitability for native vegetation restoration, (c) measurement of water quality, flow patterns, and sediment loads in adjacent natural water bodies, (d) documenting existing flora and fauna to establish a baseline for biodiversity in natural ecosystems, (e) confirming climate change threats identified in Annex 2a including flooding and increased storm frequency to the site and nearby communities, (f) identification of site specific needs for restoration including O&M activities, (f) validating climate change benefit targets in Section E and setting targets for sedimentation reduction benefits from riparian area restoration, (g) socio-economic and cultural considerations to ensure the benefits of proposed species and sites extend beyond their immediate environmental benefits, with cultural practices, traditions and beliefs of local communities, when possible and (h) conducting stakeholder consultations with local communities, provincial governments, and local partners to confirm validation exercise findings and securing their approval for restoration execution. This will include consultations with the NDA, the MoFF, and FAO to confirm final sites for both projects to ensure complementarity. The findings of the validation reports conducted for each province will be used to confirm or adjust proposed riparian forests restoration sites. As part of the Sub-Activity, protocols for assessing the efficiency and effectiveness of the project restoration activities benchmarked against localized site conditions will also be developed.

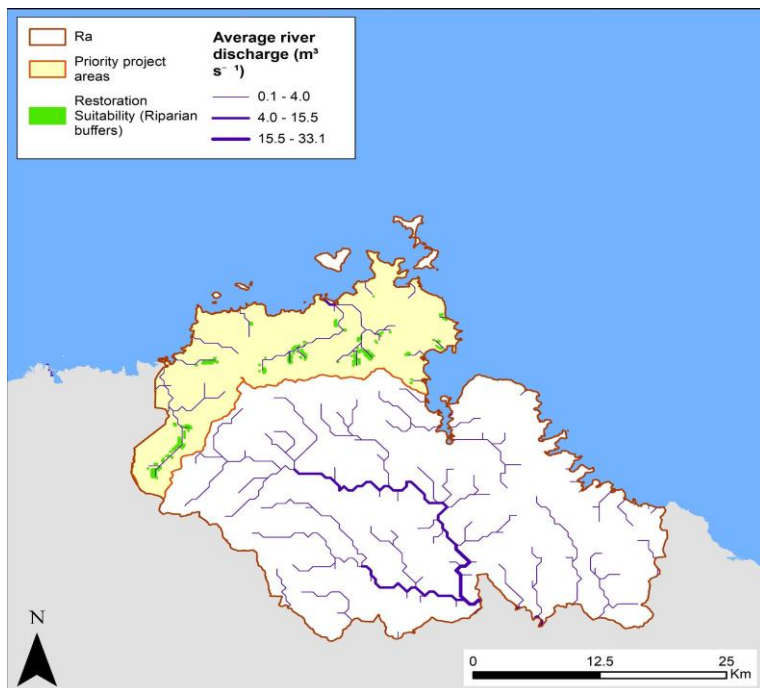
Sub-Activity 1.1.2.2: Restore riparian forests in the Ba province.

This sub-activity will involve restoring 896 ha of riparian forests in Ba, which will result in a reduction of sediment being deposited in watersheds connected to the GSR and a reduction in total area of coral reefs exposed to high levels of sedimentation.



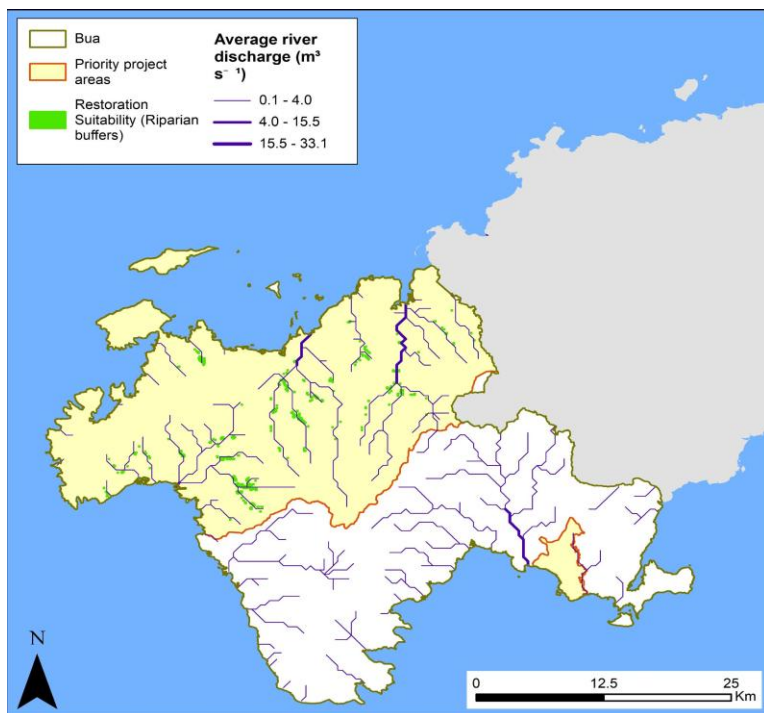
Sub-Activity 1.1.2.3: Restore riparian forests in the Ra province.

This sub-activity will involve restoring 424 ha of riparian forests in Ba, which will result in a reduction of sediment being deposited in watersheds connected to the GSR and a reduction in total area of coral reefs exposed to high levels of sedimentation.



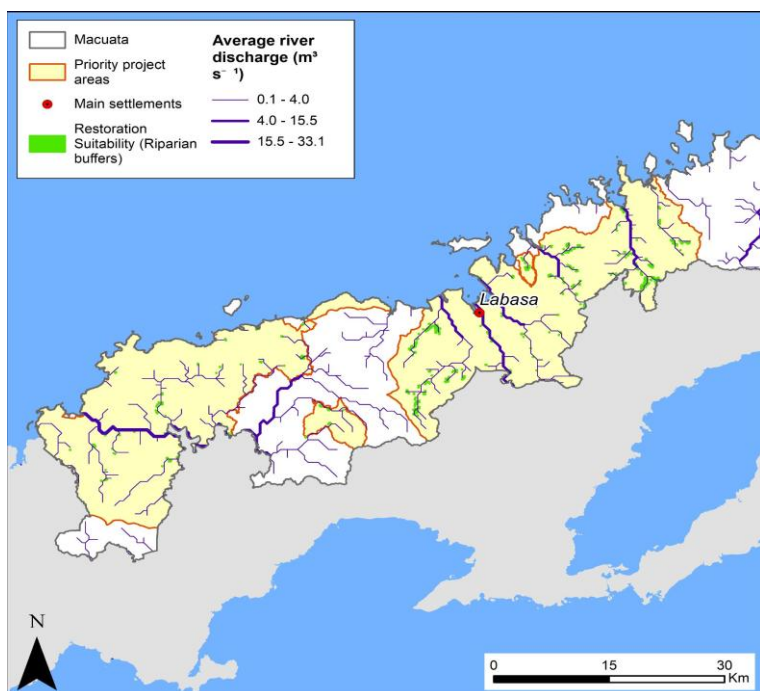
Sub-Activity 1.1.2.4: Restore riparian forests in the Bua province.

This sub-activity will involve restoring 483 ha of riparian forests in Ba, which will result in a reduction of sediment being deposited in watersheds connected to the GSR and a reduction in total area of coral reefs exposed to high levels of sedimentation.



Sub-Activity 1.1.2.5: Restore riparian forests in the Bua province.

This sub-activity will involve restoring 721 ha of riparian forests in Ba, which will result in a reduction of sediment being deposited in watersheds connected to the GSR and a reduction in total area of coral reefs exposed to high levels of sedimentation.

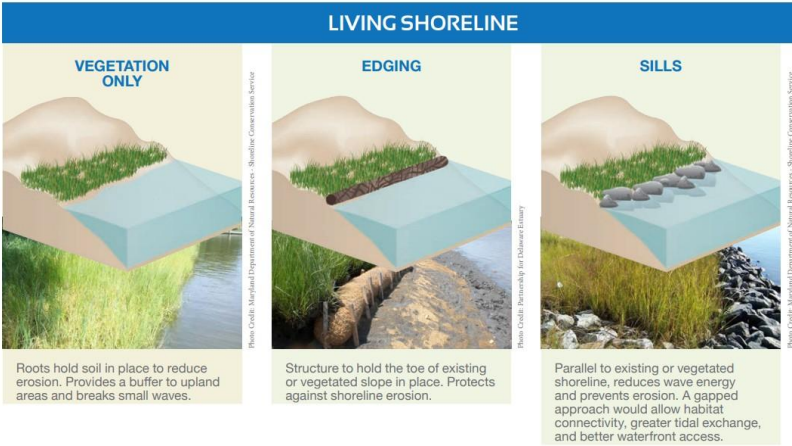
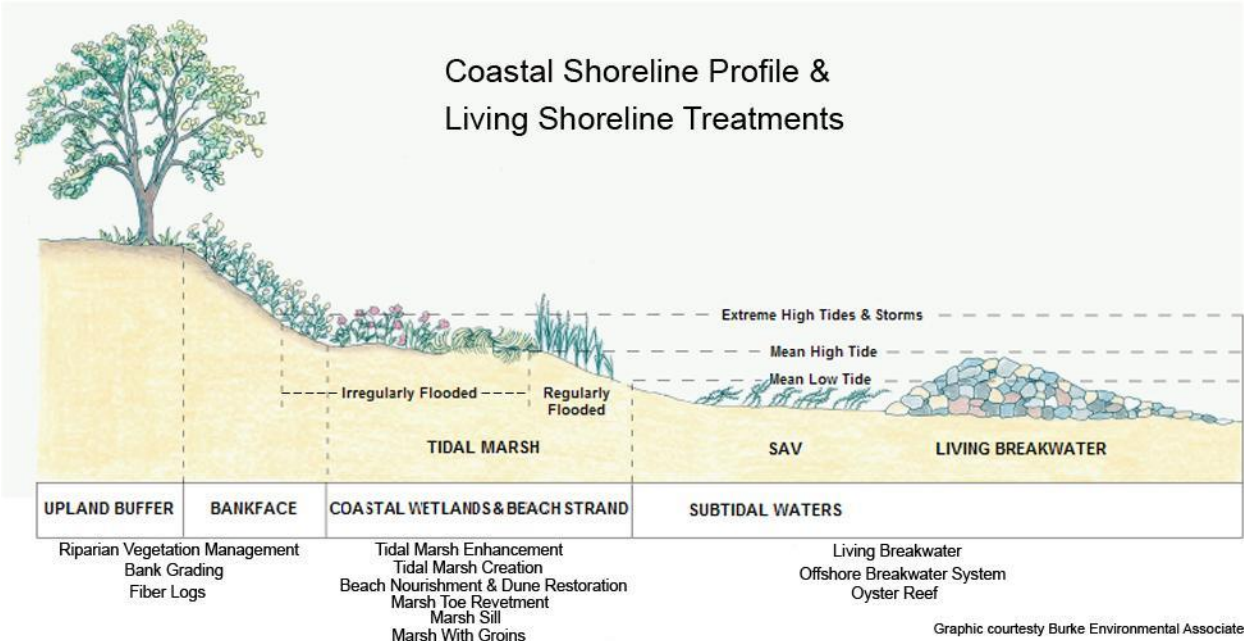


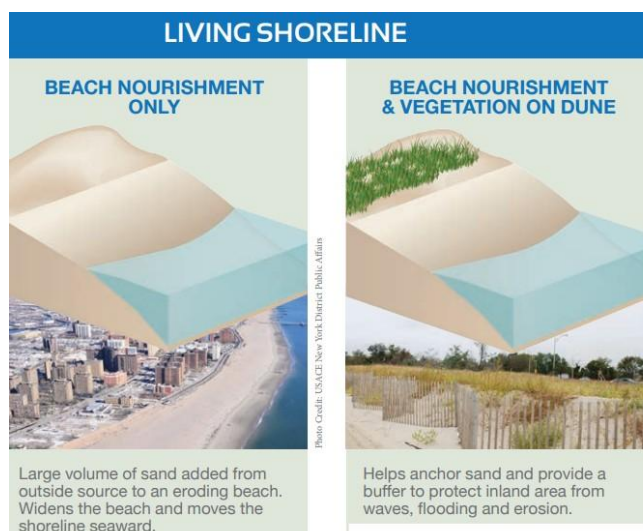
Output 1.2: Living shorelines constructed and operational.

Activity 1.2.1: Design and construction of living shorelines to reduce coastal flooding

The project will commission the design and implementation of living shorelines by a specialized local engineering firm. WWF-Fiji will execute this activity through the PMU who will commission and manage the engineering services firms responsible for the validation, design, and implementation of living shoreline measures. The PMU will determine during execution if one or more engineering firms should be hired for the execution of this activity.

The Project will build 12 km of living shorelines across the four target provinces. These living shorelines would be built combining natural elements such as mangrove rows, soil walls, vetiver grass, and boulders. The living shorelines will use native vegetation along with locally sourced materials such as stone, soil, and clay. To further reinforce the grass on the flood embankments, the riverbank slope will be armoured with stone pitching or riprap (loose stone). Living shorelines will help dissipate wave energy, reduce the impact of storm surges, and prevent shoreline erosion, thereby protecting both the marine ecosystem and reefs and local communities. This integration fosters a biodiverse environment that supports marine life and enhances coastal resilience. By mimicking natural processes, living shorelines offer a sustainable alternative to conventional seawalls, which often disrupt marine habitats and fail to provide long-term protection. The Government of Fiji is providing co-finance for the implementation of this activity.





Types of Living shorelines as detailed in the Systems Approach to Geomorphic Engineering (SAGE) Natural and Structural Measures for Shoreline Stabilization brochure (SAGE 2015).

Cost estimates for Living Shoreline and Coastal Engineering Solutions from Fiji

<u>Project Location</u>	<u>Type/Materials used</u>	<u>Total Cost est. (USD)</u>	<u>Length</u>	<u>Est. Cost per Linear km (USD)</u>
<u>Raviravi Village</u>	<u>Low-tech hybrid; boulders, vetiver grasses</u>	<u>\$9,070</u>	<u>146 meters</u>	<u>\$62,000</u>
<u>Kiwa Initiative</u>	<u>Mangrove hedges, boulders, soapstone, clay vetiver grass</u>	<u>\$309,000</u>	<u>1,565 meters</u>	<u>\$197,000</u>
<u>Lakeba Hospital</u>	<u>Standard grey infrastructure – boulder seawall</u>	<u>\$110,600</u>	<u>150 meters</u>	<u>\$737,000</u>
<u>Namuana Village</u>	<u>Locally sources boulders</u>	<u>\$265,442</u>	<u>300 meters</u>	<u>\$885,000</u>
<u>Dravuni Village</u>	<u>Heavy boulders and engineering</u>	<u>\$221,200</u>	<u>212 meters</u>	<u>\$1,043,000</u>

The project budget (Annex 4) assumes an average unit cost of USD 350,000 per linear kilometer for constructing living shorelines in Fiji. These costs will vary across the different which each present localized conditions influencing these costs. This figure is intentionally positioned between the lower costs associated with easy-access mainland sites and the much higher costs observed on remote islands, and it reflects a realistic, deliverable approach to nature-based coastal protection across the range of site conditions we expect to encounter.

Living shorelines are greener, climate-resilient solutions that rely predominantly on natural and locally available materials—vetiver grasses, mangrove planting, clay, soapstone and quarried boulders—combined with ecological engineering. Because these interventions work with natural processes, they deliver multiple long-term benefits

beyond shoreline stabilization: enhanced biodiversity, improved fisheries habitat, sediment retention, carbon sequestration and increased coastal resilience for communities.

The USD 350,000/km rate recognizes the practical realities of implementation in Fiji. Mainland sites generally benefit from road access, proximity to quarries and more uniform terrain, which reduce transport times, fuel use and labor costs. For example, an easy-access mainland site such as Raviravi has an observed cost near USD 62 per linear meter, reflecting those efficiencies. Conversely, very remote island sites—such as Dravuni—can require complex marine logistics, heavy lifting equipment and extended on-site engineering, pushing costs to upwards of USD 885–1,043 per linear meter. Our unit cost sits between these extremes and therefore represents a prudent median estimate suitable for planning and budgeting across mixed portfolios of mainland and maritime sites.

The USD 350,000/km figure is consistent with delivering durable, ecologically sound interventions that account for mobilization, site preparation, specialized ecological engineering expertise, community engagement and monitoring. It is neither a low-risk underestimate nor an excessive contingency: it is a realistic, median cost that enables us to scale nature-based shoreline protection across Fiji while balancing fiscal prudence and the higher costs of the most logistically challenging sites.

Sub-Activity 1.2.1.1: Validate proposed living shorelines sites and baseline conditions

Considering conditions in the proposed sites for living shorelines sites could vary between GCF's approval and the effectiveness of the project, in year 1 WWF-Fiji will conduct rapid validation of baselines conditions and feasibility of the proposed interventions in the sites identified in Annex 2. This will include but not be limited to: (a) land surveys to determine the availability and suitability of land for living shorelines interventions, (b) creating maps of topography and hydrological features present in and around the sites, (c) ensuring that the proposed sites prioritize sites with current high flooding hazards and proximity to human settlements to maximize the benefits of flood mitigation, and (d) conducting stakeholder consultations with local communities, provincial governments, and national agencies including the MECC and the MoAW local partners to confirm validation exercise findings. The findings of the validation reports conducted for each province will be used to confirm or adjust proposed living shoreline interventions. As part of the Sub-Activity, protocols for assessing the efficiency and effectiveness of the project living shoreline activities benchmarked against localized site conditions will also be developed.

Sub-Activity 1.2.1.2: Design and implement pre-construction measures

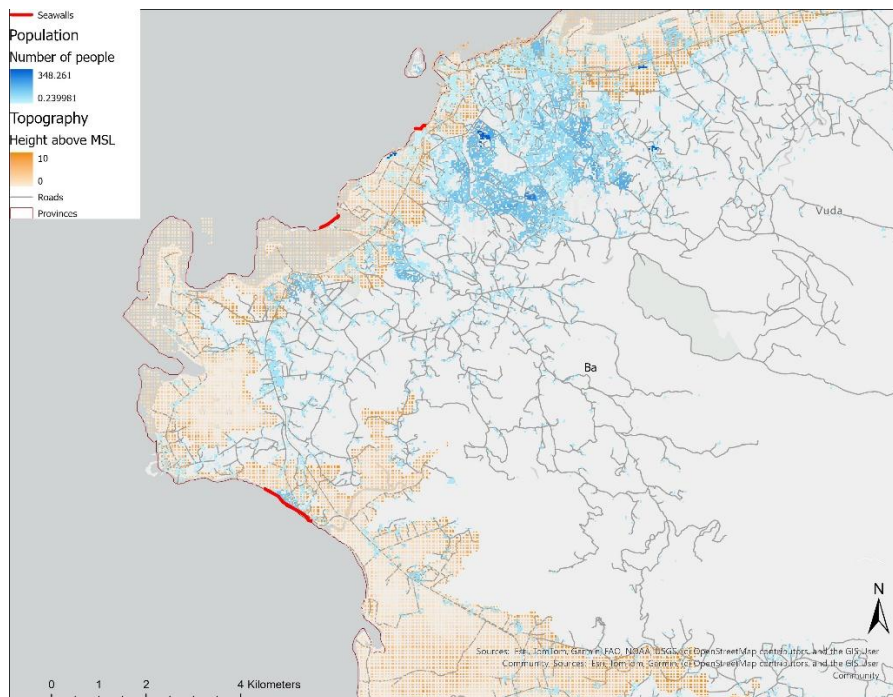
Design and planning: Under this sub-activity the detailed engineering designs and blueprints will be developed for living shorelines, informed by the findings of the preliminary assessment completed under Annex 2 and the site validations conducted under sub-activity 1.2.1.1. The design process will include: (a) a site visits in each proposed location; (b) the preparation of site-specific engineering designs for each proposed structure; (c) site-specific costs for constructing each structure, and (d) detailed workplans, including timelines, for construction in each site. The designs will integrate traditional knowledge and practices where applicable.

Regulatory compliance: Under this sub-activity the necessary regulatory requirements, such as Environmental Impact Assessments (EIAs), permits, and licenses will be obtained from local authorities necessary for construction to begin to ensure compliance with national and sub-national regulations. The site-specific assessments and regulatory compliance measures will start in Year 1 of the project period and be completed by the end of Year 2. Certified consultancies recommended by the Ministry of Agriculture and Waterways will be selected to complete these requirements.

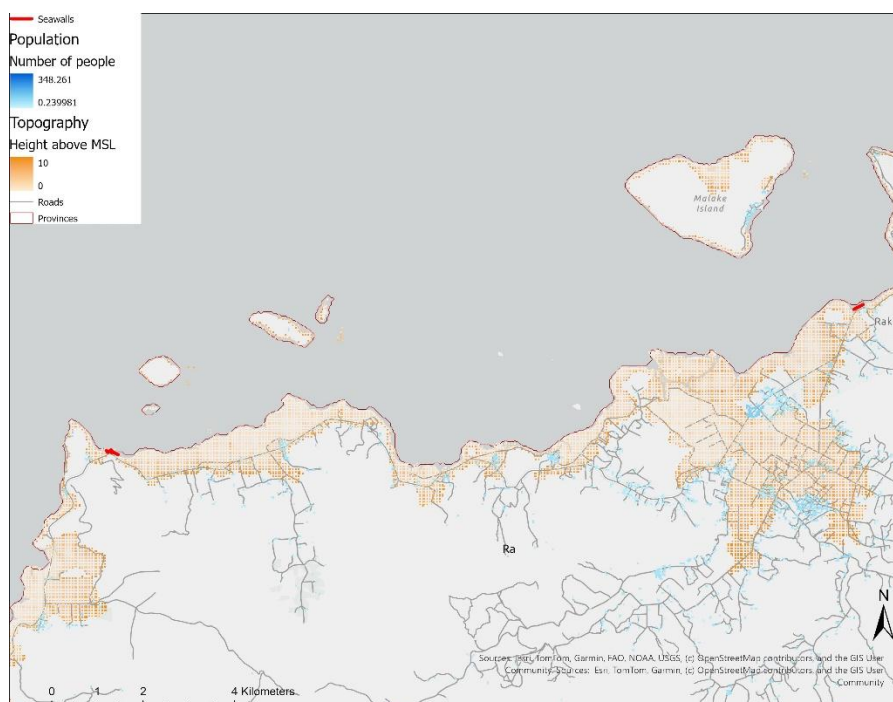
Sub-Activity 1.2.1.3: Construction of living shorelines

Under this sub-activity, 12 km of living shorelines will be built across all four provinces to reduce the risk of flooding for vulnerable coastal communities. These areas were selected based on their proximity to human settlements and high flooding hazards to maximize the benefits of coastal protection.

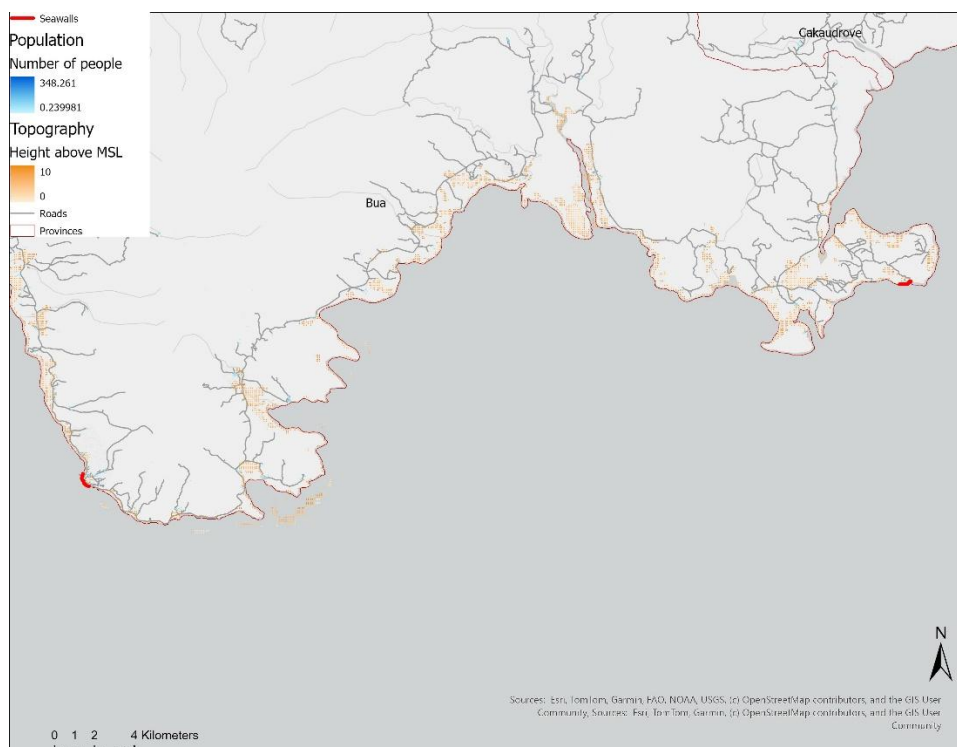
The analysis identified suitable areas for living shoreline implementation, focusing on regions outside the current mangrove cover and areas designated for mangrove restoration. The interventions will reduce flood risk vulnerability by approximately 14%.



