



Blue Foods Systems as a Nature-based Solution for Climate Resilience

Prepared by Institute for Sustainable Futures





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Cover photo

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Acknowledgment of Country

UTS acknowledges the Gadigal People of the Eora Nation, the Boorooberongal People of the Dharug Nation, the Bidiagal People and the Gamaygal People upon whose ancestral lands our university stands. We also pay respect to Elders past, present and future, acknowledging them as the traditional custodians of knowledge for these lands.

Summary

Blue foods—defined as foods derived from marine, freshwater or aquaculture systems—play a critical yet under-recognised role in our global food systems.

Despite their nutritional, economic and ecological significance, blue foods have historically been marginalised in food security and climate policy discussions when compared to land use and agriculture. This report addresses this gap by exploring how blue foods systems can function as nature-based solutions (NbS) that simultaneously deliver biodiversity conservation, food security, livelihood and climate resilience benefits.

The study focuses on small-scale coastal communities in Fiji, where blue foods are central to cultural identity and everyday livelihoods. It investigates how blue foods activities—specifically mangrove oyster farming and seagrass restoration—support multiple nature-based outcomes. By centring community perspectives and using systems thinking as a methodological tool, the research provides a novel lens for capturing the trade-offs and co-benefits associated with traditional and emerging blue foods practices.

Blue foods systems overview

Blue foods are rich in essential nutrients such as omega-3 fatty acids, vitamin B12 and iron, making them vital for addressing malnutrition and non-communicable diseases. In Pacific Island Countries and Territories (PICTs), fish account for 50–90% of the protein intake in coastal communities, underscoring their importance to food security. However, rising consumption of low-nutrient imported foods threatens these traditional diets.

Blue foods systems also support the livelihoods of over 600 million people globally, with small-scale fisheries employing 90% of the sector's workforce. Women play a crucial but often under-documented role in harvesting and marketing, contributing significantly to household food security and intergenerational knowledge transfer. Compared to terrestrial agriculture, blue foods systems generally have a lower environmental footprint, particularly in terms of greenhouse gas emissions and land use. However, the sustainability of blue foods activities is highly dependent on practices and monitoring systems. While small-scale operations tend to be more environmentally friendly, industrial practices such as bottom trawling and intensive aquaculture can cause significant ecological harm. Overfishing and habitat degradation remain pressing concerns.

As well as being integral to household economies, blue foods are deeply embedded in the cultural and spiritual life of Pacific communities. Ecosystems such as seagrasses and mangroves are ecological and cultural touchstones, linked to traditional knowledge systems and community identity. These dimensions are essential for understanding the full value of blue foods systems.

Research approach: systems thinking and participatory methods

This study employs a systems thinking framework to explore the interconnections between blue foods activities and NbS outcomes. This approach enables a nuanced understanding of how conservation, food security and climate resilience are co-produced within blue foods systems. The research is grounded in qualitative methods, including key informant interviews, focus groups, community workshops and site visits in Fiji. Two case studies—mangrove oyster farming in Muanaira and seagrass restoration in Dawasamu—were selected based on their potential to illustrate diverse blue foods outcomes. Causal loop diagrams are used to synthesise the desktop and interview data, and present holistic visual representations of how the blue foods systems exist across two communities.

Regional and national context: policy framing and strategic priorities

Fishing and aquaculture continue to be of cultural and economic importance to Fiji and other PICTs. In Fiji, we found that the outcomes from blue foods systems are embedded in different activities and sometimes championed by different ministries. The Ministry of Fisheries (MoF) prioritises aquaculture and inshore fisheries as drivers of economic growth and food security. Strategic Development Plans and the country's new aquaculture policy set ambitious targets for aquaculture expansion, aiming to increase sector value and reduce seafood imports. Despite this growth, climate change considerations remain vague in policy frameworks, with limited indicators or adaptation strategies embedded in planning documents. This makes achieving climate resilience outcomes challenging.

Conversely, the Ministry of iTaukei Affairs adopts a more holistic approach, integrating conservation and climate resilience into village development through traditional governance structures. Conservation NGOs and regional organisations, such as the Pacific Community (SPC), emphasise the need for climate-smart practices and sustainable management, noting increasing awareness among communities and industry stakeholders of climate risks.

There are ongoing tensions and trade-offs to negotiate between economic development and ecological sustainability. While productivity and income generation dominate policy agendas, recognition is growing of the need to embed climate resilience and conservation into blue foods initiatives. This requires coordinated efforts across ministries, NGOs and communities to ensure that blue foods systems contribute to long-term ecological and social resilience.