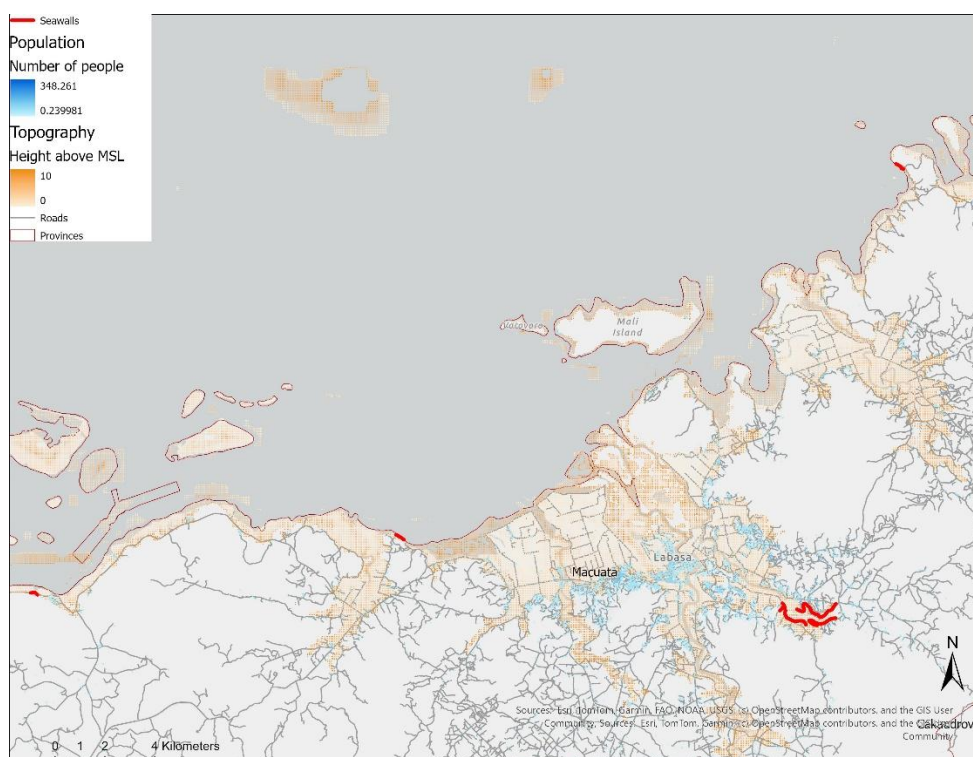
Suitable areas to build the sea walls in Ba province



Suitable areas (green) to build the sea walls in Ra province



Suitable areas (green) to build the sea walls in Bua province



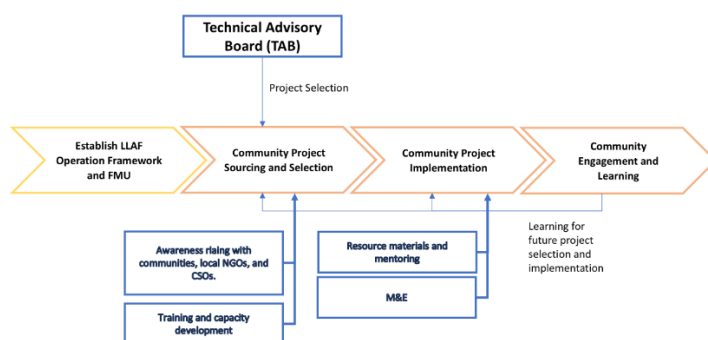
Suitable areas to build the sea walls in Macuata province

Output 1.3: Locally Led Adaptation initiatives are supported and implemented to enhance climate resilience of reef-reliant communities in the GSR.

Supplementary information to Output 1.3

While the proposed interventions under Components 1 and 2 offer critical expert-led solutions to climate risks in the four provinces of Fiji, they alone cannot fully address the localized and evolving vulnerabilities faced by communities. These interventions, though technically sound, require complementary mechanisms that empower communities to take ownership of adaptation efforts and sustain them beyond the GCF project lifecycle. To fill this gap by enabling community-driven initiatives that build resilience from the ground up a Local Level Adaptation Facility (LLAF) is planned and will be set up as part of implementation. LLAF recognizes that long-term climate adaptation must be rooted in local knowledge, leadership, and capacity, especially in areas where institutional reach and resources are limited. The need for such a complementary facility became evident during the community consultations conducted across the four provinces in early 2024. Section 9.3 of the feasibility study (Annex 2) provides detailed learnings and takeaways from the meetings. For example, in Ra Province, villagers reported that increasingly intense rainfall has disrupted traditional planting cycles, eroded fertile topsoil, and increased sedimentation in rivers—directly impacting food security and agricultural productivity. In Macuata, communities have observed more frequent flooding and landslides, with sedimentation affecting water quality and agriculture. In many provinces, poor waste management and lack of collection services have led to garbage being dumped in mangroves and water systems, threatening ecosystems and public health. Additionally, many local governments lack sufficient resources to effectively manage and monitor fishing grounds, sensitive ecosystems, and various NbS projects.

The LLAF will deploy USD 1.5 million in finance to an estimated 10 community-based adaptation projects such as localized shoreline stabilizing projects, restoration work, capacity building programs, waste management awareness campaigns, and projects which show potential to become reef positive enterprises. In doing so, LLAF strengthens local capacity, supports livelihood resilience, and ensures that adaptation efforts are responsive to the specific needs and priorities of reef-dependent communities. These projects will demonstrate the viability of ecosystem-based adaptation and living shorelines (Barrier 1) and generate practical evidence that can inform and strengthen national and provincial planning processes (Barrier 2). Critically, LLAF aligns with the GCF’s Local Level Climate Action (LLCA) principles, including devolved decision-making, local ownership, and investment in local capabilities. This alignment reinforces LLAF’s relevance and appropriateness as a mechanism to overcome barriers to community resilience and climate justice. Details around selection of projects, eligibility criteria and other operational procedures are provided under Output 1.3.



LLAF process

Activity 1.3.1: Operationalize the LLAF.

The innovative cornerstone of Component 1 will be the operationalization of a LLAF that will benefit and build capacity of 10-12 local community-based organizations and non-profits and about 6,000 people directly working with communities in the four provinces. A total of USD 1.5 million in GCF grant resources will be channelled through the LLAF for the beneficiary communities to implement climate adaptation programs and interventions. The facility will be implemented by WWF-Fiji as its Executing Entity and run by a dedicated team illustrated in Annex 2a Chapter 9.

The facility will be managed by a LLA Lead responsible for day-to-day activities, supported by shared finance and monitoring & evaluation officers from the PMU. This structure ensures streamlined operations, cross-component collaboration, and effective delivery of both adaptation and enterprise-focused grants.

The EE will select and approve interventions proposed by local community associations and organizations on behalf of their beneficiary communities. Accordingly, communities will access the funds by presenting their proposed adaptation interventions. The EE will allocate grant funding to the selected proposals based on LLAF's eligibility criteria (See Annex 2c) on an annual basis, or as needed by the Project's implementation timeline.

WWF-Fiji, as EE for Component 1, will ultimately assess the proposals and have the final approval over sub-grants in accordance with its role as EE to ensure compliance with the LLAF's approval process, and to confirm that the proposed beneficiaries, and the practices and interventions, meet the eligibility criteria described in Sub-Activity 1.3.2.4. (See Annex 2a Chapter 9 for details). The flow of funds under the LLAF will be in the form of grants from WWF-Fiji (EE) to the relevant community associations and organizations to use the funds for the benefit of 10 native beneficiary communities. See Section B.4 for further details on the flow of funds.

The design of the LLAF follows the principles for locally led adaptation with the goal of providing communities in the GSR with direct access to finance and more power in the decision-making processes of this Project. In addition, the LLAF will follow an inter-cultural, inter-generational and gender-based approach to directly address prevailing conditions of vulnerability in communities. The LLAF will also promote collaborative action across different project partners and build local capacities to manage climate risk over the long-term for communities.

Sub-Activity 1.3.1.1: Develop the LLAF operational framework.

In year 1, WWF-Fiji, as the EE, will set up an operations framework including an Operations Manual will be created outlining: i) roles and responsibilities, ii) decision-making process, including enhancing selection criteria (see sub-activity 1.3.2.3) for the eligible community interventions and fund allocation, iii) financial management procedures, including financial reporting guidelines and audit requirements for the implementation of grants provided, and iv) compliance structures for grant monitoring and implementation, including an accountability mechanism.

The Facility will be tasked with: LLAF outreach and awareness raising, community training and capacity development on how to access grant funds, project sourcing, managing the proposal revision process, engagement with the TAB (see next sub-activity) for project selection, grant disbursement and management, providing technical assistance to grant recipients to carry out M&E, coordinating with key governmental and non-governmental stakeholders, and generating learning products from community projects. The Facility will also be responsible for monitoring the utilization of grants to ensure they meet the facility's principles and goals, tracking both the implementation of the funded projects, and providing regular updates to stakeholders to maintain transparency and accountability. The monitoring of each sub-grant will be undertaken by the M&E Officer.

The combined organogram Small Grants Facility for LLAF and BDS Enterprises

Sub-Activity 1.3.1.2: Establish the Technical Advisory Board (TAB) responsible for project selection.

To support the selection of project beneficiaries, LLAF will develop Terms of Reference (ToRs) in both English and Fijian to establish a Technical Advisory Board (TAB). To localize decision making on grant making, TAB members will include 10-12 members from academia, INGOs, provincial governments, local NGOs, and representatives from community groups in the project areas of the 4 provinces. The LLAF team will write Terms of Reference (ToRs) for each TAB member, identifying prospective members either through a single ToR with descriptions of each expert or individual ToRs. Interviews will be held in Year 1 and the first half of Year 2. The team will ensure no conflict of interest among TAB members. Further eligibility criteria are described in the table below.

TAB members will operate under a clear code of conduct and decision-making protocol to ensure transparency and fairness. Decisions will be made through consensus or majority voting, depending on the nature of the selection. The TAB may also provide advisory input on project design and feasibility, especially where technical or contextual challenges arise. Meeting frequency will be flexible, based on project cycles, and may include virtual participation to accommodate remote members. Please note that there will be a separate TAB for the Reef-Positive Enterprise Facility under Component 3 due to the unique skillsets each component would require.

Based on project eligibility criteria in 1.3.2.3, over a two-day workshop, the LLAF team and TAB will expand and detail criteria for project sourcing, identification, filtering, and selection, including examples of project types, areas of focus, financial eligibility requirements, submission requirements, and timelines. The TAB will be activated Year 2 onward on a needs basis to accommodate varying project selection cycles and timelines. The small grants facility manager and the LLA lead will be responsible for overall coordination with the TAB.

The TAB members will be selected based on the eligibility criteria below:

Criteria for TAB member selection	Description
Relevant Expertise	Experience in one or more of the following: climate adaptation and resilience, community conservation, living shorelines, climate communications, waste management, climate policy and planning, water management, gender and social inclusion, and traditional ecological knowledge (e.g., Qoliqoli leadership).
Geographic Representation	Based in or actively engaged with communities in at least one of the four target provinces: Ba, Ra, Bua, or Macuata.
Community Engagement Experience	Proven ability to work with and guide communities in designing, implementing, and monitoring nature-based solutions (NbS) and locally led adaptation projects.
Institutional Diversity	Affiliated with academia, INGOs, local NGOs, provincial government, or recognized community groups to ensure a mix of perspectives.
Representation of Marginalized Groups	Preference for individuals representing or advocating for women, youth, Indigenous Peoples, and persons with disabilities.
Commitment to LLA Principles	Demonstrated understanding and support for the eight principles of Locally Led Adaptation, including devolved decision-making and transparency.
Conflict of Interest	Must declare any potential conflicts and have no direct financial or personal interest in LLAF-funded projects.
Availability and Participation	Willingness to participate in interviews, workshops, and project selection cycles as needed.
Language Proficiency	Ability to engage in discussions and review documents in English and/or Fijian.
Support for MEL Processes	Capacity to contribute to monitoring, evaluation, and learning (MEL) activities to strengthen project outcomes.
Term-Based Participation	Willingness to serve on a rotational or term-based basis to allow for broader participation and fresh perspectives over time.

During the Feasibility Studies of the Project existing decision-making units have been identified such as those established under the Global Environment Facility's (GEF) Small Grant Program or the Coral Reef Rescue Initiative's (CRRRI) Technical board. During execution, the FMU will determine if these include the necessary expertise and capacity to serve as the TAB for the Project. The benefit of this approach would be to create operational efficiency for any government and community members of the TAB as well as creating synergies and avoiding replication with other donor funded projects. If this option is chosen fully or partially, necessary Memorandums of Understanding (MoUs) and agreements will be established by WWF-Fiji with the individual experts or with the entities and organizations that they will represent. These documents will clearly define the roles, responsibilities, and time commitments for each expert involved.

Activity 1.3.2: Source and select LLA projects.

In Year 2 of the Project, the facility will begin raising awareness of the LLA grants by conducting the necessary outreach to begin supporting communities in applying for LLA grants. This will include marketing the LLA grants through local networks, conducting outreach to local community-based organizations or relevant local stakeholders in the project areas, and providing technical assistance to community groups to develop and submit

project proposals. The Facility will then review the grant applications received and share the proposals which successfully meet all application requirements and project criteria to the TAB. All projects must contribute to building or enhancing their adaptive capacities and resilience to future climate extremes and reduce pressure on the GSR. Over the 10-year execution period of the Project, approximately 12 projects will be funded by WWF-Fiji, as EE, with a ceiling grant size of USD 125,000. The number of projects and grant size may vary depending on the scope of project proposals. The facility will establish the necessary agreements and legal arrangements with the selected counterparties to ensure smooth and transparent transfer of funds.

Sub-Activity 1.3.2.1: LLAF marketing and awareness raising.

The Facility will advertise and communicate the establishment of the LLA and the availability of community grants for climate adaptation through local media networks, field campaigns, newspaper advertisements, including radio, and through community networks including local churches and community groups. The Ministry of iTaukei Affairs will support WWF in communications and awareness raising for the LLAF through their communication networks. The LLAF will hire and support marketing and awareness-raising consultants to develop a campaign guidance document and deliver awareness-raising campaigns. The guidance document will detail target areas and communities in the four provinces based on Annex 2, outline the roles and responsibilities of consultants and LLA lead and other team members, identify formal and informal media channels for raising awareness, and provide timelines. The campaign aims to raise awareness about climate change and its impacts, the LLA grants and its call for proposals, and the impact of LLA projects. The team can leverage the TAB's feedback on the awareness campaigns to ensure factual correctness of climate-related concepts, and target communities.

Sub-Activity 1.3.2.2: Training and capacity building workshops.

Under this Sub-Activity, the FMU will hire a consultant to provide training and capacity development workshops to interested communities in the development of climate change adaptation project proposals. The consultant will be responsible for delivering two types of training. First, they will develop project management and proposal development training materials, including guidance on the process to apply for funding, developing projects, capacity requirements, and orientation toward the project eligibility criteria. Second, the consultant will create manuals, guides, handouts, and other educational resources. Using these, the consultant with support from LLA lead and other team members will deliver trainings on climate change adaptation and technical skills necessary to develop, manage, design, implement, and monitor local climate adaptation projects. Additionally, the consultant will conduct workshops and seminars, provide one-on-one mentoring, develop evaluation metrics for training effectiveness, and offer ongoing support and follow-up sessions on a case-by-case basis. These trainings materials will be compiled into LLA project development toolkits and resource materials communities can use independently to inform LLA project development. Initial criteria and requirements are included under Sub-Activity 1.3.2.3. These training courses are intended to not only enable community associations and organizations to access LLA funding but also give them the necessary skills to develop proposals for other potential donors who finance small-scale community adaptation activities.

Sub-Activity 1.3.2.3: Proposal review and selection.

The LLA lead with support from other facility team members and component 1 members, if needed, will be responsible for sourcing, shortlisting and reviewing proposals for communities to ensure that the applications follow the criteria and complete all requirements of LLAF applications. The LLAF may engage in multiples reviews with communities providing feedback for any required changes. To ensure that the LLAF has a balanced portfolio covering target thematic areas and has a fair distribution of projects across the four target provinces, the facility will issue and disseminate Requests for Proposals (RFPs) on a rolling basis through online and off-line media channels, to source proposals covering a diversity of thematic and geographic areas as described in the criteria table below. The Ministry of iTaukei Affairs and local NGOs will be important partners in helping disseminate these RFPs. This will help ensure that these opportunities reach many communities that might otherwise lack access to funding opportunities and encourage applications.

Shortlisted grant applications from communities that have met all the requirements following the facility review will be submitted to the TAB for review and recommendation for approval. As EE, WWF-Fiji will have final approval for all grant applications. In addition to reviewing proposals on their potential benefits and costs, the TAB will also ensure that the proposals are well aligned with larger provincial adaptation objectives. Depending on the number

of proposals and the success of Sub- Activities 1.3.2.1 and 1.3.2.2, the facility will determine during execution how often the TAB will be convened to review proposals and how many proposals should be recommended for approval during each meeting. Prior to TAB's review meeting, the team must hold presentation meetings for the TAB, to showcase the applications and proposed projects. The projects will be selected based on the eligibility criteria provided in Annex 2c.

Sub-Activity 1.3.2.4: Fund Disbursement and Financial Management.

For those projects approved under the LLAf, the relevant communities associations and/or organizations that submitted the proposals on behalf of the beneficiary communities will enter into sub-grant agreements with WWF-Fiji which define the project scope, activities to be delivered by grantees, targets to be achieved, grant size and disbursement schedules, and applicable reporting, financial and operational requirements. Following the execution of these agreements, funds will be disbursed to the relevant community associations and/or organizations following the defined disbursement schedule. In total, USD 1.5 million will be disbursed over a period of 10 years, supporting approximately 12 LLA projects each with a maximum budget of USD 125,000. The LLAf Lead supported by the PMU finance and operational staff will hold two meetings with each of the LLA project teams before disbursing each instalment. These meetings will focus on conducting financial due diligence, offering advice on financial management, and ensuring accurate reporting. Additionally, weekly or bi-weekly check-ins will be scheduled to provide necessary support to the grantees during the design and implementation of the projects. The technical support will be provided by the same consultant responsible for developing the technical training modules on a case-by-case basis.

Sub-Activity 1.3.2.5: Project M&E and Learning across the LLAf portfolio.

Our community consultations during the development of our feasibility studies have indicated that community capacity to monitor the benefits of local interventions is very limited. To build capacity for locally led adaptation by communities the Project through the PMU's M&E Manager and Officer will support grantees by providing M&E training to grantees, following the selected project's approval, specific to the needs and scope of their projects and provide M&E assistance and mentoring during execution of community projects with the objective of over time building community capacity to conduct M&E for small-scale adaptation projects independently. During sub-grant execution, the PMU M&E team will also work with the beneficiary communities to create knowledge and learning products highlighting important lessons learned from LLA approaches to be shared in Fiji through WWF-Fiji and internationally through the WWF Network and WWF-US staff supporting execution of the Project. The LLAf will develop M&E materials, including step-by-step guidance documents for monitoring projects, and provide technical assistance on project monitoring and target setting. To build capacity of the grantees the M&E Officers will support grantees by providing M&E training specific to the needs and scope of their projects following project approval. The M&E Officers will offer M&E assistance and mentoring during the execution of community projects, aiming to build community capacity to independently conduct M&E for small-scale adaptation projects over time. Additionally, the Project will create knowledge and learning products that highlight important lessons learned from LLAf approaches. These products will be shared in Fiji through WWF-Fiji and internationally through the WWF Network and WWF US staff supporting the execution of the Project.

Sub-Activity 1.3.2.6: Stakeholder Engagement and Feedback.

During LLAf implementation, the FMU will conduct annual stakeholder engagements with existing grantees, communities interested in accessing LLAf funding, community leadership, local NGOs, and provincial governments to discuss lessons learned and consider adaptation management interventions to ensure that the LLAf is most responsive to evolving and dynamic community needs.

Component 2: Enabling a paradigm shift toward integrated R2R coastal ecosystem management in Fiji's GSR

Outcome 2: An enabling environment and R2R ecosystem planning frameworks are conducive to the effective management and implementation of EbA, NbS, and living shorelines interventions within the GSR.

Output 2.1. New management arrangements to reduce climate change vulnerability developed for the GSR.

Activity 2.1.1: Develop a GSR Management Unit and the required operational procedures for implementing a 10-Year R2R Land and Marine Use Management Plan.

Under this activity, a first of its kind GSR MU will be established for the GSR. The MU will be comprised of Project staff responsible for the development and implementation of a GSR Management Plan.⁵⁶⁵ During the Project, the MU will establish an Advisory Board to ensure that national and provincial governments, as well as community and civil society approve and contribute to planning and management decisions and ensure alignment with the GoF's climate policies and plans. The MU will also support communities, provincial governments, and national agencies in creating agreements which outline roles for each of these constituents including community and government functions for management of ecosystems, EbA and NBS assets implemented under Component 1, and requisite ecosystem monitoring. Under this activity, the establishment and operation of the GSR MU will be executed by WWF-Fiji, in its role as the EE; however Sub-Activity 2.1.1.4 will focus on developing future operational arrangements for the GSR MU beyond the GCF Project period. Future management of the GSR MU will be fully funded by MECC starting in Year 9 of the project. Activity 2.1.1 will be executed by WWF-Fiji. The Government of Fiji is providing co-finance for the implementation of this activity.

Sub-Activity 2.1.1.1: Establish the GSR Management Unit.

Under this sub-activity, a first of its kind GSR MU will be established by WWF-Fiji to be responsible for the development, implementation and monitoring of the GSR Management Plan. This plan will define allowable seascape and connected landscape uses which reduce pressures for coral reefs from overfishing, water sedimentation and pollution, and coastal development. The GSR MU will operate within the MECC and other agencies responsible for managing Fiji's coastal ecosystems, following the policies of the Environment Management Act, Climate Change Act, Coral Reef Act, and National Oceans policy. Management functions and authorities of the GSR MU will be guided by the laws and regulations in Fiji.

The GSR MU will also be responsible for coordinating different management functions across national agencies, provincial governments, communities, and civil society defined in the GSR Management Plan (described in further detail under Activity 2.1.2). The plan will define identified climate and non-climate threats to ecosystems and communities and identify mitigation measures for those risks through various land and seascape use and management practices which will fall under the responsibility of a number of agencies in Fiji. These will include MECC, the Ministry of Fisheries and Forestry, the Ministry of Agriculture and Waterways, the Ministry of iTaukei Affairs (Community Affairs), and the Ministry of Lands and Natural Resources. To ensure coordination, participation, and knowledge transfer the GSR MU staff (hired by WWF-Fiji) will be embedded across these agencies under the terms of the relevant MOUs between WWF-Fiji and such agencies.

GSR MU Team

GSR MU Team Members	Host Agency	Role within Agency
GSR MU Lead & Coordinator	MECC (GCF-NDA)	• Coordinate overall GSR MU activities • Coordinate participation of MECC and other agencies in the GSR management plan design and implementation • Ensure alignment and applications of provisions of the EMA and Climate Change Act • Develop MECC capacity in R2R ecosystem planning and management
Coordinator Min. of Fisheries and Forestry, Min. of Agriculture and Waterways, Min. of iTaukei Affairs (MoIA), Min. of Lands and Natural Resources	Ministry of Fisheries and Forestry	• Coordinate participation of MoFF, MoAW, MoIA, and the MoLNR in the GSR management plan design and implementation • Ensure alignment and applications of provisions of the Fisheries Act and Forest Act, the Rivers and Streams Act Cap 136, and the iTaukei Affairs Act, • Develop ministerial capacity in R2R ecosystem planning and management

⁵⁶⁵ See Activity 2.1.2 for further details.

(MoLNR)		
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Sub-Activity 2.1.1.2: Establish community advisory boards to ensure local involvement in decision-making processes of the GSR MU.

To ensure that the GSR MU and the development and implementation of the GSR Management Plan is aligned with national climate change objectives and community needs, the GSR MU will engage with and be guided by existing Development Councils who operate under the District Councils in Fiji. The Development Councils have oversight over Fiji's district development plans which are meant to define district level strategies to achieve the objectives of Fiji's by the National Development Plan (NDP) which outlines a comprehensive vision for the country's social, economic, and environmental development across a 20-year timeframe, currently focusing on the period 2017-2036. Representatives from the District Development Committees will serve as the Advisory Board for the GSR MU. The primary functions of the Advisory Board will be to: i) ensure that GSR planning and management efforts are aligned with the NDP and community development plans, ii) provide guidance to the GSR MU, iii) facilitate engagement with District Councils in planning and management efforts, and iv) to review annual and provide feedback on GSR MU workplans.

Sub-Activity 2.1.1.3: Develop operating agreements with communities, provincial governments, and national agencies to define roles and responsibilities under the GSR Management Plan related to management, enforcement, and monitoring.

Under this sub-activity, operating agreements will be developed by WWF-Fiji, in consultation with the Development Councils and the provincial governments, to establish roles and responsibilities for communities, provincial governments, and national ministries for implementing the GSR Management Plan. Operating agreements will be developed between communities and the Provincial Departments in Ba, Ra, Bua, and Macuata Provinces, MECC, the Ministry of Fisheries and Forestry, the Ministry of Agriculture and Waterways, the Ministry of iTaukei Affairs (Community Affairs), and the Ministry of Lands and Natural Resources. The agreements will include provisions for ecosystem management as well as operations and maintenance of the EbA and living shoreline interventions under Component 1. Operational agreements (terms of partnership & FPIC) will be created by WWF-Fiji with provincial governments and communities assigning specific operation, maintenance, monitoring, and stewardship roles among communities and Provincial Departments.

Sub-Activity 2.1.1.4: Develop arrangements for long-term sustainability the GSR MU.

During project implementation, the GSR MU will be embedded within MECC and other key agencies in Fiji (see Sub-Activity 2.1.1.1) and managed by WWF-Fiji (EE). The GoF will host the GSR MU under MECC with the long-term objective being for the GSR MU to continue to operate within MECC and oversee the proper management of the GSR beyond the Project period. During Project implementation, WWF-Fiji will work with MECC to integrate the GSR MU into the MECC over the long-term ensuring that resources are secured to finance the necessary teams within government agencies to sustain future planning and management efforts in the GSR and continue to resource district governments and communities with the resources necessary to execute the provisions of the 10 year plan for the GSR and future planning beyond this period. WWF-Fiji will provide support to MECC during and after the Project to raise funds — including future budget allocations from the GoF and additional resources from international donors and foundations — to ensure the GSR MU can continue its operations beyond the Project closure.

A preliminary budget for the costs of operating the GSR MU and implementing the 10-year plan by MECC once the GCF project is concluded has been added below. This budget will be developed in further detail with MECC during project implementation along with the necessary funding strategy which will include government funding allocations and fundraising needs and strategy with local partners, including WWF Pacific.

Category	Costs (USD)
Staffing (MECC)	250,000

Administration	250,000
Monitoring	380,000
Research and Science	580,000
Education and Outreach	380,000
Contingency	160,000
Total	2,200,000

We have also included a preliminary staffing list and estimated salaries benchmarked against Fijian Civil Service salary bands for the GSR MU starting in Year 11 once the GCF funding period is concluded. These roles are covered in the GCF project budget with some of these positions being covered by the MECC project co-finance starting in Year 9 of the project. As described above the final staffing list for the GSR MU within MECC will be developed in more detail along with SOPs during project implementation.

Job Title	Fijian Civil Service Salary Bands (FJD)	Expected Annual Salary - Mid Range (USD)
GSR MU Lead	(I) 43,296 - 70,495	\$24,625
GSR MU Coordinator	(H) 34,760 - 56,596	\$19,770
GSR Government Liason/Coordinator	(G) 28,605 - 47,675	\$16,920
Community Engagement Officer	(F) 22,528 - 36,103	\$12,813
NbS Coordinator	(H) 34,760 - 56,596	\$19,770
Fisheries Officer	(G) 28,605 - 47,675	\$16,920
Human Resources Officer	(F) 22,528 - 36,103	\$12,813
I.T Officer	(F) 22,528 - 36,103	\$12,813
Finance Officer	(G) 28,605 - 47,675	\$16,920
Communications and Knowledge Management Officer	(F) 22,528 - 36,103	\$12,813

Activity 2.1.2: Develop a 10-Year R2R Land and Marine Use Management Plan for the GSR.