Case study 1: Mangrove oysters in Muanaira

Muanaira village, in Fiji's Rewa Province, exemplifies how community-led aquaculture can support conservation and livelihoods, with an added co-benefit of supporting climate resilience. The mangrove oyster farming initiative has grown over the past decade and fostered strong awareness of mangrove ecosystems, with villagers actively protecting juvenile mangroves to sustain oyster habitats. Oyster farm structures have also created new habitats for seaweed and fish, enhancing local biodiversity. However, environmental threats, such as sewage contamination and sedimentation, pose risks to ecosystem health and oyster quality, underscoring the need for improved water management and pollution control.

Climate resilience benefits from mangrove oyster farming are largely indirect and dependent on community desires to protect the ecosystem. Mangrove replanting, driven by the need to sustain the oyster habitats, contributes to shoreline protection and carbon sequestration. While community members recognise the role of mangroves in buffering storms and absorbing carbon, climate adaptation is not a primary driver of oyster farming activities. There is a gap between national climate policies (mitigation and adaptation) and community-level implementation of climate action, highlighting the need for targeted support to translate policy into practice.

Mangrove oysters provide critical livelihood support, particularly for women, who lead harvesting and sales. Income from oyster farming has funded household needs, education and infrastructure, demonstrating its socio-economic value. However, market limitations—such as inconsistent demand, a lack of marketing skills and competition—constrain income potential. The community expressed a desire to expand oyster farming and establish Marine Protected Areas to safeguard biodiversity and enhance food security. Addressing market barriers and building business capacity is essential to realising these aspirations.

Case study 2: Seagrass restoration in Dawasamu

The seagrass restoration pilot in Dawasamu district highlights the ecological importance of seagrass meadows as habitat for diverse marine species. Restoration practices are being enabled by international partners and Fiji National University, given the decline in seagrass meadows.

Community members recognise seagrasses as feeding grounds and habitat for a diverse range of marine species, with restoration expected to improve species abundance and water quality. Historically, seagrass meadows were abundant and enabled fishing near-shore, which was of particular importance to women, who could source blue proteins close to their community. In recent decades, land-based activities such as quarrying and intensive agriculture, along with fishing practices, have impacted the seagrass ecosystems. Community involvement in replanting has been limited but is expected to grow, with interest in integrating restoration into communal programs and youth activities.

Community members perceived climate change as a driver of seagrass degradation, with rising temperatures and stronger waves affecting ecosystem health. While seagrass restoration is acknowledged for its potential to reduce shoreline erosion, its role in climate mitigation—particularly blue carbon sequestration—is not widely understood or prioritised by communities. Blue carbon is an emerging area of research, and seagrasses potentially have high carbon sequestration potential. Building blue carbon evidence and literacy, including among community leaders, is crucial as markets gain prominence in policy and funding landscapes.

Seagrass restoration is expected to enhance food security by increasing fish availability for consumption and sale. Reduced fishing effort and fuel costs are additional benefits, particularly for women who previously relied on near-shore diving. Restoration may also support ecotourism, offering new income streams. However, overfishing and the granting of external fishing licences, including to remote communities, pose risks to sustainability. The community suggested the development of a seagrass-oriented marine management plan as a strategy for balancing conservation and livelihoods.

Implications for blue foods systems as nature-based solutions

This study underscores the importance of framing blue foods systems as nature-based solutions that support co-existing conservation, food security and climate resilience outcomes. While global assessments of blue foods are recent and provide valuable macro-level insights, local studies are essential to capturing community experiences and traditional knowledge. In the Pacific, where ecological and cultural systems are deeply intertwined, NbS investments must reflect multi-generational understandings, community priorities and knowledge of how blue foods support their development. These local insights need to form part of future large-scale NbS investment design.

Blue foods systems offer significant co-benefits, but managing trade-offs is essential for future investment. The systems thinking tools applied in this study, including causal loop diagrams, enable stakeholders to identify feedbacks, and design interventions that balance productivity, conservation and resilience. This approach moves beyond disciplinary silos (such as fisheries or climate science) to support integrated decision-making. Importantly, it enables the use of participatory methods that capture community insights and perspectives.

As NbS investments grow in the Pacific, it is vital to ensure that equitable ecological and social outcomes are achieved. Blue foods activities, often rooted in traditional practices and crucial for livelihoods and national economic prosperity, need to adapt to the realities of climate and demographic change in the region. Funders and researchers need to urgently prioritise holistic approaches that connect marine activities to broader climate and development goals. This includes embedding climate adaptation in aquaculture and fisheries strategies, supporting market development, and augmenting community capacity to navigate the changing blue foods contexts of the region.

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1. Introduction

Three out of seven people depend on the ocean as their primary source of protein. Yet, traditionally, discussions on sustainable and just food systems have focused on land-based agriculture (FAO, 2020; Simmance et al., 2021).

Blue foods¹, which play a substantial role in contemporary food systems, have traditionally been included in fisheries and aquaculture policies, but are less frequently integrated into nutrition and climate policy (Blue Food Assessment, 2022; Crona et al., 2023; Tigchelaar et al., 2022). In recent years, significant efforts have sought to shed light on the role played by blue foods in food security, nutrition, livelihoods and employment, most notably through the 2022 Blue Food Assessment, a project that aimed to “provide the scientific foundation for decision-makers to make blue foods part of an improved food system” (Blue Food Assessment, 2022, p.6). The assessment highlighted that the environmental footprint of blue foods is often lower than that of land-based agriculture with regards to greenhouse gas (GHG) emissions, nitrogen and phosphate use, and land and water requirements. However, it does not address whether or how blue foods can contribute to broader environmental and resilience outcomes, such as biodiversity conservation or climate resilience.

Our project aims to identify the extent to which blue foods activities can act as nature-based solutions (NbS) and enable biodiversity conservation, food security, livelihoods and climate resilience outcomes. NbS are defined as “actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature” (Cohen-Shacham et al., 2016). The uptake of NbS should contribute to addressing major societal challenges, including climate change, food security and biodiversity loss (IUCN, 2020).

This project specifically sought the perspectives of small-scale coastal fishing communities and regional experts on the role of blue foods as NbS. We implemented two targeted, systems-based case studies focused on mangrove oysters and seagrasses in Fiji to illustrate how blue foods support various development outcomes for people and nature. The goal of this study was to provide a localised approach to the question of blue foods sustainability, which has so far only been addressed through the development of global policy priorities (e.g. Blue Food Assessment, 2022; Crona et al., 2023; Tigchelaar et al., 2022). Understanding small-scale coastal community perspectives is essential because they account for 37 million tonnes (40%) of blue foods stocks globally, and 492 million people are at least partially dependent on these fisheries (FAO et al., 2023). The blue foods discussion is often skewed toward large-scale fisheries, marginalising small-scale fishers in fisheries policy. This is even though small-scale fisheries play an essential role in providing livelihoods, food security and healthy nutrition at the local scale.

The study was led by the University of Technology Sydney, Institute for Sustainable Futures (UTS-ISF) and conducted in partnership with WWF-Australia. This research forms part of WWF’s Climate Resilient by Nature (CRxN) program.² Through the use and promotion of equitable NbS to climate change, CRxN’s goal is that Pacific and Southeast Asian communities are more socially, economically and ecologically resilient. To conduct this research, fieldwork activities in Viti Levu, Fiji, were designed and carried out with strategic advice and support from academic staff and students from the Fiji National University (Dr Shalini Singh as lead advisor), SPC Fisheries,

¹ “food derived from aquatic animals, plants or algae that are caught or cultivated in freshwater and marine environments” (Blue Food Assessment, 2022).

² Climate Resilient by Nature is funded by Australia’s Department of Foreign Affairs and Trade (DFAT), with additional funding provided by the Mekong Australia Partnership-Water, Energy and Climate (MAP-WEC).

Aquaculture and Marine Division (FAME), Dr Chinthaka Hewavitharane), the Ministry of Fisheries and WWF-Pacific.

The project team conducted a literature review to investigate the links between blue foods and climate resilience, food security, livelihoods and conservation. This review supported the development of a framework and research questions to unpack how blue foods systems contribute to various NbS outcomes. Two case studies were then developed to understand how different blue foods systems—mangrove oysters and seagrasses—contribute to resilience and NbS within the Pacific.

This part of the report first provides a summary of the literature (Section 2) and framework of inquiry (Section 3), then presents a summary of the regional Pacific context of blue foods systems (Section 4). This section describes the public policy strategies and associated international funding that is directed toward blue foods system activities. Sections 5 and 6 then present the two case studies, focused on blue foods systems that support mangrove oysters in Muanaira and seagrass restoration in Dawasamu. Finally, Section 7 presents insights drawn from the entire study to guide the design and implementation of all blue foods projects. The aim is to support food security, livelihoods, conservation and climate resilience.