Although the GSR is an important natural climate asset for reducing the economic and social costs of climate change in Fiji, the GSR remains unprotected from these threats because there are currently no plans for landscapes and seascapes, including coral reef and coastal ecosystems, focused on protecting and sustainably managing these ecosystems to ensure they continue providing valuable climate change adaptation benefits to communities in Fiji over the long term and under future climate change conditions.

To address this significant regulatory gap, the GSR MU (established under Activity 2.1.1) will facilitate the development of a GSR Management Plan through an interdisciplinary and multi-stakeholder consultation process engaging with communities in the GSR, industry members including tourism, agriculture, fisheries, forestry and waste management, implementing partners working in the GSR including for other GCF projects such as FAO, and sub-national and national government agencies. The Plan will determine suitable land and seascapes uses to protect and restore the resilience benefits they provide.

Development of the GSR Management Plan will include prioritization of sites for improving the management of designated landscapes and seascapes with high potential for climate change adaptation and community resiliency benefits based on the findings of the Feasibility Study (Annex 2a) and Sub-activity 2.1.2.1 (Annex 2a Chapter 9). The plan will include zoning for different sectors to include fisheries, forestry, tourism, etc. It will also set guidelines for businesses to minimize harmful impacts on GSR. The plan will be developed to include the Provinces of Ba, Ra, Bua, and Macuata and will include community lands and waters, areas under lease hold, and government managed lands and seas.

The GSR MU will build on past donor finance and established best practices for developing spatial plans for vulnerable coastal areas in the Fiji and the Pacific. Specifically, the GEF Pacific International Waters R2R Regional

Project implemented by Pacific Community (SPC) developed R2R spatial prioritization and planning guidelines intended for stakeholders and resource managers to use and apply in their work to up-scale R2R integrated planning of ecosystem. This activity will be executed by WWF-Fiji through the GSR MU in coordination with MECC.

Sub-Activity 2.1.2.1: Gather necessary data and information to set baselines for land and seascape uses.

Under this sub-activity, the following actions will be taken to set baselines for land and seascape uses which will be used to inform the strategies proposed in the 10-year Management Plan (Sub-activity 2.1.2.2) for the GSR: (a) coordination with MECC to prepare detailed workplans for the development of the land and marine use plans, (b) carry out a literature review and collect national spatial data building on the Feasibility Studies (Annex 2); (c) conduct Climate Vulnerability Analysis (CVAs) of at risk sites in the GSR that would benefit from adaptation interventions such as the EbA and living shoreline interventions proposed under this Project and make recommendations to address these risks – additional CVAs will be conducted following the release of future IPCC reports (estimated in 2029) to ensure that the latest climate change information is reflected in the GSR Planning efforts; (d) develop potential future land-use or marine-use change scenarios for the GSR, define criteria such as resilience indicators (e.g. fisheries supply and sediment reduction); (e) identify relevant data gaps important for analyses and inputs into land-sea models including marine and terrestrial biodiversity and land-use data, hydrology/ water quality data, bathymetry, resources and habitats, (f) if there are spatial data gaps in certain areas important for modelling work, then prepare and carry out field work and collect primary data; and (h) data processing and analyses – this includes transcribing raw data, cleaning, collating and entering data into a database, extraction and formatting data for model inputs, calibrating of models, and conducting of spatial analysis on model outputs.

Sub-Activity 2.1.2.2: Develop the GSR Management Plan for the GSR which includes targets and indicators for climate change adaptation.

Informed by the data gathering under Sub-Activity 2.1.2.1, the 10-year Management Plan for the GSR will be prepared, including the methodology, modelling results, mapping of priority landscapes and seascapes to be placed under improved management, and recommendations for protecting and sustainably managing and using the GSR's natural resources (watersheds, forests, coral reefs, etc.). The process for developing the plan will be as follows:

The GSR MU will identify representatives from necessary government agencies, provincial departments, communities, local civil society and NGOs, and industry representatives with decision-making power that need to be involved in the GSR planning process to ensure its success and obtain buy-in from senior leadership in relevant departments for their participation. The MECC will help coordinate and ensure participation from other government representatives.

Once participants have been identified and have committed to participating in the GSR Plan development, the GSR MU will schedule a series of charrettes co-hosted with MECC assembling multi-disciplinary teams with the aim of developing the management plan for the GSR. Charrettes are typically intensive multi-day events and promote joint ownership of solutions to problems and attempts to diffuse traditional confrontation between different stakeholder types. These charrettes will be planned and moderated by expert facilitators.

During the charrettes participants will: (a) validate results of Sub-Activity 2.1.2.1 and Annex 2 of the FP; (b) validate the proposed interventions under the FP; (c) define R2R ecosystem management practices for the GSR which address threats and enhances coastal community vulnerability including those from overfishing, coastal development, and watershed pollution and sedimentation; (d) define allowable land and seascape uses in the GSR for different land use categories for government, communities, and industry; (e) align and harmonize the provisions of the GSR Management Plan with other complementary ecosystem planning efforts, (f) assign roles and responsibilities for implementing the GSR plan; (g) assign monitoring requirements and indicators, methodology, and responsibilities for communities, government, and industry, and (h) identify other project sites for adaptation and/or mitigation interventions to scale and replicate future R2R ecosystem management approaches, beyond the GCF project to be financed by the GoF and/or other donors. The Plan will be reviewed every 2-3 years holding consultative sessions with government, communities, and relevant experts. The exact frequency of these reviews will be better determined during implementation of the Project to ensure the GSR management efforts are responsive to evolving local conditions in Fiji. The GSR MU will be responsible for developing the GSR Plan drafts following the conclusions and agreements during the charrettes.

Sub-Activity 2.1.2.3: Hold national and sub-national validation workshops with GSR communities, provincial governments, enterprises, the expert consultative group and scientific and technical advisory Taskforce of NAP to validate the management plans developed under Sub-activity 2.1.2.2.

Once complete, the GSR MU will hold local workshops in each Province with representatives from provincial departments, enterprises and communities to present the proposed GSR Management Plan and gather local feedback as well as the expert consultative group and the scientific and technical advisory Taskforce of NAP in Suva.

Sub-activity 2.1.2.4: Launch the GSR Management Plan.

Following the integration of feedback from local communities on the GSR management plan, the final plan will be drafted and submitted for final endorsement to all participating agencies, provincial governments, community representatives, and industry participants. After endorsement is received, the GSR Management Plan will be launched during an official event hosted by the MECC.

Activity 2.1.3: Support for national and divisional staff, as well as community leaders/representatives, to implement the GSR Management Plan, EbA, and living shoreline interventions.

This activity will strengthen the capacity of national and sub-national staff, as well as community leaders/representatives, to implement the GSR Management Plan. Wide-scale implementation of EbA and NbS interventions to reduce ecosystem threats and enhance coastal ecosystem and community resilience is not yet institutionalized in Fiji. There is a need to train national and divisional technical staff in the necessary skills to design, implement, operate and maintain these interventions, executed under Outputs 1.1 and 1.2, to ensure they continue delivering adaptation benefits over the long term. Similar training is also required for community representatives to secure their buy-in to and ownership of these new approaches for Fiji, fostering the sustainable adoption and use of these approaches at the community level.

This activity is complemented by the implementation arrangements established under Sub-Activity 2.1.1.1 (See Annex 2a Chapter 9) where WWF-Fiji will embed project staff in key agencies responsible for the management of Fiji's ecosystem, including MECC. In addition to providing these agencies with the necessary expertise and resources, in the form of staff secondments, to participate in the planning for the GSR and support these agencies in the implementation of the GSR plan, the Project will also work to address capacity needs within these agencies to participate and lead in this work. This will include training for national and division level planners in: i) the design, implementation, operation, and maintenance of EbA and NbS interventions both to sustain the interventions under Outputs 1.1 and 1.2 of the Project and to plan for future interventions in these areas outside the Project to reduce the impacts of climate change on vulnerable communities in elsewhere Fiji, ii) the implementation of the GSR Management Plan, and iii) best practices in R2R ecosystem planning approaches to enable government planners to design and implement similar frameworks in other geographies in Fiji. Participants will be selected from the ministries listed above which have direct influence over coastal ecosystem regulation and planning. Those departments within these agencies will be sent requests to nominate trainees from their department. Participants will be selected from the ministries which have direct influence over coastal ecosystem regulation and planning. As part of this capacity-building, participants will visit Component 1 project sites where local stakeholders are engaged in implementing EbA and NBS interventions to enhance their learning and enable scaling up and replication across Fiji.

As the EbA and NbS interventions under Outputs 1.1 and 1.2 will be executed on community lands, and as the majority of the areas where the GSR management plan will be implemented will be in community lands, the Project will also train local communities on: i) the impacts of climate change, ii) benefits of EbA and NbS interventions and how to operate and maintain these interventions, and iii) how to implement community ecosystem management to meet the community requirements of the GSR Management Plan.

WWF-Fiji will lead the implementation of this Activity. The GSR MU and its coordinators will be responsible for leading the annual training of national and divisional staff and community leaders.

Sub-Activity 2.1.3.1: Support for national and divisional staff to implement the GSR Management Plan, EbA, and living shoreline interventions.

Under the Project, the GSR MU will determine capacity developments needs across the agencies included under Sub-Activity 2.1.1.1 and design and deliver training curriculums for national and division level planners in: i) the design, implementation, operation, and maintenance of EbA and living shoreline interventions both to sustain the interventions under Outputs 1.1 and 1.2 of the Project and to plan for future interventions in these areas outside the Project to reduce the impacts of climate change on vulnerable communities in elsewhere Fiji, ii) the implementation of the GSR Management Plan, and iii) best practices in R2R ecosystem planning approaches to enable government planners to design and implement similar frameworks in other geographies in Fiji. These capacity development efforts also include the provision of necessary equipment such as monitoring kits and boat access to conduct the necessary ecosystem management and monitoring functions.

O&M costs for the restoration sites and living shorelines are estimated to range between 5-10% of the overall construction cost annually. During years 2-8 covering the GCF funding period, these costs will be borne by the project, starting in years 8 these costs will be assumed by MoAW and the Provincial Departments of Forestry.

Under *Sub-Activity 2.1.3.1*, the GSR MU will determine capacity developments needs within MoAW, MECC, and the Provincial Departments of Forestry and design and deliver training curriculums for national and division level planners in the design, implementation, operation, and maintenance of restoration sites and the living shoreline. To reduce risk of shortfalls for annual O&M costs TA will include training on long term maintenance requirements and budgeting, as well as M&E and decision making to guarantee performance and adaptive management by identifying performance indicators requiring O&M actions or changes such as conditions of structural elements such as rocks or boulders, wave attenuation effectiveness, and plant cover.

Sub-Activity 2.1.3.2: Support for community leaders/representatives to implement the GSR Management Plan, EbA, and living shoreline interventions.

Under the Project, the GSR MU will determine capacity developments needs for communities in the project area and design and deliver training curriculums for community leaders and local CBOs on: i) the impacts of climate change, ii) benefits of EbA and living shoreline interventions and how to operate and maintain these interventions, and iii) how to implement community ecosystem management to meet the community requirements of GSR Management Plan. The CBOs will help ensure that the most relevant community members participate. Furthermore, to ensure the participation of local communities in decision-making, tools such as Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) will be used, and community elders and CBOs will be engaged to ensure the trainings respond directly to the needs of communities and local-level beneficiaries. These capacity development efforts also include the provision of necessary equipment such as monitoring kits and boat access to conduct the necessary community ecosystem management and monitoring functions.

Activity 2.1.4: Develop and support to implement fisheries management plans in 20 Qoliqolis in the GSR.

Overfishing ranks amongst the highest threats to Fijian coral reefs even in traditional fishing areas used mainly for subsistence such as those around smaller offshore islands, as described in Section B2(a). Under the Constitution, indigenous Fijians have the exclusive ownership of inshore fisheries resources and of their traditional fishing rights for the 410 registered qoliqoli. These rights serve as a basis for traditional leadership in decision-making processes concerning local resource use. While the State legally has sea tenure, most of the everyday decision-making lies with the local communities.

There is a need to engage local communities to improve management of traditional fishing areas to sustain the local fisheries on which they depend on and preserve coral reef ecosystems and the resilience benefits they provide these same communities. This can be done by expanding community roles beyond resource users into ecosystem stewards and managers.

WWF-Fiji has significant experience working with communities in developing FMPs to ensure long-term viability of community fisheries. These FMPs, established in 10-12 qoliqolis provide guidelines and management arrangements to improve fisheries resource governance and use. Under this Activity, WWF-Fiji will help scale and replicate its past work by establishing FMP in 20 additional qoliqolis. Together with the already existing 12 FMPs, the 20 additional FMPs would cover the entire community fishing grounds which cover the GSR. These FMPs will make use of the results from Sub-activity 2.1.2.1 to ensure they are addressing the most significant climate and non-climate threats to Fiji's GSR. Additionally, while the FMPs will not fall under the GSR Management Plan, the FMPs will align with this broader strategy for the GSR and act as the regulatory vehicle through which improved management of coral reefs and productive fisheries practices can be achieved.

This Activity will be executed by WWF-Fiji, who will coordinate with other conservation organizations including the Wildlife Conservation Society (WCS) and Conservation International (CI) in establishing these FMPs with communities with whom they work.

Sub-Activity 2.1.4.1 Review and establish the most applicable fisheries management plan template and guide to suit the Governance structures and information needs.

WWF-Fiji will work with partners including WCS and CI to agree on a common methodology, stakeholder engagement strategy and process, and templates for the FMPs to be applied across the four Provinces to ensure consistency across the FMPs. This will include a review of existing FMPs created from past projects in Fiji and the Pacific and those under development. All plans will use an open and collaborative process with frequent consultations with communities and fishery participants, fishery scientists, and provincial governments.

Sub-Activity 2.1.4.2 Conduct a desktop review and consultations with communities and provincial governments to establish the status of FMPs in each of the Provinces covered by the Project.

WWF-Fiji and its partners will plan and facilitate consultations with coastal communities and Provincial Government Fisheries Officers to: (a) map existing FMPs under execution or development across the four Provinces, (b) identify goals and objectives of the FMPs including the reduction of overfishing to reduce pressures on coral reef ecosystems which provide climate resilience benefits to vulnerable coastal communities in the GSR, (c) select areas where detailed biological assessments will be carried to identify key species, level of threat, and areas where benefits can be achieved, and (d) select final qoliqoli using the results of the assessments and agreement between participant communities and provincial governments.

Sub-Activity 2.1.4.3 Conduct a biological assessment of the 20 qoliqolis.

Prior to the selection of final qoliqoli's for FMP development, biological assessments will be carried out to identify key species in identified fishing areas, level of threat, and impacts and benefits linked to coral reefs and coastal ecosystems. The assessments will also look at the biological, social and economic implications of different harvesting strategies and management options. The assessments will include historical catch information, the size composition of the catch, sex and sexual maturity characteristics of the catches, and proposed enhanced community management practices on coral reef and coastal ecosystem health.

Sub-Activity 2.1.4.4: Develop FMPs and implementation plans for the 20 qoliqolis.

WWF-Fiji and its partners will organize a series of charrettes with representatives from communities and provincial governments using expert facilitators. The FMPs must be achievable, based on scientific evidence and coherent with wider fisheries and wider development policy to be effective. The development of FMPs will ensure consistency with the National Fisheries Act and other national and provincial regulations and plans government community fisheries and use existing available data and the results of the biological assessments carried out under Sub-Activity 2.1.4.3 to inform management practices. The FMPs will be required to follow the overall GSR Management Plan developed under Activity 2.1.2. Development of the FMPs will follow international best practices using guidance materials, such as the Fisheries Management Plan Template and Guidance from the Marine Stewardship Council and lessons learned from the extensive experience developing FMPs in Fiji, the Pacific and globally from WWF, WCS, and CI who are leaders in community-based approaches to fisheries management. The FMPs will include implementation arrangements and monitoring requirements for communities and provincial governments across the 4 provinces. Once finalized the FMPs will be developed in both English and in iTaukei and made available to each village.

Sub-Activity 2.1.4.5: Provide TA and training for communities for FMP enforcement and monitoring.

Community-based W&Ws systems are community managed enforcement networks of individuals responsible for and taking ownership of, in this context, the improved management of ecosystems on which they depend. These W&W systems will be established in each participating community to facilitate the implementation of the FMPs. This will be operationalized by the development of 4 W&W Plans by the communities and Provincial Departments to protect local fisheries. These plans will include: i) ecosystem protection and restoration commitments; ii) provisions for the execution of FMPs; and iii) a process for operationalizing ecosystem and community impact monitoring; and iv) specific operation, maintenance, and stewardship roles agreed between CBOs and the Provincial Departments.

Sub-Activity 2.1.4.6: Launch communications and awareness campaigns targeting the Qoliqoli to ensure the provisions of the plans are well understood.

Under this sub-activity, awareness-raising campaigns will be developed and implemented for target communities to increase their knowledge and awareness of climate change impacts and the benefits of sustainable fisheries management. The campaigns will focus on i) the implementation and benefits of EbA and living shoreline interventions and improved coral reef and coastal ecosystem management for extreme event, flooding, and sea level rise risk reduction; ii) raising awareness about the impacts of climate change on ecosystems, communities and economic sectors; iii) how FMPs will help reduce community vulnerability and improve livelihood sustainability. Several different channels will be used to communicate this information to communities, including consultations with community leaders and elders, signboards, newspaper publications, local radio stations, short videos, photography and other digital media.

Output 2.2: Evidence base to support the adoption of EbA and living shoreline interventions by the GoF.

Activity 2.2.1: Develop an evidence-based case of the climate change adaptation benefits of EbA and living shorelines in Fiji.

The evidence will be generated under the Project through an economic valuation of the project's EbA and NbS interventions (described in detail in Component 1) which will include monitoring and analysis of these interventions' cost-effectiveness and efficiency in reducing the impacts of climate change-induced extreme events and coastal flooding and human induced overfishing, coastal development, and sedimentation and pollution on vulnerable communities and ecosystems in Fiji. Communities will be engaged throughout this process through their representative CBOs to ensure the analysis of the adaptation benefits of EbA and NbS captures communities' experiences and appropriately addresses communities' needs.

The EbA interventions are expected to begin delivering adaptation benefits after 7 years, with the analysis work commencing in Year 7 of the Project. The analysis will consider: i) avoided costs and losses — impacts or losses that would otherwise occur in the absence of ecosystem services generated by the project's EbA interventions, such as increased flood extent, damages and/or losses to agricultural land and infrastructure, including tourism assets, and the subsequent reduced productivity, and reduced water quality and sedimentation; and ii) alternative costs — the implication of implementing 'grey' artificial systems (as opposed to 'green' EbA solutions) that would be required to deliver the same adaptation benefits as ecosystems. The analysis will also consider a wide variety of sustainable development co-benefits, including but not limited to enhanced biodiversity, decreased pollution of water resources and improved access to clean water (see Section D.3 for additional details on the sustainable development potential of the Project).

To ensure the evidence generated under this output is used to expand Fiji's regulations and plans climate change and coastal ecosystem management, this evidence will be used for the development of updated procedures under Output 2.2 for Fiji's key regulations and policies for — namely the NAP, NBSAP, Provincial plans, and community plans of Ba, Ra, Bua, and Macuata provinces — on the proper execution of EbA and NbS interventions to reduce the impacts of future extreme events and coastal flooding in Fiji.

Sub-Activity 2.2.1.1: Prepare baselines and indicators for the biophysical benefits of EbA on ecosystems and their flood attenuation and water resource-related services.

Because an economic valuation of the adaptation benefits of EbA and living shoreline interventions has not yet been conducted for Fiji, the baseline for the valuation to be undertaken under Activity 2.1.1 will be assessed and established under this sub-activity. The relevant indicators that will be used to monitor and analyze the performance of the EbA and living shoreline interventions will also be set under this sub-activity. Establishing the baseline and setting appropriate indicators is the first step in undertaking the economic evaluation, so this will happen in Year 1 before the monitoring and analysis work can begin.

Sub-Activity 2.2.1.2: Monitor the biophysical benefits of EbA and living shorelines on ecosystems and their flood attenuation and climate buffering services using the baselines and indicators prepared under Sub-activity 2.1.1.1.

Under this sub-activity, the biophysical benefits of EbA and living shorelines on ecosystems and their flood attenuation and climate buffering services will be monitored annually using the baselines and indicators prepared under Sub-activity 2.1.2.1. This will include measuring these interventions' extreme events and coastal flooding reduction benefits, as well as their ecosystem service-related benefits, such as improved infiltration, and

enhanced soil and water quality to build a case for integrating EbA and living shorelines into policy and planning (Output 2.2). The Project's M&E staff will undertake this monitoring (supported by community leaders/representatives wherever feasible) and compile the data in an appropriate format for the economic valuation study (Sub-activity 2.1.1.3 below).

Sub-Activity 2.2.1.3: Conduct an economic valuation of the benefits of EbA and living shorelines on ecosystems and their coastal flood and extreme event impact attenuation services.

The economic valuation of ecosystems and their services and benefits will be conducted by WWF-Fiji under this sub-activity using tools such as Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) to value natural capital and evaluate the contribution of EbA and living shorelines towards coastal flooding flood and marine and coastal ecosystem management under future climate change conditions.

Sub-Activity 2.2.1.4: Identify additional opportunities and sites at the national level across Fiji for scaling up and replicating the project's EbA and living shoreline interventions for coastal flood risk and marine and coastal ecosystem management.

Once the economic value and benefits of the Project's EbA and living shoreline interventions have been assessed (under Sub-activity 2.1.1.3), site assessments will be conducted to identify opportunities for scaling up and replicating these solutions across other suitable areas in Fiji that are vulnerable to extreme events and coastal flooding. The identification of opportunities for scaling up and replicating EbA and living shoreline interventions across Fiji under this sub-activity will consider additional sites to the sites identified during the Project's Pre-Feasibility Study stage, with the Project's EbA and living shoreline interventions serving as blueprints for addressing increasingly severe extreme events, coastal flooding, and sea level rise caused by climate change across similar contexts nationally and regionally.

Sub-Activity 2.2.1.5: Collate and store the data and information generated under 2.2.1.1–2.2.1.4.

The data and information generated by sub-activities 2.2.1.1–2.2.1.4 will be collated, managed and stored by WWF-Fiji for Years 1–7 of the Project implementation period. After Year 7, the information will be transferred to the MECC and the Provincial Departments to serve as evidence for future marine and coastal ecosystem management and planning in Fiji. While the collated data and information will be managed by WWF-Fiji, it will still be made readily available to Project partners throughout the Project period. The MECC will be responsible for sharing the collated evidence with the relevant decision-makers as described in Activity 2.2.2 below.

Activity 2.2.2: Develop and disseminate an evidence report to national and provincial government agencies for implementing EbA and living shoreline interventions in response to extreme events, coastal flooding, and sea level rise in Fiji.

Under Activity 2.2.2, the data and information generated under Activity 2.2.1 will be collated and synthesized into an evidence report, highlighting EbA and NBS interventions' extreme events, coastal flooding, and sea level rise risk reduction potential, economic value and environmental and social benefits. This report will serve two main purposes. First, it will be used to develop updated procedures under Output 2.3 for Fiji's key regulations and plans for marine and coastal ecosystem resources management on the proper execution of EbA and NBS interventions to reduce the impacts of extreme events, coastal flooding, and sea level rise in Fiji. Second, this evidence report will stand alone as an important knowledge product and decision-making tool for policymakers and planners in Fiji to use in other decision making around climate change planning and marine and coastal ecosystem management. Moreover, because Fiji has limited data on the cost-effectiveness of EbA and NBS interventions, the economic valuation underpinning this evidence will demonstrate the cost-effectiveness and wide variety of adaptation benefits delivered by these interventions and serve as a key reference for policymakers in future marine and coastal ecosystem management.

WWF-Fiji will work with MECC to disseminate this evidence report to the relevant national and divisional government agencies, academic and research institutions, as well as other relevant national and provincial stakeholders. The MECC, as the NDA and chair of the PSC, will be responsible for the integration of lessons learned and best practices for EbA and NBS from the Project into other ongoing and future projects in Fiji.

Sub-activity 2.2.2.1: Prepare an evidence report on the use and benefits of EbA and living shoreline interventions in response to extreme events, coastal flooding, and sea level rise in Fiji.

Under this sub-activity, WWF-Fiji will lead the preparation of an evidence report on the use and benefits of EbA and living shoreline interventions in response to extreme events, coastal flooding, and sea level rise in Fiji. This report will be informed by the economic valuation undertaken under Activity 2.2.1 and contain stepwise instructions for how to implement EbA and living shoreline interventions efficiently and cost-effectively in Fiji. Importantly, this report will be used under Activity 2.3.1 for the development of updated procedures for Fiji's key regulations and plans for marine and coastal ecosystem management, namely the NAP, NBSAP, Provincial plans, and community plans. The set of guidelines will be prepared by WWF-Fiji.

Sub-activity 2.2.2.2: Disseminate the evidence report developed under Sub-activity 2.2.2.1 to national and provincial planners and regulators as well as academic and research institutions.

The evidence report prepared under Sub-activity 2.2.2.1 will be disseminated by WWF-Fiji and the MECC through the National Working Group (which will be established under Sub-activity 2.3.1.1), the PSC, and existing inter-departmental communication channels.

Output 2.3: Updated procedures for implementing EbA and living shoreline in Fiji.

Activity 2.3.1: Update the National Adaptation (NAP), Provincial Adaptation Plans in Ba, Ra, Bua, and Macuata, the National Biodiversity Strategy and Action Plan (NBSAP) to integrate the GSR as a priority seascape and landscape for implementing EbA and living shoreline interventions in Fiji.

This activity will contribute to transforming Fiji's approach to coastal ecosystem management by establishing a National Working Group chaired by the MECC to: i) review of the NAP, NBSAP, Provincial plans, and community plans to identify entry points to integrate the GSR as a priority seascape and landscape for the implementation of NbS to address threats in the GSR; and ii) lead the development and adoption of updated procedures for Fiji's key regulations and policies for coral reefs and climate change — namely the NAP, NBSAP, Provincial plans, and community plans — on the proper execution of EbA and NbS interventions, which captures past lessons learned highlighted under Barriers 2 and 3 under Section B.2, to reduce the impacts overfishing, sedimentation and pollution reduction, and coastal development to preserve the resilience benefits of the GSR for vulnerable coastal communities in Fiji.