Muanaira, Fiji © WWF-Pacific

2. Blue foods literature

Blue foods systems thinking is an emerging concept and requires contextualisation. The following two sections provide an overview of why blue foods matter, looking specifically at four types of blue foods benefits identified in the literature: food and nutrition security; socio-economic value; reduced GHG emissions; and cultural and spiritual significance.

Existing PICTs blue foods production systems are then examined, followed by a description of the challenges these systems face, and a range strategies that can be adopted to address the challenges. Finally, the links between blue foods and NbS are unpacked.

Why blue foods matter

The term blue foods refers to “foods derived from aquatic animals, plants or algae that are caught or cultivated in freshwater and marine environments” (Blue Food Assessment, 2022). This encapsulates all fishing and aquaculture activities carried out in aquatic environments, including oceanic, coastal and freshwater fishing activities. Globally, this equates to approximately 2,200 wild-caught and 600 farmed species (Crona et al., 2023).

Blue foods systems encompass diverse ecosystems and practices, ranging from large-scale trawling operations to small fish ponds integrated into agricultural systems, and provide nutritious food through global and local markets (Tigchelaar et al., 2022). Food systems research and policy has traditionally ignored fisheries and aquaculture, but the vulnerability of these sectors to climate shocks and over-harvesting has begun to incentivise an increased blue foods focus in food systems investments (Tezzo et al., 2020).

Food and nutrition security

Over 2,500 blue foods species are consumed by humans (Tigchelaar et al., 2022). They are typically rich in micronutrients (e.g., zinc and iron), vitamin B12, omega-3 fatty acids and proteins, and can contribute to preventing and reducing health issues such as malnutrition, maternal and infant mortality, and non-communicable diseases (Crona et al., 2023; Gephart et al., 2021; Tigchelaar et al., 2022). This is particularly evident in island nations, which are the largest consumers of blue foods globally (Hicks et al., 2022).

In PICTs, blue foods play an important nutritional role, with fish accounting for 50-90% of the protein intake of coastal communities (Bell et al., 2009; Wabnitz et al., 2023). However, PICTs are also experiencing a rise in the importation and consumption of cheap food of low nutritional value, which has exacerbated the prevalence of non-communicable diseases (Sievert et al., 2019). The substantial health benefits of blue foods make them crucial to the future health of the Pacific’s growing population.

Socio-economic value

Blue foods make major socio-economic contributions and are critical to Pacific revenue and health. They constitute the most important source of wild food globally (Tigchelaar et al., 2022) and this is particularly true for island nations. Blue foods provide livelihoods for 600 million people (FAO, 2024), with small-scale fisheries employing 90% of all workers in the sector (FAO et al., 2023). The estimated economic value of Pacific fisheries and aquaculture was over US\$2.5 billion in 2023, with a combination of off-shore fishing licences and traditional fishing and aquaculture for local markets the major drivers of economic activity (Gillett and Fong, 2023). Statistics vary on the total contribution of coastal fishing to household incomes, however a study found that in households

that fish, alone, the average is approximately 10% (Roscher et al., 2023). This highlights that fish are part of a diversified and wider set of livelihood strategies applied by fishing communities.

Socially, fishing also plays a major role in rural and coastal communities. Participation is often gendered: men tend to collect larger fish species in deeper waters, while women harvest shellfish and other invertebrates in shallower waters and lagoons (Barclay et al., 2018; Lawless et al., 2019). Men's contributions to blue foods are often captured economically through higher-value, deep-water fishing. Women's efforts remain largely undocumented, despite contributing substantially to household food security and food marketing (Barclay et al., 2018). Women also play a critical role in household food choices, further supporting food security, and initiate children into fishing practices (Ram-Bidesi, 2015).

Reduced environmental footprint

Blue foods may also contribute to sustainability targets by reducing dietary environmental footprints (Spencer and Tigchelaar, 2023). These systems release less GHG emissions than livestock production systems, and minimise land use/conversion and impacts on freshwater resources compared to terrestrial agriculture (Crona et al., 2023, p.105). Specifically, farmed seaweeds, bivalves and small-scale pelagic fisheries have particularly low GHG emissions compared to other blue foods (Gephart et al., 2021).