Sub-Activity 2.3.1.1: Establish a National Working Group responsible for amendments to the NAP, NBSAP, and Provincial Adaptation Plans.

A National Working Group will be established to lead the development and adoption of amendments for Fiji's key strategic documents related to coral reefs and climate change — the NAP, NBSAP, Provincial plans, and community plans. These amendments will include the latest guidance on the implementation of EbA, living shorelines, and R2R ecosystem management to reduce the impacts of overfishing, sedimentation and pollution, and coastal development to preserve the resilience benefits of the GSR for vulnerable coastal communities in Fiji. This working group will also ensure these procedures align with current national and provincial climate change planning frameworks. The National Working Group will include representation from the MECC, the MoFF, MoAW, and academic and research organizations. The National Working Group members will be selected based on their subject matter expertise and decision-making capacity or influence within national and subnational government. The National Working Group will participate in Sub-activities 2.3.1.2–2.3.1.4. At project completion, the National Working Group will be transitioned into specialized working groups within MECC responsible for continuing the uptake and use of EbA and living shorelines in future coastal R2R and adaptation initiatives in Fiji beyond the Project.

The Project Steering Committee (PSC) and Divisional Oversight Committees (POCs) will be critical in facilitating engagements under this sub-activity, securing government and community buy-in, and driving approval/decisions at the national and provincial levels related to adopting the updated procedures. Targeted engagements will be held between the abovementioned national and provincial level stakeholders and program partners to enhance coordination between these stakeholders, improve knowledge sharing on coastal ecosystems, strengthen water governance, and promote evidence-based decision-making for climate change adaptation with an emphasis on EbA and living shorelines.

Sub-Activity 2.3.1.2: Review the NAP, NBSAP, Provincial plans, and community plans to identify entry points for improved management of the GSR.

The National Working Group, supported by WWF-Fiji, will review the NAP, NBSAP, Provincial plans, and community plans and identify entry points for EbA and living shorelines as cost-effective adaptation interventions for addressing threats to coral reefs and coastal ecosystems. This review will consider the evidence generated under Output 2.2.

Sub-Activity 2.3.1.3: Draft recommendations for amendments to the NAP, NBSAP, Provincial plans, and community plans.

Following the review under Sub-activity 2.3.1.2, and using the evidence generated under Output 2.2, the National Working Group, supported by WWF-Fiji, will draft updated procedures for EbA and living shorelines as cost-effective adaptation interventions for addressing threats to coral reefs and coastal ecosystems. These updated draft procedures will be presented to the National Working Group for review and finalization.

Sub-Activity 2.3.1.4: Validate the updated documents.

A series of consultative sessions will be held between the National Working Group and stakeholders to review the draft updated procedures produced under Activity 2.3.1. Following the review, the required adjustments will be made and the final the NAP, NBSAP, Provincial plans, and community plans will be submitted to the National Working Group for endorsement and adoption.

Sub-Activity 2.3.1.5: Strengthen the technical and institutional capacity of government staff, communities to implement the updated procedures.

Under this sub-activity, training will be provided by WWF-Fiji, as an EE, to government staff from MECC, MoFF, MoAW, and communities to increase their knowledge and awareness of climate change impacts in Fiji, types of efficient and effective EbA and living shoreline interventions, and the updated procedures and how they should be applied in future landscape and seascape management in the GSR. Awareness raising workshops will also be implemented by WWF-Fiji targeting these staff to ensure they are aware of the new procedures and how they align with the GSR Management Plan. Several different channels will be used to communicate this information, including training workshops facilitated by experts, consultations with community leaders and elders, signboards, newspaper publications, local radio stations, short videos, photography and other digital media.

Component 3: Strengthening access to finance for reef-positive enterprises

Outcome 3: Businesses that reduce threats to the GSR have improved access to commercial capital

Output 3.1: Business development support providers and relevant national and provincial institutions have enhanced capacity to support reef-positive businesses the GSR.

Activity 3.1.1: Improve capacity of BDS providers in Fiji to support reef-positive businesses.

As stated above, the existing business development support ecosystem in Fiji does not cater currently to the early-stage, informal, small-scale reef-positive enterprises. There is thus a need to strengthen the capacity of existing business development intermediaries so they can support such enterprises. The Project proposes to do this through shortlisting BDS providers who can be supported through this Activity to support reef-positive enterprises (sub-activity 3.1.1.1), supporting the identified BDS providers to create tailored programs to incubate and accelerate reef-positive enterprises (sub-activity 3.1.1.2), monitoring the progress of supported BDS providers using relevant key performance indicators (KPIs) (sub-activity 3.1.1.3), providing them with ongoing technical assistance (sub-activity 3.1.1.4) and facilitating knowledge exchange and peer learning among BDS providers (sub-activity 3.1.1.5). WWF-Fiji will serve as the executing entity responsible for delivering this activity.

Sub-Activity 3.1.1.1: Shortlist BDS providers to support reef-positive enterprises.

Building on the feasibility study's assessment of Fiji's BDS providers, this sub-activity will validate and, where necessary, update the mapping of existing BDS providers. The feasibility study has already identified leading providers, analyzed their capabilities, areas of focus, geographical reach, and capacity gaps (e.g., sourcing enterprises, assessing environmental sustainability, providing business incubation, and financial literacy support). This process will refine those findings to ensure the most accurate and current understanding of the BDS landscape.

Using this updated assessment, the Project will identify and shortlist 3 BDS providers that are best positioned to support reef-positive enterprises. The identification of the BDS providers will be done using a set of pre-established criteria including demonstrated experience of business development support- preferably to small-scale enterprises- including capacity building, financial literacy training, business registration, business planning, market access support and access to capital; a strong understanding of the local ecological, political, and regulatory environments; ability to offer long-term support to impact-oriented small-scale enterprises and existing and potential networks with financial institutions and other relevant stakeholders.

By engaging BDS providers, the Project aims to address the critical gap in support for early-stage, small-scale, and informal enterprises. This multi-partner approach strengthens the overall BDS ecosystem by fostering competition, innovation, and shared learning among providers. It also enhances the resilience and continuity of project outcomes by mitigating potential institutional or capacity-related risks tied to reliance on a single provider. Supporting multiple providers will build local capacity and ensure that reef-positive enterprises continue to benefit from robust BDS services beyond the Project's duration.

Sub-Activity 3.1.1.2: Support identified BDS providers to develop incubation and acceleration programs for reef-positive enterprises.

This sub-activity will focus on providing direct grant financing to BDS providers in designing and implementing tailored incubation and acceleration programs specifically aimed at supporting early-stage reef-positive enterprises. These programs will be customized to address the unique challenges faced by reef-positive businesses.

The feasibility assessment revealed critical gaps preventing Fiji's existing BDS providers from effectively supporting early-stage reef-positive enterprises. These include the high transaction costs of sourcing and supporting mostly informal and early-stage reef-positive enterprises, a lack of capacity and resources among BDS providers to offer targeted support needed for these very early-stage enterprises to achieve investment-readiness, and an absence of expertise to evaluate and integrate environmental impacts into their decision-making processes, making it difficult to prioritize businesses with environmental benefits.

To bridge these gaps, the Project will support the identified BDS providers to establish robust incubation and acceleration programs specifically designed for early-stage, reef-positive enterprises in the Project's target provinces. To overcome the challenge of sourcing informal, small-scale reef-positive enterprises, the programs will focus on building the capacity of BDS providers to identify and engage these enterprises while forging strong connections with relevant GoF institutions mandated to support entrepreneurship, such as provincial administrations, divisional commissioners, and the Ministry of Trade, Cooperatives and MSME. Further, the customized incubation and acceleration programs will be different from conventional BDS programs tailored to established businesses by offering highly targeted and a longer-duration support, including business registration, step-by-step guidance on financial planning, mentorship on sustainable business models, and market access, as well as tools to help navigate regulatory and legal requirements. Finally, to address the lack of expertise in integrating environmental impacts into decision-making, the Project will invest in capacity-building initiatives for BDS providers, equipping them with the skills to evaluate ecological considerations effectively (Sub-activity 3.1.1.4).

Sub-Activity 3.1.1.3: Support BDS providers to develop a monitoring framework to assess the environmental, socio-economic impacts of the businesses.

This sub-activity will focus on supporting BDS providers in developing a monitoring framework to track the environmental, social, and economic impacts of businesses. Such framework will provide BDS providers with a structured approach to assess the impacts of reef-positive businesses supported through the Project through measurable indicators, and will combine baseline assessments, progress tracking and periodic evaluations. Leveraging WWF-Fiji's expertise, this framework will include the impacts that businesses have on the drivers linked to GSR's degradation through indicators such as water quality, coral cover, fish populations, while also including socio-economic indicators such as job creation, revenue growth and financial sustainability.

Sub-Activity 3.1.1.4: Provide ongoing support including technical assistance (TA) to the identified BDS providers.

The identified BDS providers will be supported through ongoing technical assistance to ensure that they can continue to provide effective business development support to reef-positive enterprises in the target provinces and enable them to make any adjustment to their incubation and acceleration support based on the evolving

needs of reef-positive enterprises. This will include capacity-building of the staff of the BDS providers being supported through the Project on identifying, assessing, and supporting reef-positive enterprises. It will also include support to BDS providers on developing specific tools and resources that they may need to provide the necessary support to reef-positive enterprises.

Sub-Activity 3.1.1.5: Facilitate knowledge exchange and peer learning among BDS providers.

This sub-activity will focus on organizing workshops and peer-learning platforms where BDS providers can exchange best practices and lessons learned in supporting early-stage enterprises, especially those focused on environmental sustainability. This exchange will be ongoing through the project's duration and will include BDS providers supported through the Project and other BDS providers in the country. This knowledge exchange will allow BDS providers to learn from each other's successes and challenges, particularly in fostering reef-positive businesses. By fostering a collaborative environment, BDS providers can enhance their methodologies and approaches, ensuring more effective support for reef-positive enterprises.

Activity 3.1.2: Supporting national and provincial government institutions in fostering reef-positive enterprises.

This activity focuses on strengthening the capacity of key government institutions, including provincial councils and their investment arms (provincial holding companies), the Ministry of Rural and Maritime Development- at the national level and at the provincial level through the Divisional Commissioner Offices- the Ministry of Commerce, Trade, Tourism and Transport, and the Ministry of Agriculture and Waterways.

These institutions play a vital role in fostering entrepreneurship within indigenous and rural communities but often face challenges such as limited resources and expertise. However, as detailed in the feasibility assessment, they face significant resource constraints that hinder their ability to effectively support reef-positive enterprises. A key challenge is the lack of adequate personnel to provide consistent outreach and support. For example, provincial councils and holding companies often do not have sufficient staff to engage with all *matanqalis* (traditional land-owning units) within their jurisdictions on a regular basis. Similarly, the Ministry of Trade, Cooperatives, and Small and Medium Enterprises operates with only four personnel responsible for delivering business training and advisory services across five entrepreneurial support programs, limiting the reach and depth of their efforts. Resource limitations also curtail these institutions' capacity for long-term engagement with enterprises. For instance, the Ministry of iTaukei Affairs offers eight-week community development training programs, which are often insufficient for helping enterprises transition from subsistence or semi-commercial activities to fully commercial operations. Without sustained support, many businesses struggle to gain the skills, guidance, and market access needed to achieve viability and growth.

This activity will include developing tailored capacity development plans for key national and provincial government institutions (sub-activity 3.1.2.1), embedding new staff within these institutions to address capacity and other gaps (sub-activity 3.1.2.2) and providing ongoing training and capacity building to the key government institutions (sub-activity 3.1.2.3). WWF-Fiji will serve as the executing entity responsible for delivering this activity.

Sub-Activity 3.1.2.1: Develop tailored capacity development plans for national and provincial government institutions.

This sub-activity will focus on developing tailored capacity development plans for the key government institutions at the national and provincial level, including provincial councils and their investment arms (provincial holding companies) in the four target provinces, the Ministry of Rural and Maritime Development- at the national level and at the provincial level through the Northern and Western Divisional Commissioner Offices-, the Ministry of Commerce, Trade, Tourism and Transport, and the Ministry of Agriculture and Waterways. Building on the broad assessment conducted during the feasibility studies, this sub-activity will conduct in-depth evaluations to pinpoint specific capacity gaps and needs within individual institutions.

Based on an assessment of the existing roles, programs, mandates, and the availability of resources, the capacity development plans will outline actionable steps, including need for additional capacity, training, creation of specific resources etc. Needed to strengthen institutional capacities of the key government institutions for long-term engagement with the reef positive enterprises.

Sub-Activity 3.1.2.2: Establish necessary arrangements within the government to address capacity and other gaps.

This sub-activity focuses on establishing necessary arrangements within the identified government institutions to help bridge existing gaps that are preventing these institutions from effectively supporting reef-positive enterprises (identified through sub-activity 3.1.2.1). This will be done through embedding dedicated staff hired by WWF-Fiji within these key government institutions to help bridge who will play a dual role: ensuring that the Project's objectives, particularly around fostering reef-positive enterprises, are integrated into the institution's day-to-day activities, and supporting them, and simultaneously contributing to the long-term capacity building of their host institutions.

The embedded staff will serve as liaisons between WWF-Fiji and the government institutions, ensuring that Project goals such as promoting entrepreneurship, supporting early-stage reef-positive enterprises, and facilitating access to finance are effectively advanced. Their responsibilities will include providing day-to-day support in the design and implementation of key programs relevant for reef-positive enterprises, coordinating with other stakeholders such as provincial councils, government ministries, and BDS providers and developing and implementing strategies to align institutional resources with the Project's outcomes.

In addition, these embedded staff will support institutional staff by offering technical assistance, developing training materials, and building internal systems that can sustain the work initiated by the Project. Over time, they will transfer critical skills to their host institutions, such as monitoring reef-positive businesses, identifying funding opportunities, and providing tailored business development support. This approach will not only support immediate Project objectives but also ensure that the institutions are equipped to continue supporting reef-positive enterprises beyond the Project's duration.

Sub-Activity 3.1.2.3: Provide ongoing training and capacity building to key government institutions.

This sub-activity will focus on delivering training and capacity-building programs for key government institutions, both at the national and provincial levels. The specific needs for training and capacity building will be identified in the tailored capacity development plans created for the key national and provincial government institutions (sub-activity 3.1.2.1). The training will aim to enhance their ability to support and promote reef-positive enterprises by equipping them with knowledge on sustainable business practices, financial literacy, environmental conservation, and entrepreneurship development. These programs will also cover how to integrate reef-positive enterprise support into existing government frameworks and development programs.

As a part of this sub-activity, standard tools to be utilized for ongoing training and capacity building will be identified and developed. Examples of such tools include training modules and case studies to build government staff capacity in analyzing business financials, investment risks and long-term viability of reef-positive enterprises, a structured evaluation framework with checklists and scoring criteria to help government staff assess the environmental, social and economic sustainability of enterprises applying for support, etc. This exercise will also consider the existing tools and ways to strengthen those to make them fit-for-purpose for the project.

Output 3.2: Coordination between reef-positive enterprises, business development support providers, financial institutions and government is strengthened, improving enterprise visibility to capital providers.

Activity 3.2.1: Enable effective coordination between enterprises, community organizations, BDS providers, financial institutions and government.

The establishment of a centralized institutional mechanism coordinated by the Project Management Unit (PMU) to support reef-positive enterprises in Fiji is a crucial activity that aims to address the coordination challenges and foster a more conducive environment for sustainable marine-based businesses. This will involve two sub-activities, namely setting up of a multi-stakeholder working group to streamline support for reef-positive enterprises (sub-activity 3.2.1.1) and facilitating engagement with the wider stakeholder network (sub-activity 3.2.1.2). WWF-Fiji will serve as the executing entity responsible for delivering this activity.

Sub-Activity 3.2.1.1: Set up a multi-stakeholder working group to streamline support for reef-positive enterprises.

The first sub-activity is the establishment of a working group coordinated by the Project Management Unit (PMU). This working group will be convened at regular intervals as agreed jointly between PMU and the members of the working group, and it will bring together key government institutions and non-governmental organizations including BDS providers, financial institutions, and representatives of reef-positive enterprises. The frequency of

the multi-stakeholder working group will be determined during implementation, but it is expected to meet approximately every six months.

The working group will facilitate dialogue, align efforts, share best practices, identify challenges and ensure effective utilization of various resources available for reef-positive enterprises. Various members of the working group will also be responsible for different resources and capacity building initiatives (Activity 3.2.2) included in the Project. Another key role of the working group will be to facilitate knowledge sharing among stakeholders through collaborative engagement of stakeholders including discussion of challenges, sharing success stories and exchanging innovative strategies to enhance support reef-positive enterprises.

The PMU will play a central role in ensuring that all key players are represented, meetings are held at appropriate intervals, and action items are followed up to ensure tangible outcomes. The working group will also function as a platform for resolving cross-sectoral issues and making collaborative decisions that reflect the priorities of the government, private sector, and local communities.

Sub-Activity 3.2.1.2: Facilitate periodic stakeholder engagement forums to engage the wider stakeholder network.

This sub-activity will involve organizing regular forums to convene and engage a wider stakeholder network beyond the members of the working group, including key government agencies, non-governmental organizations, financial institutions, community representatives, and industry experts involved in supporting reef-positive enterprises. These forums will provide a structured platform for stakeholders to share updates, discuss ongoing initiatives, identify challenges, and explore collaborative opportunities. Each forum will feature thematic discussions focused on specific aspects of supporting reef-positive enterprises, such as financing strategies, capacity-building initiatives, and best practices in environmental sustainability. To ensure inclusive participation, outreach efforts will be made to engage stakeholders from various sectors and regions, particularly those representing indigenous and rural communities. The frequency of these forums will be determined during implementation, but it is expected to meet annually.

Activity 3.2.2: Develop resources and deliver capacity-building programs in support of reef-positive enterprises.

Strengthening the overall enabling environment for reef-positive enterprises requires addressing gaps that no single stakeholder would have the resources or incentive to bridge alone. This activity focuses on developing resources for different stakeholders and delivering capacity-building programs to create a unified and supportive environment for these enterprises.

Resources such as toolkits, monitoring frameworks, and best practice guidelines can provide a standardized foundation for various actors to engage effectively, ensuring that all stakeholders are equipped with the necessary tools to contribute to the common goal of sustainable enterprise development. The capacity-building programs will include targeted training for the relevant stakeholders to help them understand and act on the unique challenges and opportunities associated with the reef-positive enterprises. This will include technical training on environmental risk management and practical skills such as assessing the financial viability of small-scale, eco-friendly businesses. The goal is to build a robust network of well-informed stakeholders who can work together to foster a supportive ecosystem for these enterprises.

This activity will be closely aligned with all other project activities to ensure it addresses identified gaps in resource needs, such as those highlighted in capacity development plans for government institutions. Additionally, the resources developed through this activity will be designed for cross-utilization across the project, avoiding duplication. For example, the monitoring and evaluation framework created to assess the impacts of businesses on the GSR ecosystem will also support BDS providers in evaluating the environmental performance of reef-positive enterprises.

The sub-activities in this activity will include developing and implementing a communication strategy to educate and engage stakeholders (sub-activity 3.2.2.1), creating a framework to identify, and assess reef-positive enterprises (sub-activity 3.2.2.2), providing training and capacity building for the relevant stakeholders (sub-activity 3.2.2.3), developing a comprehensive monitoring and evaluation framework to assess impacts on the GSR ecosystem (sub-activity 3.2.2.4), and developing a sustainability strategy to ensure ongoing support to reef-positive enterprises beyond the duration of the project (sub-activity 3.2.2.5). WWF-Fiji will serve as the executing entity responsible for delivering this activity.

Sub-Activity 3.2.2.1: Develop and implement a communication strategy to educate and engage stakeholders.

The project will support building awareness among key stakeholders about the critical climate resilience benefits of the GSR and the importance of businesses addressing key threats to the reef ecosystem. The initiative will develop and implement a comprehensive communication strategy to educate and engage various stakeholders, including local communities, businesses, government agencies, and financial institutions. Through targeted outreach programs, workshops, and media campaigns, the activity will highlight the ecological and economic significance of the GSR, emphasizing its role in climate adaptation and mitigation. A crucial aspect of this effort will be to inform reef-positive enterprises about available government programs, business development services, and financial support mechanisms, including the support available through this project. The communication strategy will also showcase success stories of businesses that have successfully implemented reef-positive practices, serving as inspiration for others.

While building overall awareness around the GSR ecosystem and the available avenues of support for enterprises and communities, this communication strategy will also ensure that the support available to the stakeholders through this Project, is effectively communicated to ensure adequate outreach and awareness.

Sub-Activity 3.2.2.2: Create a framework to identify and assess reef-positive enterprises.

The Project will develop a comprehensive framework that could be used by different stakeholders to identify, assess, and support reef-positive enterprises. This framework will be crucial for financial institutions, enabling them to evaluate potential investments with a focus on environmental sustainability and ensuring that investments positively impact reef ecosystems. This framework will include key factors such as the business's ecological footprint, potential for positive environmental outcomes, financial viability, and alignment with sustainable development goals. A preliminary set of investment criteria for financial institutions has already been developed in this feasibility study, and this sub-activity will focus on building on it.

Sub-Activity 3.2.2.3: Provide training and capacity building for the relevant stakeholders.

The Project will provide comprehensive training and capacity building for key non-government stakeholders involved in supporting reef-positive enterprises and create standardized tools and resources to support this on an ongoing basis. The PMU will coordinate with and support the BDS providers being supported through the Project to provide direct capacity building for communities and community-based enterprises including financial literacy, entrepreneurship development, and business training. The Project will also strengthen the capacity of financial institutions to integrate environmental risks and opportunities related to reef ecosystems into their due diligence processes. This will enable financial institutions to be better equipped to fund emerging reef-positive enterprises while also engaging with existing businesses in their portfolios to help mitigate their negative impacts on the reef.

To avoid duplication and ensure appropriate synergies, this sub-activity will be closely coordinated with sub-activity 3.1.2.3 which focuses on training and capacity building for appropriate government partners. And like sub-activity 3.1.2.3, standard tools to be utilized for ongoing training and capacity building will be identified and developed and ways to strengthen the existing tools to make them fit-for-purpose for the Project will be identified.

Sub-Activity 3.2.2.4: Develop a comprehensive monitoring and evaluation framework to assess impacts on the GSR ecosystem.

The Project will also develop a robust monitoring and evaluation framework that can be used by different stakeholders to ensure positive impacts on the GSR through various interventions. The framework will establish standardized metrics and methodologies for assessing the ecological health of the reef, the effectiveness of conservation efforts, and the impact of reef-positive businesses. It will include key performance indicators for biodiversity, water quality, coral cover, and fish populations, and socio-economic indicators to measure the well-being of local communities dependent on the reef. The framework will incorporate, to the extent possible, innovative technologies such as remote sensing, underwater drones, and AI-powered image analysis to facilitate efficient data collection and analysis. To ensure widespread adoption, the framework will be developed through extensive consultations and training sessions for key stakeholders including government agencies, financial institutions, BDS providers and local communities. Regular review and update mechanisms will be built into the framework to adapt to new scientific findings and changing environmental conditions. This sub-activity will

leverage the impact assessment framework that the BDS providers will be supported to develop under sub-activity 3.1.1.3.

Sub-Activity 3.2.2.5: Develop a sustainability strategy to ensure ongoing support to reef-positive enterprises beyond the duration of the Project.

The Project will create a long-term sustainability strategy to ensure that the support for reef-positive enterprises extends beyond the Project's duration. This strategy will focus on several key areas: first, by institutionalizing partnerships between BDS providers, financial institutions, and government entities to establish lasting networks of support. Second, the PMU will work on embedding reef-positive enterprise support into national and provincial policy frameworks to secure ongoing commitment and resources from government agencies. Additionally, the PMU will work to build capacity within local institutions to independently manage and expand the database, matchmaking services, and other support mechanisms created during the project. Finally, the strategy will emphasize training and knowledge transfer to ensure that local partners and stakeholders can continue to drive the development of reef-positive businesses without external intervention. Through these measures, the sustainability strategy will enable continued growth and support for reef-positive enterprises well into the future.

9.3. Project Co-Benefits

Adaptation intervention type	Co-benefits		
	Environmental	Social	Economic
Restoration of degraded mangroves	• Mangroves provide critical habitats for a variety of terrestrial, aquatic, and avian species, including many that are endangered or commercially valuable. • Mangroves act as breeding and nursery grounds for fish, crustaceans, and mollusks, supporting marine food webs and fisheries. • Restored mangroves facilitate ecological connectivity between terrestrial, freshwater, and marine ecosystems. • Mangroves filter pollutants, excess nutrients, and sediments from runoff, improving the health of adjacent marine ecosystems like coral reefs and seagrass beds. • Mangroves store significant amounts of carbon in their biomass and soil, often referred to as "blue carbon," mitigating GHG emissions.	• Communities can sustainably harvest mangrove products like timber, honey, and medicinal plants, creating alternative income streams. • Restored mangroves attract tourism and recreation activities such as bird watching, kayaking, and fishing, offering new employment opportunities. • By increasing fish stocks and biodiversity, mangrove restoration enhances food availability for local communities.	• Mangroves provide a natural alternative to expensive hard infrastructure like seawalls, reducing upfront construction and long-term maintenance expenses. • Healthy mangroves boost fish and shellfish populations, directly benefiting commercial and subsistence fishers and increasing income for coastal communities. • Restoration projects provide jobs in planting, monitoring, and eco-tourism,

			reducing dependence on single economic activities.
Restoration of degraded riverine forests	• Revegetation provides long-term stabilization of riverbanks, prevents erosion, and enhances protection of the bank toe from continual scour while reducing fine sediment input. • Improved forest cover. • Improved carbon sequestration. • Enhanced habitats for local wildlife species.	• Improved drinking water quality and supply. • Communities gain access to sustainable resources like fruits, honey, medicinal plants, and fodder, supporting livelihoods without degrading the ecosystem. • Cleaner water resulting from forest restoration lowers the incidence of diseases like diarrhea and cholera. • Restored forests create spaces for activities like hiking, picnicking, and birdwatching, enhancing quality of life.	• Improved water supply for agricultural activities. • Riverine forests help stabilize riverbanks and mitigate erosion, reducing the need for expensive engineered solutions like levees or riprap. • Riverine forests provide non-timber forest products (e.g., honey, fruits, and medicinal plants) that can be harvested for income. • Restored riverine forests attract tourists for recreational activities such as birdwatching, hiking, and river exploration, supporting local businesses. • Stabilized riverbanks and reduced erosion protect roads, bridges, and other infrastructure near

			waterways.
Construction of living shorelines	• Living shorelines create habitats for various marine organisms, including fish, mollusks, crustaceans, and seaweed, promoting species diversity. • They enhance ecological connectivity between coastal, intertidal, and marine ecosystems, supporting migration and lifecycle needs of marine species. • Living shorelines trap sediments, reducing turbidity and enhancing nearby ecosystems such as seagrass beds and coral reefs. • When incorporating vegetation such as mangroves or salt marsh plants, living shorelines contribute to carbon sequestration, storing atmospheric CO₂ in biomass and soils. • Living shorelines promote natural nutrient cycling through the activities of marine organisms, enhancing ecosystem productivity.	• By enhancing habitats for marine species, living shorelines • directly support local fisheries and aquaculture, benefiting coastal livelihoods. • Improved water quality and reduced coastal erosion lead to healthier ecosystems, reducing exposure to waterborne diseases. • By protecting coastal areas from erosion and flooding, living shorelines reduce the likelihood of climate migration and displacement.	• The enhanced ecosystems supported by living shorelines provide long-term resources for coastal communities, contributing to economic stability. • The construction and maintenance of living shorelines generate jobs in eco-engineering, construction, and long-term monitoring. • Living shorelines, designed with natural and eco-friendly materials, often have lower long-term maintenance costs compared to traditional concrete seawalls. • Living shorelines with integrated natural features such as tidal pools and vegetation create aesthetically appealing coastal areas, attracting tourists for activities like bird

			watching, kayaking, and snorkeling. • Improved coastal access and enhanced natural beauty contribute to recreational industries, supporting businesses like tour operators, restaurants, and hotels.
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10. Annex

10.1. Model validation

Many local threat data were based on observational survey data. Some uncertainty was introduced from the need to interpolate survey data across a larger region, and the incomplete coverage of survey data across years. However, this is the best available data to assess trends in environmental parameters. Livestock information was only available at the Tikina level due to privacy concerns with the census information. To account for this, it was assumed that the abundance within a Tikina was proportional to the area, to estimate abundances at a finer resolution.

The soil erosion and nutrient pollution from human wastewater models were the most technical outputs for the feasibility study. While the soil erosion model was originally global, it was validated across 65 coastal basins globally. Unfortunately, no validation data was available for Fiji. However, several changes to the model were made to make it more applicable to Fiji, such as consolidating all catchments into main basins and determining the pour point per main basin using the Hydroatlas dataset. The observed trends in the models were also validated during site visits in February 2022 where similar relative differences between regions were observed as seen in the models (i.e., Ba and Ra having higher levels of soil erosion than Bua and Macuata).

The sediment export model was developed based on the InVEST sediment delivery model, which produces spatially explicit outputs illustrating the sediment erosion reaching streams. This is achieved by utilizing land cover data to estimate the potential sediment yield from each land cover type. Sediment export per pixel was obtained from the newly developed dataset on sediment export for Fiji (Suárez-Castro et al., in prep). Human wastewater nutrient pollution relative differences were validated by comparing modelled nutrient outputs from sewage treatment plants to observed levels, with strong agreement found across each wastewater treatment plant.

Mangrove loss and degradation were calculated based on the best available dataset on monitoring sites, however, only covering years 2020 to 2021. The analysis used included Landsat 8 satellite imagery, Google Earth Engine, and machine learning techniques to create accurate baseline maps for mangrove extent in 2020, with a resolution of 30 meters. For the year 2021, a two-step methodology based on Random Forest classification and NDVI anomalies was used to assess stable regions, areas of loss, and areas of gain within mangrove ecosystems. Historic changes in mangrove degradation were therefore not captured in our assessment.

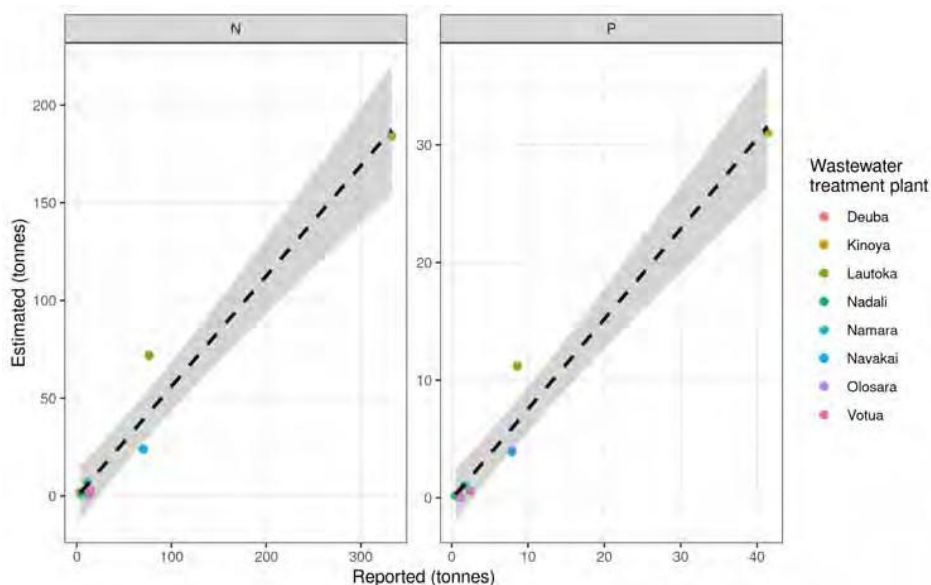


Figure 10-1 Modelled nutrient pollution compared to reported nutrient pollution from wastewater treatment plants in Fiji.

The climate vulnerability and disaster risk index was developed based on several observational datasets, including the 2017 Population Census. A Data Quality Assessment has been performed that shows the Open Street Map coverage by comparing the number of Open Street Map object counts (number/km²) to the local population density (population/km²). Given that most data inputs to determine climate vulnerability were based on buildings and characteristics of the population, this assessment gives an idea of how accurate population density estimates are.



Figure 10-2 Data Quality Assessment of population density estimates compared to Open Street Map object counts to validate the quality of population estimates.

Historical climate validation and analysis methodology is a process that involves the collection, quality control, and analysis of historical climate data. This data can include variables such as air temperature, pressure, precipitation sum, and the number of precipitation days. The data is usually collected from weather stations and other sources and then processed into a common format for analysis. The methodology involves several steps⁵⁶⁶:

⁵⁶⁶ IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

1. **Data Compilation:** This involves gathering historical climate data from various sources, including existing databases and newly rescued data.
2. **Quality Control:** The collected data undergoes a quality control procedure to ensure its accuracy.
3. **Data Processing:** The data is then processed into a common format for analysis. This can involve converting sub-daily series to monthly mean values.
4. **Analysis:** The processed data is analysed to identify trends, patterns, and anomalies. This can involve statistical methods, model simulations, and comparisons with climate proxies.

Applying this methodology to this FS involved collecting and analysing historical climate data for Fiji (greater than 30 years). These data provided valuable insights into the local climate patterns and trends, which can inform various aspects of the feasibility study.

10.2. Scenario and time frame

The IPCC's sixth assessment report (AR6) makes the following conclusions based on observed alterations in the climate: (1) there is no doubt that global warming is occurring, and many changes observed since the 1950s are unparalleled over decades to millennia, and (2) recent shifts in climate have broadly affected both human and natural systems. Fossil fuel extraction, cement, forestation, and gas flaring are major components behind increasing concentrations of greenhouse gases in the atmosphere as drivers of climate change. There is, however, potential variability in terms of the contribution and interactions with global versus regional human activities.

The SSP and RCP tools are used for making projections of these emissions and they outline four distinct pathways for the 21st century concerning GHG emissions and atmospheric concentrations, air pollutants, and other land use. These four scenarios have been broadly useful for linking time, annual emissions apertures

These scenarios are instrumental in adjusting climate model projections to improve their accuracy. SSP2-45 and RCP 4.5 lie around the middle range of scenarios, where they reach a peak around mid-century and then decline thereafter. This scenario assumes that global annual greenhouse gas emissions (measured in CO₂-equivalents) will peak around 2040, followed by a decline. In this scenario, the concentration of greenhouse gases in the atmosphere stabilises by the end of the century due to a combination of technological advancements and changes in societal behaviour. For the purposes of this Report, the RCP4.5 and SSP2-45 scenario is used as a middle-range scenario for comparisons.

10.3. Mission reports

10.3.1. RA PROVINCE

Between Feb 12-15, 2024, the WWF team along with the consultants from the University of Queensland visited the Ra province to meet with local communities and government officials to understand climate impacts faced by the people in the region coupled with non-climate stressors increasing pressures on the Great Sea Reef and communities relying on it.



CLIMATE CHANGE & IMPACTS

- **The government stakeholders representing the Ra's Ministry of Maritime Affairs, Itauki Affairs, and the Ministry of Forestry** had the common opinion that rainfall patterns have changed in their lifetime, with rain events getting more intense. Such events have fundamentally impacted not just the wet but also the dry seasons and during intense rain events, they have noticed increased pollution levels and decreased water quality (sedimentation) in the lower watersheds. They attributed the decreased water quality to the increased runoff during rain events from sugarcane fields.
- On the other hand, local communities (a village head from Turaga ni Koro and a former village head) mentioned that, increasingly, there is a misalignment between the traditional timescales of planting crops and the changing rainfall patterns. Rainfall season is now going beyond March and the traditional months for Sevu. Like the government reps, even the community members conceded that increased rainfall was causing erosion of fertile topsoil, increasing sedimentation and reducing land fertility. Flooding has increased sedimentation at the end of rivers, making them shallower.
- **In the district of Navolau**, February traditionally marks the month for harvesting certain crops and presenting them to traditional and church leaders. However, residents have observed changes in seasons, particularly affecting yam (Uvi) cultivation. They note that the new species of yam takes longer to mature. **According to the district representative, "For many many years, the villagers have always planted tavioka, but due to the change in weather, they've noticed it is taking longer to mature."** Additionally, they've adapted their planting methods for tavioka due to the weather changes, including coping with heat by adding baking soda to soften the roots. Furthermore, there are concerns about animals, particularly pigs, running loose through the plantations, impacting crop growth. In the villages around Rakiraki, the primary livelihoods revolved around selling pandanus for mats, as well as coconut and sugarcane farming. Additionally, many villagers generate income from lease agreements and tourism.
- Rising temperatures causing increased wildfires, especially during the dry seasons have also been observed by the Ra province government representatives. Unattended fire burning has exacerbated the fire situation. Rising temperatures have led to higher humidity levels, resulting in more uncomfortable and restless nights due to excessive sweating.
- **Turaga ni Koro Malake** shared that "several coastal villages in the Ra province have observed significant penetration of waves inland." Not everyone knows what drives rising sea levels but risk is experienced as land is claimed by the sea and displaces communities.
- The aftermath of Tropical Cyclone Winston resulted in significant damage to the Penang Sugar Mill in Rakiraki, leading to the loss of over 500 jobs. This had a profound impact on the local economy, causing a ripple effect felt throughout the community. With farmers unable to supply cane and consequently lacking income, they faced challenges in purchasing basic necessities, exacerbating the economic strain in Rakiraki.

- There was a lack of clear perception regarding biodiversity changes attributable to climate change, although it's understood that biodiversity is closely linked with forest cover. The government as well as community participants expressed interest in conserving cloud forests due to their medicinal value, which is increasingly difficult to access. Several invasive species, such as the African tulip tree, are identified as significant challenges. Mangrove forests are experiencing poor water quality, possibly due to increased upland burning and there is an increased loss of endangered and indigenous tree species like Moli Karo dina, the fruit trees. Observations from 2023 indicate new coral reef growth but also instances of coral bleaching. There's a noted decrease in bird populations and after Tropical Cyclone Winston, greyfish heron invasion has increased. Additionally, invertebrates like Mana and Laira are no longer visible along the coasts in the mangrove ecosystems.
- Part of their strategy for villages and clans is to support each other and work together as a team to plant crops for families and work in their respective

GREAT SEA REEF (climate and non-climate threats and impacts)

- The Ministry of Maritime Affairs representative along with the ministry of Forest and Itaukei affairs mentioned adverse changes in weather patterns and seasonal variations, impacting fish abundance. Previously, spawning occurred between November and December, but it has shifted to February, with aggregations happening during this period. This alteration, coupled with weather differences, has forced fishermen to travel further into open waters for fishing, resulting in decreased catch quantities and species diversity. Fishermen now journey to distant locations like Wakaya, Lomaviti, and Yasawa. Market availability has also become a concern. An interesting development is that fishermen have diversified their fish sales, offering value-added products such as fish eggs, sea grapes, crabs, mussels and guts. There was a big shift in the livelihoods of the communities when the sea cucumber moratorium was put in place by the Ministry of Fisheries. Also, due to Fish Aggregating Devices (FAD) being deployed further out of the shoreline, greater fuel is needed.
- Water quality is being significantly affected due to poor land use planning practices, particularly in agriculture where lands extend up to river beds and coastlines. **Additionally, inadequate wastewater treatment poses a major challenge, especially in areas like Tavua and Rakiraki. Efforts are underway, including the development of master plans by WAF for waste treatment plants and the implementation of simple septic tank systems to address wastewater discharge issues.**
- The issue of waste management in the area is multifaceted and poses significant environmental challenges. One major concern is the increasing use of mangroves as dumping grounds for rubbish from both Rakiraki and Tavua towns. This lack of proper waste management extends to villages outside town boundaries, where waste is often dumped in nearby water systems or burned and buried. The dump site near Latoka, located by the coast, exacerbates the problem by releasing garbage into the sea, posing environmental risks. Rakiraki Town Council, with funding from JICA and JPRISM, works beyond town borders to raise awareness about waste management, emphasizing the importance of the 3Rs: Reduce, Reuse, and Recycle. However, national and local waste management plans often operate independently, leading to synchronization issues.
- Additionally, there is a proposal for a centralized landfill in Ra to address waste management challenges, but villages like Namuaimada struggle with garbage collection due to resource constraints and distance, resorting to dumping in mangroves or oceans. While grants from KOICA to Municipal councils support waste management initiatives, such as quarterly reports, waste audits, and awareness programs on the 3Rs, the effectiveness of waste collection outside town areas requires further evaluation, including cost-benefit analyses. Limited monitoring by the Department of Environment (DoE) complicates efforts to ensure proper waste management practices. The government's proposal for a centralized landfill in Nadi aims to improve waste collection efficiency, but a lack of environmental awareness in some villages exacerbates waste management issues, leading to improper disposal practices.
- Sand mining and aggregate extraction pose significant challenges, primarily driven by local private companies operating without proper permissions. The Ministry of Maritime Affairs representative indicated that obtaining mining permits involves mandatory consultation with the Land Ministry, Matanqalis, and Qoliqolis, who are the primary land owners. Despite regulations, extensive extraction from creeks leads to riverbank erosion and creek destruction. Moreover, concerns arise regarding mining activities encroaching into protected areas and exploiting government-owned underground resources. Stakeholders, including the **CEO of Rakiraki and Tavua Town councils, highlighted** instances of illegal sand and gravel mining occurring even after hours, particularly in waterways and seabeds. Additionally, the stakeholders mentioned that illegal

extraction in foreshore areas by local private companies exacerbates environmental degradation. There is a pressing need for enhanced enforcement and coordination with the Ministry of Waterways to address pollution concerns associated with illegal mining activities.

- Fisheries management faces significant challenges, as highlighted by stakeholders during consultations. The Ministry of Maritime Affairs provincial representative noted that fish wardens lack sufficient resources to effectively manage and monitor extensive fishing grounds, contributing to overfishing. Additionally, data from the Ministry of Fisheries is outdated, and licensed fishermen often fail to provide the required data to the ministry. To address these issues, there are ongoing fisheries management projects focusing on fishing techniques and identifying suitable areas for fishing. Furthermore, a trust has been established to manage marine areas and coral reefs; however, illegal fishing remains a concern. While a national strategy exists, there is a lack of a provincial-level strategy to address fisheries management comprehensively.
- The breakout session with the TNK -Turaga ni Koro (Village Headman), 1 District rep, 2 x Yaubula District reps and 1 former TNK, emphasized shifting mindsets towards individual responsibility rather than community reliance, recognizing diverse drivers and the need for action-oriented projects to instigate change. Engagement strategies should prioritize inclusion over mere consultation, empowering local committees and leaders to drive climate change adaptation and mitigation efforts through tangible implementation projects.

INSTITUTIONAL FRAMEWORK: GAPS, CHALLENGES AND ONGOING PROGRAMS AND PROJECTS

- **The Ministry of Maritime Affairs (Provincial Administrator) mentioned that** under the National Environment Council (NEC), Integrated Coastal Management (ICM) Committees are established. In Ra, there is a province-level ICM committee that convenes on an ad-hoc basis subject to funding availability. These provincial committees directly contribute to the National ICMs under NEC. At the district level (Tikina), ICM operates, involving department heads from provincial levels and representatives from Qoliqoli communities. However, ICM encounters challenges related to funding and staff turnover, impacting its effectiveness. Member discussions highlight concerns such as declining biodiversity attributed to pollution and gravel extraction. Additionally, Ra's ICM initiatives include efforts towards sustainable finance, such as establishing a trust fund for reef management.
- There are significant challenges related to policy mismatch and jurisdictional overlaps, as highlighted by various stakeholders. For instance, the **Ministry of Maritime Affairs and Conservation International representatives together mentioned that mangrove sites are governed by multiple ministries: the standing mangroves fall under the Ministry of Forestry, the land underneath the trees is managed by the Ministry of Land Resources, and the fish and marine life within the mangrove areas are under the jurisdiction of the Ministry of Fisheries.** Similarly, **discrepancies exist in buffer zone regulations along rivers, with some ministries advocating for a 30-meter buffer while others suggest a 10-meter buffer.** This lack of consistency reflects broader issues of capacity and coordination between national and local governments. While there is a general acknowledgement of the need to address these overlaps, limited resources and political will hinder effective resolution. Additionally, during discussions with **Rakiraki and Tavua town council members, it was noted that the jurisdiction of councils is restricted, preventing them from operating beyond their designated boundaries.** These challenges underscore the importance of enhancing coordination and clarifying responsibilities to improve governance and management of natural resources.

EXISTING SOLUTIONS

- There is a master plan for climate change adaptation⁵⁶⁷. Similarly, the Zoning Master Plan for Fiji has been completed and for the western division as well.
- UNDP, in collaboration with the government, initiate consideration of climate risk in all infrastructure projects:
 - The Pacific Risk Resilience Programme (PRRP), 2012-2018 with the United Nations Development Programme Pacific Centre (UNDP PC) as the implementing partner and the Live and Learn Environment Education (LLEE) as the responsible party.
 - The Governance for Resilient Development in the Pacific or Gov4Res Program was initiated in January 2020 with support from the Governments of Australia, New Zealand, South Korea, and Sweden.

⁵⁶⁷ <https://fijiclimatechangeportal.gov.fj/>

- The Ministry of Forestry mentioned that they are implementing the Reforestation of Degraded Forest program, aiming to plant one million trees annually at the national level. The target for Ra is 34 hectares per year, contributing to the national goal of 50 million hectares by 2050. The forestry department is in charge of monitoring and planning reforestation activities.
- The Ministry of Water Resources has initiated the development of seawalls from locally sourced materials in four villages affected by coastal inundation. However, due to inadequate planning and design, some villages are experiencing drainage issues. Overall, not much awareness exists of the impact of NbS in adapting to and mitigating climate change.
- Conservation International (CI) representative mentioned that they are collaborating with the Ministry of Fisheries on a project to plant a million corals on degraded coral reefs. CI is particularly active in the Lau province, aiming to plant 200,000 corals by 2025, with each village expected to plant 3,000 corals. CI is also leading similar projects on mangrove and forest replantation.
- The Job for Nature program, funded by the World Bank, provides grants to registered Community- Based Organizations (CBOs) to support conservation efforts regarding plant seedlings, mangroves and vetiver grass. The Ra province received the highest number of applicants for the Job4Nature program.
- Examples of locally developed solutions include:
 - Local businesses adapt to the increasing annual number of cyclones by stocking up their supplies and raw goods and cleaning up areas post-cyclone.
 - Many communities have started to build their houses on stilts.
 - In 2013, a fisheries impact assessment was conducted to evaluate viability, leading to the establishment of a Tilapia hatchery. Progress stagnated until 2019 when donor support reignited developments, focusing on milkfish, rabbitfish, Grouper acclimatization, and shrimp production, aligned with UN development goals.

10.3.2. BA PROVINCE

Between Feb 15-17, the WWF team along with the consultants from the University of Queensland visited the Ba province to meet with local communities and government officials to understand climate impacts faced by the people in the region coupled with non-climate stressors increasing pressures on the Great Sea Reef and communities relying on it.



Figure 10-3 Meeting with representatives of Marou, Naiyaca, Lewa, and Waikubukubu Villages

CLIMATE CHANGE & IMPACTS

- During consultations with the community, the Headmen (Turaga Ni Koro) of four villages (Marou, Naiyaca, Lewa, Waikubukubu) in Fiji expressed concerns about the changing climate patterns in their region. They

noted that despite being historically one of the coldest areas, temperatures have been steadily increasing annually, leading to noticeable shifts in weather phenomena. Hailstorms, once rare occurrences, have become more frequent, and wildfires are on the rise in their village surroundings. These changes are attributed not only to the gradual increase in temperature but also to the impact of developmental activities, which are altering the ecological dynamics of the region.

- The majority of residents, particularly in Waikubukubu and the surrounding villages, have traditionally relied on kava farming as a primary livelihood. However, due to rising temperatures, the village heads highlighted a gradual shift towards planting vegetables and fruits instead. Notably, mango cultivation has expanded to upland areas previously unsuitable due to colder climates. This transition reflects broader changes in agricultural practices, with declining yields of cassava and tapioca attributed to changing weather patterns. The women representatives remembered a time when the upper region of Savatu District experienced two mango seasons annually, a phenomenon now reduced to once a year or even absent in some areas.
- In recent years, the community has experienced significant disruptions to seasonal patterns, with delays in the onset of the wet season and prolonged periods of heavy rainfall. These shifts have led to an increase in the number and intensity of landslides and flash floods, particularly in lower-lying areas like Waikubukubu. Notably, the altered trajectory of cyclones, exemplified by Cyclone Winston, has prompted increased vigilance among community members. The women representatives from the four villages mentioned that the villagers now closely monitor cyclone warnings and take proactive measures to prepare for potential impacts.
- They also mentioned that these climate-related changes have profound socioeconomic implications, especially for women who often bear the brunt of household responsibilities. Decreased crop production due to weather fluctuations directly affects family income, exacerbating financial challenges for women as primary caregivers and providers. Furthermore, routine gardening and farming activities are hindered by weather-related risks, such as flooded rivers, landslides, and heavy rainfall, posing additional obstacles to livelihood sustainability and community resilience.
- There is an overflow in Sigatoka Valley whenever the Nadarivatu dam has an overflow.



Figure 10-4 Meeting with representatives of Nadi, Ba, Lautoka Town Councils, Provincial Ministries and Pine and Sugar Corporations

- Representatives from various councils in Fiji highlighted the escalating challenges posed by flooding in their respective areas. **Nadi Town Council representatives emphasized the increasing rainfall, compounded by rising sea levels causing sea water intrusion, leading to frequent flooding in the town.** A study conducted by JICA identified approximately 63 communities in need of relocation due to these factors. Similarly, **the BA Council Representative underscored flooding as a recurring issue in their town, attributing it to uncertain causes such as rainfall and sea level rise. Meanwhile, the Lautoka Town Council Officer reported notable changes in flood patterns in Lautoka town, formerly not flood-prone but now experiencing flooding even with minimal rainfall.** The inadequate capacity of flood gate pumps exacerbates the situation, necessitating urgent installation of additional pumps to manage the increased water volume effectively.

- The Fiji Sugarcane Corporation (FSC) person noted the significant changes in weather patterns, with the disappearance of distinct dry and rainy seasons that were once prevalent in the 1980s and 1990s. Climate change has directly impacted seasonal planting schedules, prompting a shift in harvesting practices from June to May to avoid adverse weather conditions. Notably, approximately 95% of the harvest comprises late maturity, resulting in a high-water content at the time of harvesting. Despite paying farmers the same amount per tonne, regardless of the quality of the harvest, this poses challenges for the industry. To diversify revenue streams and mitigate climate-related risks, FSC has implemented rotating cropping cycles, incorporating fruits and vegetables during off-periods to leverage benefits such as nitrogen fixation. Additionally, efforts are underway to genetically modify crops to withstand evolving climate conditions, particularly soil conditions and saltwater intrusion. Also, energy production is subject to weather-dependent supply variations, underscoring the impact of climate on operational sustainability. FSC has initiated waste recycling initiatives, utilizing farm waste in broiler production and electricity generation, with plans to enhance power generation for potential export opportunities.



- During a visit to coastal villages in the Ba province, representatives expressed concerns about climate change impacts and local environmental degradation. They noted rising sea levels, more frequent cyclones, and the deforestation of mangroves leading to reduced fish populations and livelihood challenges. Additionally,

observations during a boat ride off the coast of Votua village revealed unusual tide patterns and shoreline erosion caused by offshore dredging activities. Rising temperatures have further depleted traditional fishing grounds, forcing villagers to travel longer distances for catches. Cyclone Winston exacerbated the situation by destroying seawalls and increasing shoreline erosion. Despite heavy reliance on coastal resources, communities are experiencing a decline in crab abundance and reduced catches of freshwater mussels, highlighting the environmental pressures they face.



NON-CLIMATE STRESSORS and IMPACTS (Ecological degradation, development, illegal activities etc.)