It is, however, important to acknowledge that the low GHG emissions of blue foods is highly dependent on the practices adopted. For example, small-scale fisheries and aquaculture operations often use less fuel than larger ones (Tigchelaar et al., 2022). In contrast, practices such as bottom trawling may lead to significant GHG emissions and ecosystem damage. However, it is well established that fishing can cause long-term environmental damage to ecosystems. Overfishing is pervasive and worsening, with the FAO reporting that 37.7% of marine fishery stocks were overfished in 2021 compared to 10% in 1974 (FAO, 2024). Intensive aquaculture practices have been linked to numerous negative environmental impacts, such as habitat destruction (e.g. mangrove and wetland) to build aquaculture ponds, the overuse of wild aquatic species as 'input' in aquaculture systems (e.g. collection of wild juveniles to stock aquaculture ponds and the use of wild fish as feed) and the spread of diseases from farmed fish to wild populations, to name a few (Allsopp et al., 2008). Achieving the complementary system outcomes of food security and environmental sustainability, including biodiversity conservation and a low-emissions profile, is thus dependent on the fishing or aquaculture practice adopted.

Traditional and cultural significance

Many cultural, spiritual and ecological practices are associated with blue foods in PICTs. McKenzie et al. (2021) explain that seagrass ecosystems have cultural (use of shell money), as well as spiritual or religious values (worship of totem animals, such as the dugong) for some Melanesian cultures. Cultural keystone species are used for social activities, and include herbal medicines, subsistence foods, religious and chiefly artefacts (Kitolelei et al., 2021). Additionally, the marine source of blue foods is frequently linked to formal and informal protected area systems with strong cultural significance. Indigenous fishing knowledge is continuously refined over generations and continues to be a crucial contributor to marine management, however increasing financial pressures and changes to socio-ecological dynamics threaten the preservation of this traditional knowledge. Ecologically, keystone species in marine and freshwater environments include top predators, benthic cleaners, decomposers and aquatic plants, such as algae/seaweed and seagrasses, (Kitolelei et al., 2021). These species provide important ecological systems-balancing services and also form part of the broader habitat for cultural keystone species.

Blue foods activities in PICTs

There are three main blue food production systems: offshore fishing, coastal fishing and aquaculture (Figure 1).

- **Offshore fishing** comprises locally-based and foreign-based offshore fishing, with the latter dominating. Locally-based fishing consists of 199 vessels, against 740 offshore fishing vessels (FAO, 2018). Offshore fishing represents a significant source of income for PICTs governments, through the licence fees paid by foreign-based vessels (FAO, 2018).
- **Coastal fishing** typically involves small-scale commercial fisheries and subsistence fisheries (FAO, 2018). It provides a range of livelihood and nutritional benefits for Pacific Islanders and represents most of the non-imported fish supplies (FAO, 2018). However, coastal fisheries production has increased in recent times in line with population growth, which appears to support the hypothesis that fish stocks are fully exploited (Gillett, 2016).
- **Aquaculture** was introduced in the 1950s and '60s in PICTs, but only began to develop, scale and contribute to livelihoods and food security in the past few decades (Charlton et al., 2016; SPC, 2015). Although not yet widespread, aquaculture is seen as having the potential to meet increasing nutrition demands (SPC, 2014, 2013). As PICT populations grow and coastal fisheries are impacted by climate change and over-exploitation, aquaculture is increasingly seen as a potential complementary source of food and income (SPC, 2014, 2013).

Currently, five main aquaculture commodities play an economic role in the region: pearl oysters, Mexican blue shrimp, seaweed, Nile tilapia and freshwater prawns (SPC, 2014, 2013). These activities are only practised in a few PICTs, as illustrated in Figure 1.