- Community representatives, including headmen of villages, from Marou, Naiyaca, Lewa, and Waikubukubu villages voiced concerns regarding reforestation and plantation-related issues in the region. They highlighted how the proliferation of pine trees, exacerbated by climate change, has resulted in decreased water quality and extensive land clearing, displacing native forests. Moreover, the leasing of land by Fiji Pine for 99 years has obstructed traditional practices. The involvement of village men in pine plantation maintenance has perpetuated monoculture and the modifications (widening) of riverbed systems have further affected native species, leading to the extinction of valuable hardwoods and a notable reduction in bird species. The loss of these Avian species highlights the vulnerability of the ecosystem and the need for a thorough examination of the causes and effects.
- The expansion of pine plantations, overseen by the Ministry of Forestry, has also contributed to increased landslides, particularly near rivers exacerbating the decline of freshwater fish species, native hardwood trees, and wild fruits. Additionally, the planting of Mahogany trees has exacerbated environmental degradation, causing water to become brackish and deterring other plant growth. Forest fires, often sparked in a controlled but unmonitored manner by pine industry practices, have escalated in recent years. The presence of sugar cane fields and yaqona plantations has impacted the water quality of rivers due to run-off.
- In recent years, the community's agricultural practices have undergone several shifts. One notable change that the village headmen mentioned is the transition to alternative cash crops such as vegetables, driven by the decreasing productivity of indigenous crops. This shift has been accompanied by a decline in cattle raising productivity due to reduced grazing areas, impacting animal husbandry and leading to dietary issues. Access to markets varies among these villages, with Wailubukubu village benefiting from regular bus services, enabling more frequent trips to sell root crops and vegetables. However, other villages face limitations due to their rural location and transportation infrequency. Despite these challenges, some community members cultivate lesser-known crops, reflecting a diversification trend in agriculture. Nonetheless, overall agricultural productivity has declined compared to previous years due to factors such as increased pollution and changing agricultural practices. As a result, there is a growing recognition of the need for adaptation and sustainable practices to ensure future resilience in the face of ongoing changes.

- Additionally, there is a preference for purchasing animal protein such as chicken feed from markets rather than producing it locally, as it is a more cost-effective option. The community also faces challenges related to wildlife damage to crops, particularly from wild boars, prompting efforts to breed dogs for protection. However, since boars are a source of protein the community representatives seek a balance between crop preservation and hunting.
- Another significant trend is the migration of younger generations to urban areas for better job opportunities, resulting in a noticeable generational gap in agricultural activities.
- The village headmen mentioned that private companies are extending offers to villages for gravel extraction, providing compensation in return. While some villages have accepted these offers, others are becoming increasingly aware of the detrimental impacts on their lands and rivers. Licenses for gravel extraction near riverbeds are expanding, raising concerns about environmental consequences. Additionally, the Ministry of Agriculture is involved in constructing farm roads further enabling gravel extraction activities.
- The villages practice waste management by burying garbage and utilizing septic tanks for sewage disposal to address potential environmental concerns. **While the village heads initially perceived no issue of waste pollution reaching rivers from their villages, they did recognise the importance of collective land management.**
- **GEDSI** - During the meeting, 9 women leaders from the 4 villages were in attendance, highlighting the representation of women in village committees. Women have showcased leadership capabilities during disasters and community gatherings. At the family level, they bear caregiving responsibilities for marginalized members, with this responsibility shared and accepted by both genders. However, widows and single mothers often carry a heavier burden, despite family support. Women's participation in community affairs is valued, and they actively contribute to household activities, though participation rates vary depending on individual family dynamics and support systems.
- Across all 8 villages, the community exhibits greater familiarity with freshwater species compared to marine life.



- In Nadi, the town council representative mentioned that solid waste management poses significant challenges, with limited public awareness about the 3Rs (Reuse, Reduce, Recycle). There are jurisdictional overlaps concerning drainage management, with different entities responsible for waterways upstream, drainage along roads, and within the town itself. Waterways upstream are overseen by the Ministry of Water, drainage along roads falls under the jurisdiction of the Fiji Road Authority, and within the town, management is handled by the Town Council. A solid waste management plan, supported by JICA and led by the Ministry of Local Development and support from MoE, is currently in progress to address these issues. Scheduled for release in 2024, the plan aims to identify illegal dump sites and coordinate efforts across ministries.

- Despite these initiatives, recycling and waste management remain limited, compounded by a lack of education and cultural barriers to recycling. The pollution from rubbish leakage into wells further exacerbates groundwater contamination. In rural areas, burn and bury practices are common due to inadequate waste collection, although JICA is involved in addressing this issue. Master plans are being developed to tackle illegal dumping and enhance coordination across sectors.
- Meanwhile, the Lautoka Town Council representative mentioned their Clean School Program which is in its 14th year involving 37 schools, although enforcement is lacking. Inadequate underground drainage in both Lautoka and Nadi points to shortcomings in city infrastructure planning. Regarding environmental regulations, the Department of Environment operates under the 2005 Environmental Management Act (EMA) and Environmental Impact Assessment (EIA) process regulations. Waste Management regulations cover commercial and industrial sectors, while liquid waste management is overseen by the Water Authority of Fiji. Challenges persist, such as black discharge from Fiji Sugar Corporation (FSC) mills and ageing wastewater systems, prompting initiatives like JICA's wastewater system for the entire division. These efforts aim to address environmental concerns and enhance waste management practices across various sectors and jurisdictions.
- In both Nadi and Lautoka, town planning faces significant challenges. Ageing infrastructure in densely populated areas urgently requires attention, particularly concerning water management. While some efforts, like the construction of seawalls and pumping stations, have been made, they have not proven entirely effective in facilitating river discharge. Additionally, addressing the issue of illegal dumping necessitates enhancing garbage collection services. There is also a pressing need to raise awareness about the importance of living shorelines, especially at higher jurisdictional levels. Solutions such as the planting of Vetiver grass, drainage improvement, and reforestation in non-populated areas are currently lacking. The buffer zones designated for town planning purposes are currently set at 6 meters, with the possibility of alteration to accommodate development projects. These regulations were last revised in 1972. However, there is a growing trend of environmental awareness across various local jurisdictions, including crown lands, customary lands, and leasehold lands.
- According to representatives from the Nadi Town Council, ongoing approvals for mining activities, including sand mining operations along rivers and creeks, some located in Sabeto, Navua, and Namosi, are of concern. These operations have prompted communities in these areas to take ownership and report instances of illegal mining. The Director from the Ministry of Lands and Mineral Resources provided insight into ongoing legislative processes, stating that the Lands Act is currently undergoing a review process. Additionally, it was noted that the Mining Act, now in its 11th draft, has been presented to Parliament twice for consideration. The Director also emphasized collaborative efforts with the Department of Environment in monitoring river and gravel extraction activities to ensure adherence to regulations and environmental standards.
- The representative from the Fiji Sugar Cane Corporation (FSC) said that in terms of compliance with fair trade for sugar cane sustainability, the Fiji Sugarcane Corporation (FSC) operates through three Cane Producer Associations, with each farm falling under one of these associations. Additional premiums are paid for fair trade, benefiting farmers and aiding in farm improvement. Fair trade audits are conducted biennially to ensure compliance, with the scheme first implemented in 2008, yielding beneficial outcomes for both farms and mills. Certificates are suspended for non-compliance until issues are rectified. Expiring leases pose a significant issue for the industry.
- Chemical usage is regulated and approved by Fair Trade, with no banned substances employed. FSC tests the sugar cane itself for heavy metals. Effluent discharge is monitored through daily in-house samples for abnormalities, with monthly samples sent to the Water Authority of Fiji (WAF) for analysis. The Department of Environment notifies FSC of any issues, and waste disposal permits are issued for three years with conditions, with fines imposed for breaches. The Fiji Sugarcane Corporation (FSC) representative highlighted the company's waste management practices, emphasizing the utilization of by-products to reduce environmental impact. Specifically, molasses, a residue from sugar production, is sold for rum manufacturing, while another by-product, a fertilizer derived from the remnants of cane after molasses extraction, contributes to a sustainable cycle within the industry.
- The FSC representative noted that while air pollution was previously a concern, significant efforts have been made to address and manage it effectively. In Labasa alone, the company invested \$1.5 million in testing and managing air pollution. Furthermore, FSC conducts independent analyses for each mill, allocating approximately \$20,000 per mill, to ensure ongoing monitoring and mitigation of air pollution impacts.

- Also, the FSC representatives mentioned that transportation costs pose a significant challenge for farmers due to financial constraints, resulting in a preference for low-cost options. Moreover, the Pacific Labor Scheme, which sends male workers overseas, exacerbates labour shortages in the agricultural sector. As a consequence, women are compelled to take on additional harvesting responsibilities alongside their existing roles, further straining their workload and potentially impacting productivity.
- The Fiji Pine Limited representative highlighted their annual forest audits, documenting any degradation in high conservation areas, and their adherence to specific logging practices. These practices include avoiding forestation in high-risk areas with slopes greater than 35-40 degrees, maintaining a 10-meter buffer from dry and active streams, and harvesting outside sites only during dry seasons. They also mentioned efforts to restore harvested areas with vetiver grass and collaborate with environmental agencies in a similar manner to the FSC for water quality testing. Additionally, the company has begun assessing communities and land parcels vulnerable to climate change, collaborating with them to set up cones and signage within leases. However, they face challenges with unsatisfied landowners experiencing late lease payments or dissatisfaction with bonuses, sometimes resulting in retaliatory actions such as burning forests, particularly detrimental to young forests. Other challenges include landowners introducing cattle grazing and bee farming within lease areas, which can damage young forests and increase costs. Labour retention is another concern, as they lose young labourers after providing training, who then migrate to New Zealand. They also noted low female participation despite efforts to involve them. Furthermore, the company mentioned surrendering 99-year leases prematurely due to mining activities, which hampers their ability to maintain forested areas.
- However, the Nadi and Lautoka Town Council representatives did mention the land transformation issues arising from sedimentation accumulation and the presence of chemicals from sugarcane cultivation, compounded by the use of unregulated pesticides. Increased pollution coming from factories and industries due to lack of enforcement of regulations and lack of monitoring. Dredging rivers, while often considered a solution, may not be the most effective approach due to rapid sedimentation buildup, as noted by the ineffectiveness of dredging in Nadi. Widening rivers to enhance water discharge poses its own set of challenges, particularly regarding the relocation of entire villages, including houses and industries. Such relocations entail complex socioeconomic consequences and connectivity issues with other areas.

GREAT SEA REEF

- Several concerning issues related to fisheries and coastal management were highlighted during the discussion. Firstly, it was noted by the NTC representative that overfishing is rampant due to a lack of monitoring and enforcement, compounded by jurisdictional complexities. The Commissioner of the Western Province said that he issues around 300-400 numbers of fishing licenses monthly, further raising concerns about the sustainability of the reefs. Furthermore, fishermen's practices have evolved, with nets now being used around reefs despite regulations on their size. The indiscriminate disposal of nets and plastic waste by fishing companies further contributes to marine pollution. Notably, the monitoring of fish stocks by town councils is limited to markets within urban areas, leaving vast coastal regions unchecked.
- Additionally, the failure to maintain the mandated 15-meter buffer zone along the coast exacerbates environmental degradation. There are ongoing foreshore developments, leading to changes in coastlines and mangrove habitat destruction. **Anecdotal evidence from a Nadi Town Council representative revealed alarming changes in the coastal landscape, attributing the shift from sandy to muddy shores to sedimentation from river activities.** This sedimentation has also led to increased seaweed proliferation. Councils have jurisdiction only within their boundaries to address reforestation on degraded lands. However, the primary challenge lies upstream, where significant sedimentation occurs, adversely affecting coastal towns like Nadi. Councils are being granted authority to regulate development across districts, albeit with certain limitations such as land reserves, village reserves, and unalienated lands.
- Moreover, blasting activities at tourism sites for infrastructure development pose threats to coastal ecosystems. Lastly, while ecotourism thrives in the Yasawa Islands, its potential remains largely untapped elsewhere.

INSTITUTIONAL FRAMEWORK: GAPS, CHALLENGES AND ONGOING PROGRAMS AND PROJECTS

- There exists a lack of harmonization in climate change projects in Fiji, with efforts underway to consolidate plans into three main frameworks: the Local Government Masterplan, Marine Masterplan, and National Development Plan, with considerations for integrating sewage and waste management. **Additionally,**

overlapping responsibilities between urban development, river dredging, upstream retention, and the Ministry of Waterways pose challenges, exacerbated by outdated laws that fail to address climate change issues, as noted by the representative from the Ministry of Lands and Mineral Resources.

- The Ministry of iTaukei Affairs said that village development plans and Provincial Natural Resource Management Plans both are undergoing a review, with upcoming civil society meetings and mapping exercises to ensure comprehensive review and updates from the communities.
- In terms of development applications, the Department of Environment representative emphasized the need for permits, particularly for activities involving channel excavation and mangrove habitat considerations, which enforce stringent compliance conditions upon Environmental Impact Assessment approval. Although resource constraints hinder effective monitoring efforts, as highlighted by staffing limitations in the Western division.
- The participants mentioned that there are existing legal instruments, such as the Land Use Act and Rivers and Streams Act but highlighted the absence of a comprehensive National Land Use Plan. Discussions are ongoing regarding zoning in the five divisions, with participatory land-use planning integrating traditional knowledge, although challenges persist with overlapping legislation and limited community involvement.
- The Aquaculture Bill was shelved a few years ago and Land and Water Resource Management (LAWRM) Bill 2014 is going to be shelved soon. On the other side, the National Fisheries Policy and Sea Cucumber Management Plan are awaiting approval and implementation.

EXISTING SOLUTIONS

- Across the 8 villages, including Marou, Naiyaca, Lewa, and Waikubukubu, collective action for reforestation and farming, supported by the Ministry of Agriculture, is underway. **The village heads mentioned that Communities are employing sustainable practices like "Solesole vaki," a traditional collaborative approach involving local youth groups in tree replanting efforts.** They seek assistance in reintroducing native species and removing invasive ones to rewild their lands. Additionally, the villagers called for additional government intervention to restore native species and manage pests, with current pesticide bans lacking alternative solutions.
- Previously, an NGO partnered with them to install water purification tanks to address water quality issues arising from plantations.
- A comprehensive environmental impact assessment is deemed essential, alongside raising awareness about the potential complications arising from such development activities.
- The representative from the Lautoka Town Council highlighted a project funded by Australia Aid called Flood Elevation Management, led by the Ministry of Finance, with Kamal Gounder- head of strategic planning, overseeing strategic planning for the initiative. This project aims to reduce the impact of floods in Nadi and is detailed on the Australia Aid website. Additionally, support from Japan Aid and New Zealand Aid has been enlisted for this flood alleviation effort, focusing primarily on waterway bodies, especially in Nadi. Concurrently, a feasibility study addressing sewage problems has been initiated by the Water Authority of Fiji (WAF), since they manage the water quality through specific.
- The representative from the Ministry of iTaukei Affairs highlighted various initiatives aimed at community involvement and sustainable development. They mentioned the Jobs for Nature Program by the World Bank, which engages iTaukei communities in projects such as riverbank stabilization and coastal replanting, with a focus on women's and youth groups. Additionally, they discussed the establishment of Yaubula committees at different levels to address environmental concerns. Furthermore, they mentioned ongoing efforts to review village development plans and draft provincial natural resource management plans, emphasizing the importance of FPIC awareness in development processes.
- The representative from the Ministry of Rural Development shared updates on specific projects in Nabuna and Vanuakula focused on climate change adaptation and income generation to enhance community resilience.
- The representative from the Ministry of Agriculture's Lands Department discussed capital projects related to sustainable land management and climate-smart agriculture. They highlighted practices such as climate-smart agriculture and on-farm conservation using vetiver, emphasizing the involvement of women and youth in agriculture.
- Lastly, the representative from the Ministry of Fisheries outlined various community-based initiatives, including mangrove oyster farming in Waikona, mabe pearl farming along the Nakorotubu coast, and coral

planting projects led by organizations like the Mamanuca Environment Society and Reef Explorer Fiji. These efforts aim to promote sustainable fisheries and environmental conservation while also supporting local livelihoods.

10.3.3. MACUATA PROVINCE

CLIMATE CHANGE & IMPACTS

- During a recent field trip, representatives from the Ministry of Local Government in Macuata noted a noticeable increase in rainfall, leading to more frequent and severe flooding events. This rise in water levels is believed to be linked to sea level rise, exacerbating the vulnerability of coastal communities. Moreover, rising temperatures have been observed, contributing to heightened humidity levels, particularly during seasons traditionally associated with cooler weather. Labasa, in particular, has experienced a surge in flooding, sea level rise, and drought events, indicating the escalating impact of climate change on the area. Some villages in Bua had to relocate due to coastal flooding. A survey was conducted on the relocation of the villages. Nabavatu village in Driketi was one such village relocated.



- The ministry of agriculture and the ministry of public works representatives also mentioned the increase in longer spells of dry season leading to catchments drying up and causing droughts. The community leader of the Sasa village mentioned that fires are on the rise, often sparked by human activity and exacerbated by increasingly severe dry seasons. **The community representatives from Sasa village highlighted several climate-related impacts they have observed.** These include an increase in sedimentation in rivers, recent landslides due to heavy rainfall, reduced water quality for consumption caused by sedimentation during rains, more frequent flooding incidents compared to the past, and unseasoned rainfall patterns affecting local climate and agriculture. The hills previously used for goat grazing have been cleared of goats due to concerns about their impact on water quality.
- They also expressed concerns about the aftermath of Tropical Cyclones "Yasa" and "Winston," noting significant damage to coral reefs caused by overturned rocks and reduced fishing livelihoods during low tides. Additionally, the community is worried about coastal inundation and riparian flooding, seeking better drainage solutions to address these challenges.

NON-CLIMATE STRESSORS and IMPACTS (Ecological degradation, development, illegal activities etc.)

- Furthermore, the field trip revealed shifts in coral species composition along the coastlines.** Participants noted an increase in fire coral, suggesting possible changes in local marine ecosystems. Additionally, signs of coral bleaching were observed in brain coral, indicative of environmental stressors affecting reef health.

- The Ministry of Public Works representative highlighted the significant challenge of effectively monitoring reef ecosystems, citing logistical complexities in managing such vast marine areas compared to terrestrial regions. Additionally, concerns were voiced regarding the disparity in resources between law enforcement agencies and illegal fishers, with unauthorized fishing vessels often possessing higher horsepower than available police vessels. This resource gap contributes to difficulties in enforcing regulations and monitoring changes in marine environments. This was also mentioned by the Sasa village community representatives, that they need additional tools to manage the fishing ground better.
- Furthermore, stakeholders expressed concerns about the lack of enforcement from the fisheries department regarding poaching and night fishing activities. It was suggested that obtaining a fishing license should require passing a test to demonstrate an understanding of fishing rules and sustainable practices. Currently, there are no restrictions on obtaining fishing licenses, potentially leading to overexploitation of marine resources.
- The community representatives from SAsA village mentioned that illegal fishing, often involving fishers from other provinces and even neighbouring countries, is prevalent in the area, contributing to the depletion of resources. Night fishing has become a common practice, further complicating efforts to regulate fishing activities. Additionally, fishers frequently change their fishing locations, making it increasingly challenging to predict fish habitats. The diversity and abundance of fish have decreased and the spawning/ maturity times have changed over the years.
- As mentioned by the youth and women representatives of the Sasa village, the community heavily relies on the sea for sustenance and income. Women are actively involved in fishing and collecting various marine resources such as sea grapes, sea urchins, octopus, and sweet clams (kaikoso). Additionally, they utilize coconut trees for making brooms and traditional fans from coconut leaves, while coconuts are sold in the Labasa market, and coconut oil is produced for personal use.
- Men contribute to livelihood by engaging in sea fishing and selling most of the catch. Additionally, there is a notable shift in livelihoods from fishing to agriculture due to declining fish stocks, prompting communities to clear forests for agricultural purposes. Men are involved in cultivating root crops like cassava and sweet potatoes for personal consumption. It was noted that sea cucumbers, once a significant income source, have faced a decline due to regulations from the Fishery Department. Taro and other crops are becoming less productive. As a result, farmers are shifting towards planting more yams and cassava.
- During discussions with the representative from the Macuata Ministry of Local Government, concerns were raised regarding the functionality of water committees within communities. The representative noted that while water committees are being established, many are formed merely for compliance purposes without effective management practices in place. It was highlighted that only 20% of these committees are functioning adequately, while the remaining 80% face challenges in fulfilling their responsibilities.
- **Moreover, tensions between rival communities over resource management further compound the issue.** An example provided was the situation in the Bua catchment area, where a water purification project near the reservoir faced complications due to a land dispute. Despite the project's inauguration by the commissioner, neighbouring communities claimed ownership of the land, leading to disputes over access to the purified water. These conflicts underscore the need for improved governance mechanisms and conflict resolution strategies to ensure equitable access to essential resources and effective community management of water projects.
- **During discussions on forestry and plantation issues, several concerns were raised.** The ministry of forestry representative said that areas where pine and mahogany plantations are established often experience water contamination, both in nearby water bodies and downstream. Notably, Bua has a significant pine plantation, with seeds supplied by the Ministry of Forestry. Illegal logging exacerbates the problem when landowners engage directly with private companies, leading to deforestation. Sugarcane plantations are also facing challenges due to changing climate patterns, affecting planting and harvesting times.
- Sugarcane burning, a common practice, contributes to wildfires, impacting both air and water quality. Despite being a major source of pollution in rivers, there is inadequate monitoring and enforcement for prosecution. The impacts of sugarcane burning extend beyond environmental degradation, potentially affecting bee populations and agricultural productivity. Ash from burning sugarcane settles on reefs, further compromising marine ecosystems.
- The youth and women representatives of the Sasa community expressed concerns over the spread of pine shoots from non-leased areas, posing competition with native species and leading to regret over allowing widespread seeding. They highlighted the dominance of sugarcane cultivation in leased lands, with associated

fertilizer and weedicides causing river eutrophication during heavy rains. Additionally, they noted the common practice of field burning before harvest, resulting in frequent forest fires in nearby villages.



EXISTING SOLUTIONS

Implementing a climate-smart agriculture initiative in Nayarabale village, covering 350 hectares for reforestation, including pine, mahogany, and crop cultivation, as mentioned by the Ministry of Forestry representative.

- Advocating for the "Jobs for Nature" program supported by the World Bank, highlighted by the Ministry of Local Government representative. This program involves community-led tree planting initiatives, including both native and exotic species, in various locations such as grasslands and hills, aiming to benefit local communities.
- Promoting governmental and community-led programs for mangrove replanting, focusing on both upstream and downstream river sections. However, it was noted that mangrove restoration efforts are facing challenges, with many projects experiencing slow progress and failures.
- Enforcing policies on minimum distances for building around rivers and watercourses, including a 20-meter buffer of native vegetation. Additionally, establishing protected areas along main waterways affected by activities such as logging, mining, and plantation agriculture, with the aim of enhancing fishing opportunities and protecting vital ecosystems.
- Various community groups in Sasa Village, including women's, men's, youth, and a wellness committee, play crucial roles in addressing village needs and ensuring well-being. The wellness committee focuses on village health and sanitation, identifying and addressing issues such as inadequate toilets. A recent survey revealed nine households lacking proper facilities, with seven upgrading to washable toilets with septic tanks by February.

Additionally, the committee oversees village cleanliness initiatives, organizing monthly clean-ups involving village youth. The committee's efforts extend to environmental conservation, with a recycling program in operation. Plastic waste is sorted and sold, while the remainder is disposed of through burial or burning.

- **The Sasa villagers have opted against replanting on hills but have initiated a mangrove restoration project.** Led by the youth, these locally managed areas (LMA) focus on mangrove afforestation to protect the shoreline. Seedlings are cultivated in a nursery before being transplanted to various sites, aiming to enhance coastal resilience.

10.3.4. BUA PROVINCE

CLIMATE CHANGE & IMPACTS

- **The women from the Tavulomo village reported several climate-related challenges.** They observed that higher heat intensity has made cassava harder in texture, and the size of fish has decreased, requiring fishers to travel longer distances. Increased erosion from the sea and changes in the availability of underground water for consumption were also noted. Women perceive an increase in temperature and find cyclones to be significant disruptions, destroying crops, reducing fish populations, and altering livelihoods. Some waterways have disappeared due to cyclones, and during disasters like Cyclone Winston, women are at the forefront, supporting the community, especially children and the vulnerable, and sheltering them in safe places. Taro is getting smaller in coastal areas due to increased salinity, and high rainfall, floods, and cyclones lead to low food crop production, increasing the care burden at home. Women now take on more responsibilities to manage their families and adjust to weather patterns. The low production of food crops results in a lack of balanced meals, leading to health issues, and the changes in weather patterns put additional stress on women, affecting their mental health. Additionally, the dry season impacts Pandanus trees (Voivoi) used for making mats, causing them to mature earlier with shorter leaves. Despite these challenges, future relocation is not considered an option, as they feel deeply connected to their land, sea, and surroundings.



- **The men in the community highlighted different climate-related impacts.** After Cyclone Yasa, they experienced a drought and spent a year surviving on rice and flour due to the inability to grow crops and the overturning of fishing spots. They noted that houses at the bottom of the hill face flooding, while those on the hill do not. Increased rainfall is seen positively as it helps refill boreholes for drinking water. However, tidal inundation occurs during high tides and heavy rain. Rapid changes between rain and dry periods have spoiled crops, including taro, cassava, and yams, which are grown for subsistence. Although they have not noticed a significant change due to their small-scale farming, they stopped planting rice due to the frequent flooding and the closure of the local rice mill. Additional issues include fish poisoning, algae in the lagoon affecting boat engines, freshwater mussels experiencing changes, and freshwater prawns leaping out of the water on hotter days. There have also been instances of fish kills along the coastline and increased cases of leptospirosis, exacerbated by cattle grazing near the village and the adjacent river.
- **A representative from the Ministry of Infrastructure and Metrology Services (MoIMS)** reported that unseasonal weather patterns are shifting from the usual seasonal patterns, and humidity levels have been drastically increasing over the years, according to data gathered in the weather office in Bua. Additionally, long durations of high heat have led to forest burning.

NON-CLIMATE STRESSORS and IMPACTS (Ecological degradation, development, illegal activities etc.)

The community members from Tavulomo village mentioned several non-climate stressors:

- Impacts from land activities are affecting areas of the sea not located in the Great Sea Reef, which has historically suffered from degradation. The community believes that solutions should not solely focus on climate change adaptation but also require proper monitoring.
- **Increased fires, mainly originating from pine plantations, are a significant concern.** Other planted trees such as mahogany, eucalyptus, and Casuarina exist on a smaller scale, but eucalypts are particularly expanding. Logging of native forests occurs for housing and other needs, but only under certain conditions such as building houses or feeding their children, and with a requirement to replant. The Ministry of Forestry provides seedlings for replanting, with native seedlings doing well after the second round of replanting and pines after the first. The historic deforestation of native trees has decreased biodiversity and resulted in the loss of native species, prompting the community's interest in restoring native forests. Exotic trees, especially pines from nearby plantations, and invasive trees like raintree, eucalypt, and African tulip are expanding, with eucalypts perceived as the primary trees initiating fires. Logs from various trees block the estuary and damage boats during flooding.
- Coastal communities rely on the shoreline for fishing and crab catching, with intermediaries buying the fish to sell in local markets. The main methods of fishing in the village include net fishing, hand lines, and diving, targeting species such as Kabatia (Emperor) and Kanace (mullet). The community has noticed changes in fish aggregation patterns, with fewer and smaller fish. They use
- nets, spears, and lines for fishing and have seen a decline in sea cucumbers. They typically fish in the same spots and have issues with licensed fishermen encroaching on their grounds and poachers using advanced techniques at night. Despite having trained fish wardens, the program lacks resources and is unsuccessful. They have a tabu area established in 2019, but communication issues exist regarding its objectives and boundaries. Men often fish, attend community meetings, and participate in development activities, while women collect crabs, fish close to shore, garden, and care for children. Women sell fish to retailers who pay them after sales and make crafts for local markets, but they lack licenses to sell internationally.
- The community perceives that the use of agrochemicals in nearby areas negatively affects plants along local shores and rivers. Invasive raintrees along waterways erode riverbanks and increase sedimentation.

Representatives from the Ministry of Infrastructure and Metrology Services (MoIMS), the Ministry of Fishery (MoF), the provincial council, and the conservation office highlighted several critical issues:

- Poaching in the Bua coastal waters is an ongoing problem, with enforcement teams conducting land patrols and monitoring activities around Yadua Island. Coastal poaching, particularly the illegal sale of sea cucumbers, persists despite regulations. The Fishery Act of 1942 needs to be reviewed for increased effectiveness. Additionally, there are concerns about the use of chemicals, such as chlorine, to catch prawns in large quantities, which has been noted and confronted in some villages.
- Mangrove destruction is a significant concern due to Fiji Pine chips killing mangroves and the lack of legislation prohibiting mangrove destruction or cutting for firewood. Mangrove reforestation is seen as a necessary but short-term solution. Logging is common, and the lack of harsher penalties leads to continued exploitation of these resources.
- Poor drainage in the town centre, coupled with high rainfall, results in flooding at the Nabowalu Jetty. Bauxite mining, which has been ongoing for 20 years, is another issue, as sediments from the mining activities end up in water bodies during rain, further impacting the environment.

EXISTING SOLUTIONS

Representatives from the Ministry of Infrastructure and Metrology Services (MoIMS), the Ministry of Fishery (MoF), the provincial council, and the conservation office reported several ongoing and planned initiatives in the Bua Province.

- They highlighted a mangrove restoration project sponsored by the World Bank, which is currently being implemented in a few villages. Additionally, they mentioned the "Vativa" planting initiative along riverbanks to prevent erosion.
- Waste management is being addressed through training, planning, and the installation of incinerators, moving away from sea dumping. This project involves registered local groups, such as women's and youth groups, and aims to diversify approaches by incorporating faith-based projects.

- Fruiting trees and native tree seedlings are being distributed to local groups for planting, fostering reforestation and local food security. Traditional protected areas, or "tabus," are established through collaboration between the "vanua" (local communities) and the Ministry of Fishery to identify and preserve critical sites.
- The 4FJ campaign promotes sustainable fishing practices by providing communities with a fish-smart toolkit that ensures the capture of fish at the required sizes. However, the success of these initiatives relies heavily on community diligence, with awareness raised during district meetings and training sessions on sustainable farming practices.
- The representatives emphasized the need for a change in mindset and increased awareness about climate change, advocating for its incorporation into the school curriculum to educate future generations about its impacts and mitigation strategies.
- The Bua Yaubula Management Support Team (BYMST), established under the Bua Provincial Office, comprises representatives from nine districts. It is primarily managed by traditional leaders or elected members who convene to discuss matters concerning the management, development, and protection of the environment, encompassing land, rivers, oceans, and the local community's customs and traditions.
- The main livelihood projects supported by BYMST include revenue from pine plantations, sales of copra, kava, and taro, as well as fishing activities targeting finfish and invertebrates such as crabs. Additionally, community members benefit from salaried positions within government offices in Nabouwalu and other districts, selling food parcels at the wharf, and employment with small-scale companies in the province, fulfilling roles such as drivers and runners.

Community members highlighted various collaborative efforts with government stakeholders and external organizations.

- **They mentioned overlaps in collaboration, noting the Wildlife Conservation Society (WCS) programs on the Ecosystem-Based Plan.** WCS has initiated a groundwater well project to provide cleaner water, replacing the previously used river water, which had become increasingly contaminated. In conjunction with the Fijian Government, WCS is expanding its programs, including a forthcoming mangrove restoration project and initiatives under the 30 by 30 conservation plan.
- The villagers have taken proactive steps by planting more root crops and vegetables that thrive in waterlogged and swampy areas to ensure food security during extended dry seasons. They have established tabu areas in both freshwater and marine environments, as well as in certain forested areas. Villagers have also undertaken reforestation efforts, establishing nurseries for seedlings including native species like vesi, savai, dakua, and damanu, with support from WCS. Additionally, village women have submitted a proposal to the National Project on Jobs4Nature for a Waste Management Project.



The community also discussed a project with the Water Authority of Fiji (WAF) to connect a drinking water supply to the village, which is currently under construction. The Water Project for villages in the districts of Wairiki, Lekutu, Dama, Navakasiga, Bua, and Nadi along the highway is currently undergoing scoping by the government through the Water Authority of Fiji (WAF). This initiative is critically prioritized by the Provincial Office and relevant stakeholders

in Bua Province to restore water sources for the identified priority villages. The WISH Fiji project has improved the sanitation infrastructure within the village.

- Women in the community play active roles, taking on responsibilities such as caring for vulnerable people, managing households, and participating in community development projects. They organize and prepare meals for visitors and community meetings and support men in various projects. While women actively participate in community meetings, they often observe as men lead the conversations and make decisions. Despite having women representatives in village committees, decision-making remains predominantly patriarchal.

10.4. Background and history of the CRRI

Fiji has extensive marine and coastal resources, including coral reef ecosystems, mangroves, cultural heritage, food production, fisheries, livelihood, and people. Fiji, however, is facing major challenges from climate change and non-climate change pressures which threaten to overwhelm Fiji's resources in the next few decades. To do so, Fiji needs to solve the many problems that threaten its coral reefs and other vital coastal ecosystems.



Figure 10-5 Locations of nations that represent the Coral Reef Rescue Initiative and 70% of least- exposed coral reefs on Earth.

The outcome of the selection of BCU is detailed in Beyer et al. (2018)⁵⁶⁸ and Hoegh-Guldberg et. al. (2018)⁵⁶⁹. In 2018, The University of Queensland, supported by Bloomberg Foundation Philanthropies, assembled a team of 20 international coral reef experts to develop a risk- sensitive planning framework. This initiative was aimed at identifying and protecting reefs experiencing lower rates of exposure to climate change than the global average. This collaborative effort led to the identification of 50 coral reef areas, referred to as 'Bioclimatic Units' or BCUs, which have had relatively lower exposure to climate change. These BCUs provide a 'head start' in aiding coastal communities. The team evaluated the relative risk and value of different coral reef sites (minimum size of at least 500 by 500 km²) based on this lower exposure, vulnerability, and conservation potential. The '50 reef strategy' was formulated, which involves identifying and protecting less exposed yet well-connected coral reefs (in developing countries) from local factors. This strategy aims to build the strategic resilience of tropical coastal ecosystems and communities to climate change by identifying and reducing local-scale pressures in the short term. In the long term, planned protection of coral reefs in less exposed BCUs (with high regenerative capacity and connectivity) is expected to help 'nurture' impacted reefs until global conditions stabilise once again. The outcome of the selection of BCU is detailed in Beyer et al. (2018)⁵⁷⁰ and Hoegh-Guldberg et. al. (2018)⁵⁷¹.

The World Wildlife Fund (WWF), the University of Queensland, and partners responded by building the Coral Reef Rescue Initiative (CRRI) to protect and restore coral reefs that are less exposed to climate change than the global average. Notably, coral reefs in just seven nations (i.e., Fiji, Solomon Islands, Indonesia, the Philippines, Cuba, Tanzania, and Madagascar) represent almost 70% of coral reefs that had relatively lower levels of exposure to climate

⁵⁶⁸ https://www.researchgate.net/publication/326034705_Risk-sensitive_planning_for_conserving_coral_reefs_under_rapid_climate_change

⁵⁶⁹ <https://www.sciencedirect.com/science/article/pii/S016953471830226X>

⁵⁷⁰ https://www.researchgate.net/publication/326034705_Risk-sensitive_planning_for_conserving_coral_reefs_under_rapid_climate_change

⁵⁷¹ <https://www.sciencedirect.com/science/article/pii/S016953471830226X>

change (Beyer et al., 2018⁵⁷²; Hoegh- Guldberg et al., 2018b)⁵⁷³. These differences are a function of varying oceanographic processes such as currents and up-welling areas (e.g., enhancing mixing and/or bringing cooler water to the surface; (De Falco, Bracco and Pasquero, 2021)⁵⁷⁴. While not permanent in the longer term (van Hooideonk, Maynard and Planes, 2013)⁵⁷⁵, these differences have important intermediate roles in the future of coral reefs, as they can act as regeneration sites or refugia once the global climate stabilises. As demonstrated by the recovery of reefs following non-climate change impacts such as storms, reefs can recover functionally over 15-20 years. They can only do so, however, if they are protected from non-climate change threats such as declining water quality, overfishing, and unsustainable coastal development.

10.4.1. Fiji's coastal and marine challenge.

Fiji is at high risk from climate change and consists of 332 high (i.e., continental islands) and low islands (i.e., associated with atolls) which makes it particularly susceptible to sea level rise, large storms and flooding. In addition, the ocean threatens to inundate coastal areas and increase wave surge and saltwater intrusion along Fiji's extensive coastal areas. In addition, Fiji's economy relies heavily on climate-sensitive sectors such as agriculture, fisheries, and tourism, which are vulnerable to changes in temperature, precipitation patterns, and extreme weather events⁵⁷⁶. Fiji, along with other small island nations, is particularly vulnerable to the impacts of climate change and has been actively involved in global efforts to mitigate and adapt to these impacts. As a result, Fiji is a strong advocate of climate action and other factors and was among the first countries to sign the United Nations Framework Convention on Climate Change (UNFCCC) on June 12, 1992, at the Earth Summit in Rio de Janeiro, Brazil. Fiji has since been actively involved in international climate change negotiations and played a leadership role in the Paris Agreement negotiations in 2015. Fiji's presidency of the 23rd Conference of the Parties (COP23) to the UNFCCC in 2017 also highlighted the need for global action on climate change, particularly for vulnerable SIDs like Fiji. Fiji has been actively involved in international climate change negotiations and played a significant role in the Paris Agreement negotiations in 2015. Fiji was the first country in the world to formally approve the UN climate deal agreed by 195 nations in Paris in December 2015. The impacts of climate change are already being felt in Fiji, with increased frequency and severity of tropical storms, regional droughts, and floods causing widespread damage to infrastructure, property, people, and food production. Tropical Cyclone Winston, for example, in 2016, was one of the strongest cyclones ever recorded in the Southern Hemisphere⁵⁷⁷ and caused extensive damage and displacement, particularly in rural and remote areas.⁵⁷⁸ The impacts of climate change also threaten Fiji's cultural heritage, which is deeply tied to the natural environment and traditional practices⁵⁷⁹ ⁵⁸⁰. Poverty and inequality in Fiji, have further exacerbated the impacts of climate change. The country has a high poverty rate, with around one-third of the population living below the poverty line. Poverty limits access to resources and services essential for adapting to climate change, such as maintaining food, clean water, sanitation, and healthcare.

Marginalised communities, such as many indigenous peoples (i.e., their women and children), are particularly vulnerable to climate change impacts due to their reliance on natural resources and their limited access to decision-making⁵⁸¹.

10.4.2. Fiji's CRR coral reefs, and the Great Sea Reef (Cakaulevu)

Coral reefs in Fiji are extensive and cover nearly 12,000 square kilometres in Fiji and are home to over 1,500 fish species and 390 species of coral. Coral reefs cover more than 6,700 km², while another source indicates that the coral reefs around Fiji cover 3,800 square miles (approximately 9,842 km²). The crowning masterpiece of Fijian reefs is the Great Sea Reef (GSR or Cakaulevu) which provides for well over half of Fiji's fish and corals. Analyses suggest that hard coral cover has been stable since the early 2000s, consistent with historic surveys indicating a regional coral cover of 31%. While algal cover remains low across the GSR, there is a slight increase from 4% in historic surveys to 5% in 2019.

⁵⁷² https://www.researchgate.net/publication/326034705_Risk-sensitive_planning_for_conserving_coral_reefs_under_rapid_climate_change

⁵⁷³ <https://www.sciencedirect.com/science/article/pii/S016953471830226X>

⁵⁷⁴ <https://www.sciencedirect.com/science/article/pii/S2667010020300184?via%3Dihub>

⁵⁷⁵ <https://www.nature.com/articles/nclimate1829>

⁵⁷⁶ <https://www.sciencedirect.com/science/article/pii/S2667010020300184?via%3Dihub>

⁵⁷⁷ <https://doi.org/10.1002/joc.5254>

⁵⁷⁸ <https://www.frontiersin.org/articles/10.3389/fclim.2020.579715/full>

⁵⁷⁹ <https://search.informit.org/doi/abs/10.3316/informit.738398775561009>

⁵⁸⁰ <https://onlinelibrary.wiley.com/doi/epdf/10.1111/disa.12462>

⁵⁸¹ <https://fijiglobalnews.com/empowering-voices-women-and-indigenous-communities-in-fiji-tackle-climate-change>

Disturbances are evident, with a significant increase in rubble on GSR reefs from 5% to 17%, indicating impacts of recent disturbances despite overall good health in coral reef benthic communities (Andradi-Brown et al., 2023)⁵⁸².

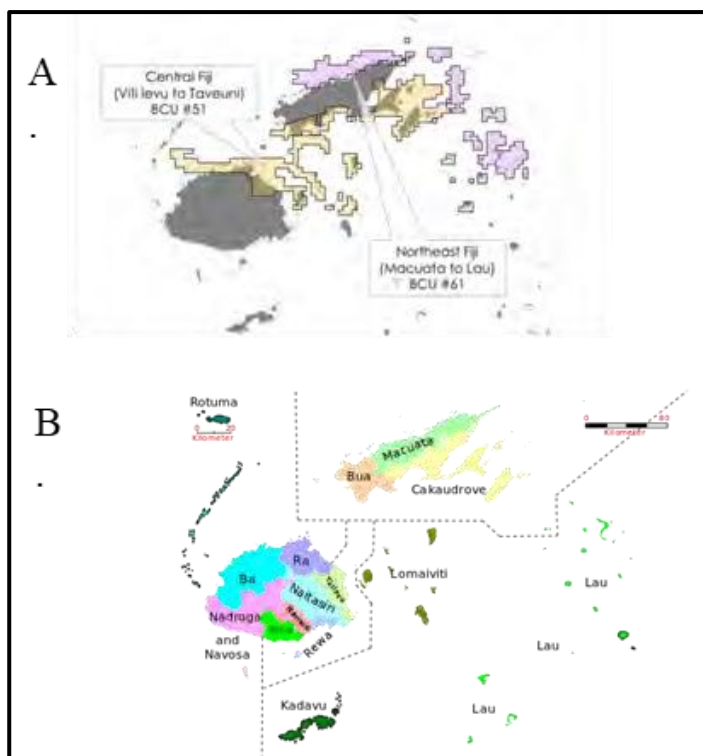


Figure 10-6 Bioclimatic Units (BCUs) in Fijian waters (BCU#51 and BCU#61; Beyer et al. 2018)⁵⁸³ which have relatively lower exposure to climate change than other locations. B. Location of the 14 provinces making up the Republic of Fiji.

The Great Sea Reef is the third-largest continuous coral reef system in the world, spanning over 320 kilometres, and providing habitat for a wide range of marine life. It is also of great cultural significance to Fiji's indigenous communities, who consider the GSR to be a sacred place and a source of traditional knowledge and practices. The GSR is part of Fiji's rich cultural heritage, with stories and legends passed down through generations about its history and significance. Fiji's coral reefs also heavily support the livelihoods of around 60% of Fijians who depend on them for food, income, coastal protection, cultural practices and other resources. The GSR has significant ecological importance, providing habitat for thousands of species, protecting shorelines from storms and floods, and playing a crucial role in carbon and nutrient recycling. In addition to their ecological and economic importance, coral reefs in Fiji are deeply tied to the country's cultural identity and traditional practices. The reefs are often revered locations that are used for fishing, traditional medicine, and spiritual rituals, underscoring the need for conserving, sustainably managing, and regulating these valuable ecosystems. Climate change, overfishing, pollution, and other human activities also threaten these efforts. In the '50 Reef' analysis Fiji was found to contain two high- ranking (i.e. less climate change exposed; Beyer et al. 2018)⁵⁸⁴ BCUs that straddle the Great Sea Reef. However, like other coral reefs worldwide, the GSR is threatened by a range of 'local' human activities and pressures, including climate change, overfishing, and pollution. Therefore, Fiji and the world must protect and manage this important coastal ecosystem to ensure its continued survival along with the enormous cultural and economic benefits it provides to Fiji's people.

10.4.3. Protecting reefs that are least exposed to climate change?

The Coral Reef Rescue Initiative (CRRI) is a collaborative effort that brings together multiple international partners in the climate and conservation sectors, such as the University of Queensland, CARE, RARE, WCS, WWF, Blue Ventures, and Vulcan (see table of Acronyms). The initiative's goal is to protect and regenerate coral reef ecosystems that have low levels of exposure to climate change. The Initiative is also working with seven nations (Fiji, Solomon Islands,

⁵⁸²https://figshare.com/articles/book/Status_and_trends_of_coral_reefs_and_associated_coastal_habitats_in_Fiji_s_Great_Sea_Reef/13228910?utm_source=chatgpt.com&file=35062711

⁵⁸³Beyer et al., 2018 <https://conbio.onlinelibrary.wiley.com/doi/10.1111/conl.12587>

⁵⁸⁴ Beyer et al., 2018 <https://conbio.onlinelibrary.wiley.com/doi/10.1111/conl.12587>

Indonesia, the Philippines, Cuba, Tanzania, and Madagascar) that represent almost 70% of coral reefs with relatively lower levels of exposure to climate change^{585 586}.

The Feasibility Study described here focuses on sites within the Fijian provinces of Ba, Ra, Bua, and Macuata which aims to harmonize and develop regulations within the country, implement Nature-based Solutions (NbS) measures, enhance the functionality of the coastal ecosystem, and create pipelines driven by the country for local businesses and projects that would attract investors. It also plans to monitor the impacts on the coastal ecosystem and communities, conduct local scientific research to improve the management of the coastal ecosystem and develop educational resources for other countries whose coastal ecosystems are at risk due to climate change. This analysis is focused on the Fijian provinces of Ba, Ra, Bua, and Macuata, where climate exposure to climate stress is relatively low, aligning with two Bio-Climactic Units (BCUs).

The current GCF project is centred on these BCUs and aims to identify intervention sites across these four regions that will enhance the resilience of the coral reefs in the Great Sea Reef region. Access to decision-making. Fiji is a country with fertile farmland, forests, rivers, lakes, wetlands, and a variety of ecosystems and climate zones⁵¹⁸. Its coastal waters are also rich in marine resources and biodiversity such as coastal and pelagic fish, shellfish, and seaweed. Fiji faces serious challenges, however, in balancing economic development and environmental protection, all within a rapidly changing climate⁵⁸⁷. The pressure on natural ecosystems in Fiji has also been increasing over time due to population growth, urbanisation, industrialisation, habitat destruction and the expansion of agriculture, including an increase in Pine and Mahogany plantations. This has led to deforestation, soil erosion, overfishing, and ecosystem degradation⁵⁸⁸. Fiji has taken steps to address these challenges, including setting targets for renewable energy and establishing protected areas, but more work is needed to ensure sustainable development and environmental protection. These threats and impacts have been intensifying due to climate change, making Fiji one of the most vulnerable countries globally.

10.5. Agriculture and the Fiji economy

The agricultural sector is an important part of Fiji's economy, contributing around 10-12% of the country's GDP and employing a significant portion of the population. While this study is not focused on agricultural activity, it is important to note some of the issues within the sector and how these might affect corals and coral reefs.

Key agricultural commodities include:

- **Sugar cane:** Sugar cane is the main agricultural product in Fiji, accounting for around 30% of the country's agricultural exports. Sugar cane is grown on large plantations and is processed into raw sugar for export (Dean, M.R.U. The Fiji Sugar Industry: Sustainability Challenges and the Way Forward. Sugar cane production has been associated with environmental concerns, particularly due to the run-off of fertilizers and pollution of waterways. An increase in fertilizer use by farmers, aiming to boost dwindling sugarcane crops in regions like Yaladro Sector, Tavua, has been reported to negatively impact both the cane and the waterways, according to local farming communities. Moreover, agricultural practices in Fiji, such as allowing fertilizer run-off and using herbicides on sugar cane fields, are identified as significant contributors to water pollution⁵⁸⁹.
- **Coconut:** Coconut production is crucial for Fiji as it provides income, sustains household food and nutrition, and alleviates poverty. About 120,000 individuals from the rural population depend on the coconut industry for their livelihood (including oil, milk, and meat), plus the production of traditional handicrafts and construction. Fiji exports high-value coconut products globally, highlighting the crop's economic significance.⁵⁹⁰
- **Cassava:** Cassava is a root vegetable that is commonly grown in Fiji. It is used as a staple food and can also be processed into flour for use in baking. A report from the Food and Agriculture Organization (FAO) mentions that

⁵⁸⁵ Beyer et al., 2018 <https://conbio.onlinelibrary.wiley.com/doi/10.1111/conl.12587>

⁵⁸⁶ Hoegh-Guldberg et al., 2018. Available from <https://www.sciencedirect.com/science/article/pii/S016953471830226X>

⁵⁸⁷ <https://www.cbd.int/countries/profile?country=fj>

⁵⁸⁸ Tuiwawa, S. et al. 2012. Species diversity, composition and the regeneration potential of native plants at the Wainiveiota Mahogany Plantation, Viti Levu, Fiji Islands. *The South Pacific Journal of Natural and Applied Sciences* 30(1):51

⁵⁸⁹ Dean (2022) <https://onlinelibrary.wiley.com/doi/full/10.1002/app5.291>

⁵⁹⁰ Lin, J. (2021), Fiji's participation in the global coconut value chain: opportunities and challenges, *Journal of Agribusiness in Developing and Emerging Economies*, Vol. 11 No. 4, pp. 345-365.

https://www.researchgate.net/publication/341459146_Fiji's_participation_in_the_global_coconut_value_chain_opportunities_and_challenges

cassava is a staple food in Fiji. The production of cassava is on the rise as it's slowly replacing other traditional food crops in the diet of Fijians, which signifies its growing importance in local food security.

- **Rice:** Rice cultivation in Fiji, particularly in the wetlands of the Western Division, is a longstanding tradition with the region housing a notable community of rice farmers, bolstered by recent infrastructural developments like new rice mills to enhance local production. This staple food, pivotal for local consumption and export, underpins Fiji's aim for self-sufficiency in rice production. However, the rice industry faces diminishing cultivation areas and stagnant yield growth⁵⁹¹.
- **Fruits and vegetables:** Fiji's tropical climate and fertile lands provide an ideal environment for cultivating a diverse array of fruits and vegetables. The agriculture sector in Fiji is a significant contributor to the local economy, supplying both domestic and international markets. Among the variety of produce grown, fruits such as papaya, pineapple, and mango, as well as vegetables like pumpkin and eggplant, are cultivated.
- **Livestock:** Livestock farming is a small but important part of the agricultural sector in Fiji. Cattle, pigs, and goats are raised for meat, while dairy farming is limited. Similarly, habitat degradation of rivers, as observed in certain areas, is caused by overgrazing by sheep and cattle, leading to the denuding of riparian vegetation and resulting in bank erosion.
- **Forestry:** Forestry plays a pivotal role in Fiji's economy with significant land areas designated for cultivating pine and mahogany trees. Over recent years, the production of native logs, mahogany, and pine logs has been substantial. From an environmental perspective, deforestation can cause increased surface runoff in catchment areas, as observed in a study where massive deforestation led to measurable erosion in the headwaters of a river catchment (Stephens, M., Lowry, J.H. and Ram, A.R., 2017. Location-based environmental factors contributing to rainfall-triggered debris flows in the Ba river catchment, northwest Viti Levu island, Fiji. *Landslides*, 15, pp.145-159)⁵⁹². Additionally, the formation of gullies and ravines, caused by large linear erosions, is a noted environmental concern worldwide, with deforestation being a contributing factor to such erosions, impacting both human lives and the broader environment⁷.

The agricultural sector in Fiji faces several challenges, including the impact of climate change, soil erosion, and limited access to markets. However, efforts are being made to improve the sector through initiatives such as the promotion of sustainable agriculture practices and the development of value-added products.

10.6. Key Natural Resources of Fiji

Fiji has also rich natural resources, including fertile land, forests, minerals, and fisheries. The country has significant deposits of gold, copper, lead, zinc, and iron, as well as offshore oil and gas reserves. There is also regional interest in deep-sea mining of minerals from the deep ocean. Again, as stated above, this broad sector of Fiji's economic and biological wealth provides a number of areas of activity that have often profound effects on connected marine and coastal ecosystems, including:

- **Minerals and mining:** Mining is a relatively small but important part of the Fijian economy, with gold being the primary mineral produced. Other minerals mined in Fiji include copper, lead, zinc, and iron, largely land-based industries. The potential for environmental destruction is high, with activities leading to habitat degradation, biodiversity loss, and particularly in coastal mining, coastal erosion and marine ecosystem destruction. Socially, mining impacts are profound, especially when operations occur on native land owned by iTaukei land-owning units called mataqali, whose rights to determine land leasing and licensing for mining are severely limited⁵⁹³. Economically, while mining can generate substantial revenue, it can also exacerbate economic disparities due to the uneven distribution of benefits, contributing to increased inequality. Furthermore, mining inherently involves the extraction and depletion of natural resources, leading to sustainability issues and potential resource scarcity in the long term.
- **Deep Sea Mining in Fiji:** The Fijian government has indeed granted several exploration licenses for deep-sea mining. A Korean deep-sea mineral exploration company, KIOST Minerals (South Pacific) Limited, has identified five prospective Fijian sites for further investigation¹. Also being explored are Manganese nodules, also known as polymetallic nodules, which are mineral concretions on the sea bottom that contain high levels of valuable

⁵⁹¹ FAO2021, *Enhancing local rice production in Fiji*, <http://www.fao.org/3/ca4503en/ca4503en.pdf>

⁵⁹² <https://repository.usp.ac.fj/id/eprint/14904>

⁵⁹³ <https://doi.org/10.1080/10106040608542372>

manganese, iron, nickel, copper, cobalt, and other trace elements. These nodules have sparked interest in their use as a mining resource. However, there has been controversy and opposition to these activities from environmental groups as well as Fijian communities, who are concerned about the potential environmental impacts and the impact on local livelihoods.

- **Forests:** Fiji has significant forest areas, covering around 57% of the country's total land area. The forests are important for producing timber and other forest products, as well as providing habitat for a wide range of plant and animal species. Fiji's forest cover is integral to its ecological balance and socio-economic stability. In 2010, Fiji had 1.42 million hectares of tree cover, which extended over 78% of its land area.⁵⁹⁴ Fiji's forests are crucial in climate change mitigation and adaptation, environmental protection, and biodiversity enhancement. They also contribute to the country's economy and improve livelihoods for the Fijians, thus leading to socio-economic and political stability.
- **Coral reefs:** Fiji has some of the most diverse and healthy coral reefs in the world, with over 400 species of coral, and 1,200 species of fish, with perhaps a million species of which 50% are unknown to western science. The coral reefs provide important ecosystem services, such as protecting the coastline from erosion and providing habitat for marine life. Fiji's coral reefs are a complex and dynamic system, serving as a crucial component in the regional marine ecosystem. These reefs are often referred to as "rainforests of the sea" due to their exceptional biodiversity. The structural complexity of the coral formations offers refuge, breeding grounds, and feeding areas for a myriad of marine organisms. This diversity, in turn, contributes to the resilience of the ecosystem, enabling it to withstand and recover from various disturbances like storms and bleaching events. The coral reefs' physical structure acts as a natural barrier that dissipates wave energy, thereby reducing coastal erosion. This function is crucial in safeguarding coastal communities, especially in the face of rising sea levels and increased storm events associated with climate change. Furthermore, the calcifying organisms, primarily corals, contribute to the biogeochemical cycling of carbon and calcium carbonate, which has implications for global carbon dynamics and ocean acidification.
- **Mangroves:** Fiji has extensive mangrove forests, covering over 500 square km² of intertidal land. These coastal forests provide important ecosystem services, such as protecting the coastline from storms and providing habitat for various plant and animal species, including the juvenile stages of many commercial fish species. They are seriously affected by a range of stressors resulting in a serious decline in terms of area coverage.⁵⁹⁵
- **Seagrass meadows:** These extensive meadows are very important ecosystems in Fiji, providing habitat and food for various marine life, including dugongs, turtles, and fish⁵⁹⁶. The extensive marine meadows in Fiji, primarily composed of seagrass beds, are integral components of the region's coastal ecosystem, exhibiting a high degree of biodiversity and playing crucial roles in the ecological and biogeochemical processes of the marine environment. Serving as a vital habitat, seagrass meadows function as nursery grounds for various fish species, offering shelter and abundant food resources for juvenile stages⁵⁹⁷. Within this ecosystem, complex trophic interactions are facilitated. The primary production from seagrasses and associated epiphytic algae form the base of the food web, supporting a myriad of secondary consumers, including crustaceans, molluscs, and various fish species, which are, in turn, preyed upon by higher trophic level predators, thus propagating energy transfer through the ecosystem.
- **Natural barriers:** Fiji's natural barriers, such as coral reefs, mangroves, and seagrass beds, protect the coastline from erosion and storm surges. These ecosystems are also important for maintaining water quality and providing habitat for various species. Coral reefs act as submerged breakwaters, breaking waves and dissipating their energy offshore before they reach coastal properties and communities. This function was notably valuable in 2017 when Hurricanes Harvey, Irma, and Maria caused over \$265 billion in damage across the US⁵⁹⁸. The study further broke down the annual flood protection benefits coral reefs provide to different regions; for instance, coral reefs protect \$184 million worth of buildings and economic activity in Puerto Rico, \$675 million in Florida, and \$836 million in Hawaii.

⁵⁹⁴ <https://www.globalforestwatch.org>

⁵⁹⁵ Cameron, C., Maharaj, A., Kennedy, B., Tuiwawa, S., Goldwater, N., Soapi, K. and Lovelock, C.E., 2021. Landcover change in mangroves of Fiji: Implications for climate change mitigation and adaptation in the Pacific. *Environmental Challenges*, 2, p.100018.

⁵⁹⁶ Singh, S., 2019. Importance of seagrasses: a review for Fiji Islands (*International Journal of Conservation Science*, 10(3), pp.587-602

⁵⁹⁷ McKenzie, L.J. and Yoshida, R.L., 2020. Over a decade of monitoring Fiji's seagrass condition demonstrates resilience to anthropogenic pressures and possibly extreme climate events. *Marine Pollution Bulletin*, 160, p.111636

⁵⁹⁸ Reguero, B.G., Storlazzi, C.D., Gibbs, A.E., Shope, J.B., Cole, A.D., Cumming, K.A., and Beck, M.W., 2021. The value of U.S. coral reefs for flood risk reduction: *Nature- Sustainability*, 2398-9629

- **Fisheries:** Fiji's fisheries are an important resource, providing employment and income for many Fijians. The country's fishery resources include tuna, mahi-mahi, snapper, and other species. Fiji's fisheries sector is a cornerstone of the nation's economy, providing both employment and income to many Fijians. The abundance of marine resources in Fiji's vast Exclusive Economic Zone (EEZ), which spans 1.29 million square kilometres, is a significant asset. Key fish species like tuna, mahi-mahi, and snapper, among others, are harvested, contributing to the livelihoods of the populace. Specifically, tuna species such as yellowfin, skipjack, albacore, and big eye are prevalent in Fiji's waters, with Pacific Island countries, including Fiji, supplying 34% of the world's tuna catch. Employment in the fisheries sector is crucial, especially in rural areas where it engages around 30,000 subsistence fishers, half of the households in these regions. Remarkably, women constitute more than 80% of these fishers. Moreover, the fisheries sector extends beyond commercial activities to encompass artisanal and subsistence fishing, which are vital for food security and cultural heritage. For instance, fishing for subsistence, alongside agriculture and handicrafts, has been highlighted as a crucial livelihood, especially in the face of adversities like the COVID-19 pandemic, which led to a collapse in tourism and consequent job losses⁵⁹⁹.
- The financial ripple effect of the fisheries sector is significant. For example, the net income from sea cucumbers, a part of the marine resources, averages FJ\$8,171 per year for fishers, with fishing and selling sea cucumbers constituting 60% of some fishers' gross annual income⁶⁰⁰. However, the sector is not without challenges. Illegal, Unreported, and Unregulated (IUU) fishing is a major concern, causing an estimated annual loss of US\$100 to US\$150 million to Fiji. This illicit activity, apart from economic losses, undermines the sustainable management of fishery resources, robbing Fiji of development opportunities⁶⁰¹.
- Efforts to curb IUU fishing and bolster legal frameworks have been initiated. For instance, outdated legislation like the Fisheries Act of 1941 has been identified as a source of confusion regarding legal and illegal fishing activities in nearshore waters, necessitating revisions and updates to align with contemporary challenges and international standards⁶⁰². Additionally, workshops and stakeholder engagements have been staged to improve the understanding and implementation of port state measures, reflecting Fiji's commitment to addressing illegal fishing and ensuring the sustainability of its fishery resources⁶⁰³.

Aquaculture: Aquaculture is a growing industry in Fiji, with a focus on prawn and Tilapia farming. Aquaculture provides an alternative source of protein and income for many communities and has the potential to contribute significantly to the Fijian economy in the future. Recent aquaculture efforts in Fiji have encompassed a variety of marine organisms, including freshwater prawns, milkfish, tilapia, giant clams, mud crab, saltwater shrimp, trochus, sponges, turtles, seaweed, bêche-de-mer, pearl oysters, and corals, contributing to sustainable seafood production, enhancing local livelihoods, and aiding in the preservation of marine biodiversity. The Fiji government and donors have invested substantially in aquaculture, though the annual production in 2015 was estimated at less than 200 tonnes of finfish and crustaceans and 550 tonnes of seaweed⁶⁰⁴.

- **Other factors (Covid-19 pandemic):** No description of the Fijian economy without some mention of the recent Covid-19 pandemic would be accurate. In March 2020, Fiji reported its first case of COVID-19, and since then, the number of cases has continued to rise. The Fijian government implemented a range of measures to prevent the spread of the virus, including lockdowns, curfews, restrictions on travel, and public gatherings. The country's borders were also closed to international travel, except for repatriation flights and essential services. The impact of COVID-19 in Fiji has been significant, particularly on its economy, which relies heavily on impacted sectors such as tourism. The closure of Fiji's borders has led to a sharp decline in tourism revenues, with many businesses forced to close and thousands of Fijians losing their jobs.⁶⁰⁵ The pandemic has also increased the strain on the country's health system, with limited resources and infrastructure to manage the outbreak. The Fijian government has implemented a vaccination program to help protect the population against the virus, but vaccine hesitancy and misinformation have posed significant challenges. Despite these challenges, the government has been working to mitigate the impact of the pandemic on the country's health and economy, and the Fijian people have shown resilience in the face of this global crisis.

⁵⁹⁹ Thomas, A., Mangubhai, S., Fox, M., Meo, S., Miller, K., Naisilisili, W., Veitayaki, J. and Waqairatu, S., 2021). *Why they must be counted: Significant contributions of Fijian women fishers to food security and livelihoods. Ocean & Coastal Management*, 205, p.105571

⁶⁰⁰ doi:10.1093/icesjms/fsy036

⁶⁰¹ <https://pina.com.fj/2022/04/05/fiji-loses-millions-to-illegal-fishing/>

⁶⁰² <https://www.sas.com.fj/ocean-law-bulletins/fiji-fisheries-law-when-is-fishing-activity-illegal>

⁶⁰³ <https://pina.com.fj/2022/04/05/fiji-loses-millions-to-illegal-fishing/>

⁶⁰⁴ FAO 2016, *Fishery and Aquaculture Country Profiles: Fiji*

⁶⁰⁵ <https://www.wsws.org/en/articles/2020/06/25/fiji-j25.html>

- Various reports and publications from the Reserve Bank of Fiji can provide a more detailed breakdown of these sectors. The 2020-2021 Fiji National Budget Report also discusses the impact of COVID-19 on the tourism sector and its ripple effects on other sectors of the economy, highlighting the centrality of the tourism sector to Fiji's economic performance (PWC 2022, 2020-2021 Fiji National Budget Report, page 3).

10.7. Climate and local threats

Climate threats were derived from the INFORM Risk Index platform for Fiji at the Tikina jurisdictional level. The INFORM Risk Index is a global, open-source risk assessment for humanitarian crises and disasters developed by the European Commission (Fiji - Decision Support System 2024)⁶⁰⁶. These threats were categorized into three groups: exposure to hazards, vulnerability, and limited coping capacity, based on the following formula.

$$\text{Risk} = \text{Hazard} \times \text{Exposure}^{1/3} \times \text{Vulnerability}^{1/3} \times \text{Lack of coping capacity}^{1/3}$$

Table 10-1 Datasets and methodology for each indicator in the INFORM disaster risk composite index.

Dimensions	Categories	Component	Indicators	Methodology
Hazard & Exposure	Natural Hazard	Physical exposure to Riverine Flood	Physical exposure to flood - number of populations inside an area of potential flood around seasonal water (inhabitants)	The indicator is based on the estimated number of people exposed to potential floods on top of seasonal rainfall. It results from the combination of potential flood zones using a relatively simplistic Digital Elevation Model (DEM) with the Height Above Nearest Drainage (HAND) technique and the number of populations living in the spatial unit. It thus indicates the number of expected people exposed in the hazard zone.
		Physical exposure to Coastal Inundation	Physical exposure to coastal flood - number of population exposed to low-lying areas (< 10m) (inhabitants)	The indicator is based on the estimated number of people exposed to coastal floods. It results from the combination of the low-lying areas using simplistic relative DEMs (less than 10 metres) and the total population living in the spatial unit. It thus indicates the number of expected people exposed in the hazard zone.
		Physical exposure to earthquakes	Population exposes to MMI scale VI or greater, horizontal peak ground acceleration 500MRP	Assumption Fiji rural areas are mostly sub-standard housing. At MMI-VII considerable damage in poorly built or badly designed structures occurs. Overlay earthquake shaking with 10% probability of exceedance in 50 years, corresponding to a return period of 500 years from pacgeo with FB population
		Physical exposure to Cyclone	Population exposed to tropical cyclone greater than category I 100MRP	Assumption Fiji rural areas are mostly sub-standard housing. At Category I considerable damage in poorly built or badly designed structures occurs.

⁶⁰⁶ Fiji - Decision Support System 2024

Dimensions	Categories	Component	Indicators	Methodology
				Overlay Windspeed zones > 110mph (Saffir–Simpson scale) for 100MRP, with FB population
		Physical exposure to Erosion	Population near high intensity of water increase from 1985–2018 from JRC surface water map	Increasing water trend refers to erosion that may be from the sea or river. Higher intensity refers to greater erosion from 1985–2018. Creating a buffer of 50m will represent an area of potential threat, which can be overlaid with FB population.
Vulnerability	Socio-Economic Vulnerability	Economic Growth	Gridded GDP	Source: ^[1]
			Gridded stock	Zonal aggregation of gridded stock
		Poverty	Poverty headcount	WorldBank 2011
		Unemployment Ratio	Unemployment Ratio	Unemployment Ratio - Proportion of No - Census 2017
	Vulnerable Groups	Children	Age less than 5 yrs old	Age less than 5 yrs old - Proportion of No - Census 2017
		Disability	No of disabled person	Disability Person - Proportion of No - Census 2017
		Elderly	Age more than 65	Age more than 65 - Proportion of No - Census 2017
Lack of Coping Capacity	Infrastructure	Communication	Access to electricity	HH without electricity - Proportion of No - 2017 Census
			Internet Access	HH without internet - Proportion of No - 2017 Census
			Mobile Access	HH without a mobile phone - Proportion of No - 2017 Census
		Physical Infrastructure	Road Density	Total Road Length (km)/ Population - Open Street Map
			Access to water	HH without access to improved water source - Proportion of No- 2017 Census
			Access to sanitation	HH without access to improved sanitation facilities - Proportion of No - 2017 Census
			Improved building materials	HH without improved building materials - Proportion of No - 2017 Census
		Access to health service infrastructure	Hospital density per 1000 people	Ministry of Lands & Mineral Resources (MLMR)

Local threats were included based on their availability and reported negative impacts on coral reef ecosystems and the GSR, and included nutrient pollution from human sanitation, sediment run-off from current land uses, recent mangrove loss and degradation, fishing pressure; as well as other threats that lead to marine pollution such as livestock production, mining, agricultural production (agricultural area and agricultural production volume), deforestation, forestry harvesting area, urban population, and landslide incidence. Local threat data

were compiled at the highest available spatial resolution, varying from the province level to Tikina and pixel levels.

Table 10-2 Datasets and methodology on local threats for the GSR in Fiji.

Local threats	Calculation details	Original raster spatial resolution	Source
Total nitrogen	The sum of total nitrogen export by basin–tikina and standardised by area. Then normalisation to 0 to 10 values.	100 m	Kuempel et al. 2024. A spatial framework for improved sanitation to support coral reef conservation
Sediment export	The sum of sediment export by basin–tikina and standardised by area. Then normalisation to 0 to 10 values.	110 m	Suarez-Castro et al. In prep. Identifying critical areas to prioritize nature-based solutions at the land-water interface in Fiji. Griffith University – World Bank
Mangrove degradation/loss	Average value between mangrove degradation and mangrove loss threat indicators.	0.00027 arc deg	Lagomasino et al. In prep. BEF Mangrove for Community and Climate Project: Mangrove extent, degradation, and carbon monitoring for Mexico, Colombia, Madagascar, and Fiji from 2020 to 2021
Fishing pressure	Historical fish abundance minus fish abundance in 2019 by monitoring site. Then interpolation between sites based on ordinary krigging and normalisation to 0 to 10 values.	NA	Andradi-Brown et al. 2022. Status and trends of coral reefs and associated coastal habitats in Fiji’s Great Sea Reef
Livestock	The sum of livestock abundance by basin–tikina and standardised by area. Then normalisation to 0 to 10 values.	NA	FAO. 2020 Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report
Mining	The proportion of area covered by mine leases by basin–tikina. Then normalisation to 0 to 10 values.	NA	Request to Ministry of Lands, Fiji
Agriculture	The proportion of area covered by agricultural areas by basin–tikina. Then normalisation to 0 to 10 values.	NA	PCRAFI Program (2020). Fiji_Landuse Landcover. Fiji, Pacific Risk Information System
Deforestation	Proportion of deforested area by basin–tikina. Then normalisation to 0 to 10 values.	30 m	Ministry of Fisheries & Forestry. 2024
Forestry harvesting area	The sum of forestry harvested area by basin–tikina and standardised by area. Then normalisation to 0 to 10 values.	NA	Ministry of Fisheries & Forestry. 2024
Urban population	The sum of urban population by basin–tikina and standardised by area. Then normalisation to 0 to 10 values.	NA	Fiji Disaster Management Committee
Agriculture (volume)	The sum of agricultural production volume by basin–tikina and standardised by area. Then normalisation to 0 to 10 values.	NA	FAO. 2020 Fiji Agriculture Census. Volume I: General Table & Descriptive Analysis Report
Landslides	Count of landslide events by basin–tikina and standardised by area. Then normalisation to 0 to 10 values.	NA	Ministry of Lands and Mineral Resources. 2024

10.8. Normalisation of climate and local threats

Within these basin-Tikina intersections, climate and local threats were normalised into a scale ranging from 0 to 1 and then aggregated to calculate the final composite index (using an average). This composite index was normalized for each variable across the priority provinces influencing the GSR (Ba, Bua, Macuata, and Ra provinces). A final composite index, on a scale of 1 to 10, highlighted areas with the highest combined climate and local threats (higher values

indicating more significant risk). The top third of areas with high local threat values (suitable for interventions) across all climate risk levels within each priority province were selected as priority project areas.

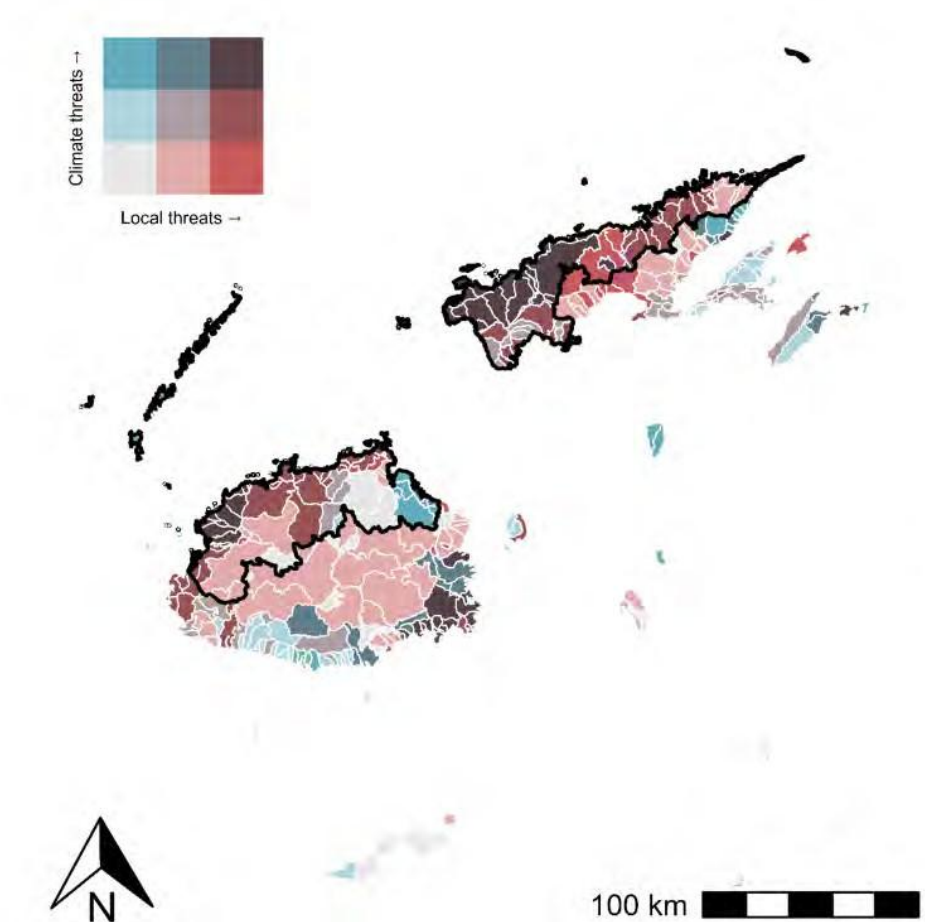


Figure 10-7 Composite indexes between climate and local threats, based on the normalisation of each variable across Fiji. The figure highlights the provinces that influence the GSR (black border). Note that the northwestern regions of Viti Levu and Vanua L Levu score high on climate and local threats while also overlapping on the four priority provinces (Ba, Bua, Macuata, and Ra), hence making them ideal as candidate areas for implementing interventions to manage threats.

10.9. Suitability analyses for interventions

After discussing with stakeholders, four types of interventions were deemed suitable and achievable for improving the conditions of the GSR in the face of climate change: riparian restoration, mangrove restoration, and green seawall construction. A GIS-based multiple criteria decision analysis (MCDA) was developed to overlay a comprehensive set of environmental, economic, and feasibility variables to determine suitable areas for implementing each intervention, at a spatial resolution of 100 m. For each intervention, relevant variables indicating suitability were rescaled from 0 to 1, where 1 meant maximum suitability and 0 meant no suitability. Each variable was then reclassified by percentiles (ranging from 0 to 1), aiming at decreasing the influence of deviations from a normal distribution that might bias final suitability models. A suitability index ranging from 0 to 1 was calculated for each intervention within project priority areas to identify the most suitable sites for each intervention in terms of feasibility and potential benefit to nature and people. For this, the minimum value across layers was obtained after rescaling each suitability value by percentiles.

For riparian restoration, a buffer of 500m along waterways, with a spatial resolution of 100m, was used to find suitable pixels for reducing sediment export accounting for the variation in sediment export at different distances from each waterway.

Table 10-3 Data layers and criteria used to select intervention sites within project areas. NA indicates that a layer was not included for a particular intervention. Criteria denoted with “max” refers to high values of a given metric indicating high suitability, while “min” refers to low values of a given metric indicating high suitability (e.g., high values of slope are ideal for restoration, while low

values for slope are ideal for improved farming practices). “Inside” indicates that suitable pixels can only occur within valid values of the named layer, while “outside” indicates the opposite.

Interventions	Sediment export	Slope	Distance to rivers	Suitable land uses	Current mangrove extent	Potential mangrove extent	Land tenure	Distance to populated areas	Flooding hazard	River discharge	Distance	Interventions
NbS: Riparian restoration	Max	Max	Inside buffer	Cropland/agriculture, grasslands – outside water, mangrove, bare soil/rock, urban/impermeable, shrubland, trees	Outside	Outside	iTaukei Land – outside freehold land and state land	NA	NA	NA	NA	
NbS: Mangrove restoration	NA	NA	NA	Cropland/agriculture, grasslands, mangroves, water – outside bare soil/rock, urban/impermeable, shrubland, trees	NA	Max	iTaukei Land – outside freehold land and state land	Min	NA	NA	Min	Inside
GI: Green seawalls	NA	Min	NA	Cropland/agriculture, grasslands, mangroves – outside water, bare soil/rock, urban/impermeable, shrubland, trees	Outside	Max	iTaukei Land – outside freehold land and state land	Min	Max	NA	Inside buffer	

Table 10-4 Datasets and description of layers used for developing the suitability analyses on selected interventions (riparian and mangrove restoration, green seawall implementation).

Name	Description	Original raster spatial resolution	Source
Sediment export	Calculation of sediment export at the pixel level based on the InVEST sediment delivery model	100 m	Suarez-Castro. In prep. Identifying critical areas to prioritize nature-based solutions at the land-water interface in Fiji. Griffith University - World Bank

Slope	Calculation on slope based on SRTM 90m Digital Elevation Database v4.1	90 m	Jarvis, A., H.I. Reuter, A. Nelson, E. Guevara, 2008, Hole-filled SRTM for the globe Version 4, available from the CGIAR-CSI SRTM 90m Database (http://srtm.csi.cgiar.org)
Distance to rivers	Calculation of buffer (500 m) to waterways from hydroRIVERS v1.0	NA	Lehner, B., Grill G. (2013). Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. Hydrological Processes, 27(15):2171–2186
Suitable land uses	Filtering of suitable land uses based on Land use and land cover (LULC) map for all of Fiji in 2022, generated from a year's worth of cloud-masked Sentinel-2 surface reflectance data and topographic data from the SRTM	10 m	Davies, K. Duncan, J., Varea, R., et al. A Dynamic, Cloud-based LULC Mapping Methodology Using Sentinel-2 to Support Climate-Smart Landscape Management in Vulnerable Fijian Communities
Current mangrove extent (Lagomasino)	Identification of current mangrove extent based on Lagomasino analyses between 2019 and 2021	0.00027 arc deg	Lagomasino et al. In prep. BEF Mangrove for Community and Climate Project: Mangrove extent, degradation, and carbon monitoring for Mexico, Colombia, Madagascar, and Fiji from 2020 to 2021
Potential mangrove extent	Potential distribution of mangroves	0.0021 degrees	Tomislav et al. 2020. Potential distribution of land cover classes (Potential Natural Vegetation) at 250 m spatial resolution
Land tenure	Identification of community, state land, and private leases	NA	Ministry of Forestry, Fiji
Distance to populated areas	Calculation of Euclidean distance to settlements identified by the Fijian government	NA	Ministry of Forestry, Fiji
Flooding hazard (coastal and riverine)	Hazard map for inundation and flood map	NA	ArcGIS Online datasets
River discharge	Identification of river discharge based on hydroRIVERS v1.0	NA	Lehner, B., Grill G. (2013). Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. Hydrological Processes, 27(15): 2171–2186
Distance to coast (main islands)	Calculation of distance to Euclidean distance to coasts identified based on administrative divisions	NA	The Humanitarian Data Exchange (2019)
Historic loss of mangroves	Calculation of lost mangrove pixels from 1996 to 2020 based on Global Mangrove Watch	NA	Bunting P., Rosenqvist A., Lucas R., Rebelo L-M., Hilarides L., Thomas N., Hardy A., Itoh T., Shimada M. and Finlayson C.M. (2018). The Global Mangrove Watch – a New 2010 Global Baseline of Mangrove Extent. Remote Sensing 10(10)