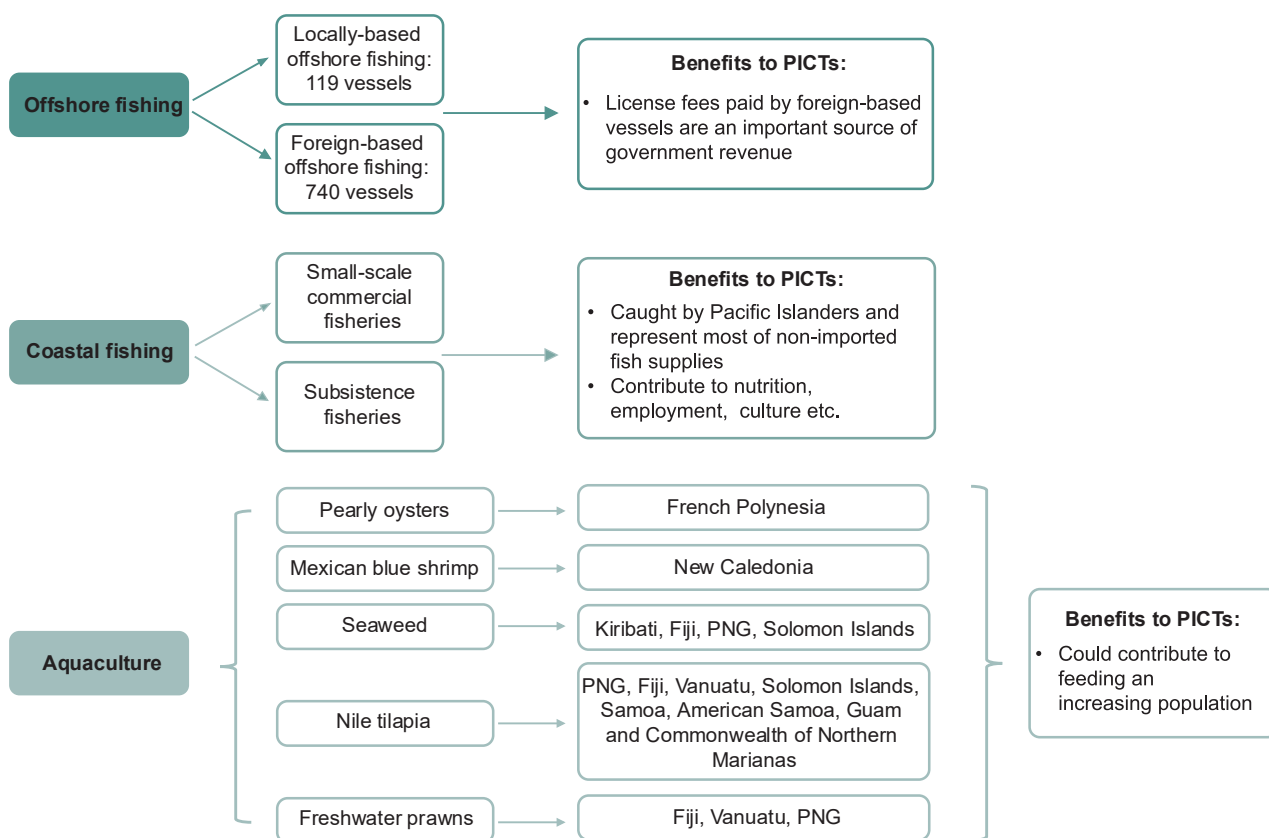


Figure 1: Blue foods production systems in PICTs.

For the purposes of our study design, offshore fishing is excluded from the analysis, given its distance from local communities and the fact that offshore fishing often focuses on international exports and markets, and less on the immediate food security and livelihoods of countries.

What challenges do blue foods face?

Blue foods face a range of environmental and socio-economic challenges (Crona et al., 2023; Gephart et al., 2021; Hicks et al., 2022; Tigchelaar et al., 2022, 2021; Wabnitz et al., 2023). These include:

- **Land use change**, notably urbanisation and industrial activity, particularly in coastal areas;
- **Pollution** generated by urbanisation, agriculture and plastic pollution, which can lead to the creation of coastal dead zones;
- **Overexploitation**, which can lead to fish depletion and long-term impact on habitat and environmental systems more generally;
- **Climate change**, which has large impacts on oceans, coral reefs and habitats that support human populations. Ocean acidification alters coral reef fisheries and bivalve production, sea-level rise affects mangroves, and rising temperatures and extreme events harm blue foods ecosystems generally. Climate change affects blue foods systems differently, with aquaculture being more vulnerable to non-climatic stresses such as disease;
- **Export versus local consumption**: Tensions exist between capturing fish for export versus capturing fish to support local livelihoods and food and nutrition security. This is visible in PICTs where offshore fishing is dominated by foreign-based vessels; and
- **Inequity**: The blue foods sector is characterised by inequities, especially in terms of small-scale fishers' access to resources and the protection of their rights. Gender inequities prevail, with women's roles in fisheries often remaining undocumented and therefore underestimated in formal statistics and reporting.

Beyond-country economic benefits are heavily linked to blue foods activities and pose unique challenges (summarised in Figure 2). The range of strategies to address offshore fishing, commonly conducted by middle and high-income countries in lower-income country waters, includes:

- **Policies**: redistributive policies can be developed to address the inequities that exist in the blue foods sector, including greater socio-economic benefits directed to households from large-scale offshore fishing licences;
- **Practice change**: such as livelihood diversification and marine monitoring systems adopted by individuals or communities to adapt to an evolving context;
- **Technologies**: adopting fish aggregating devices, blockchain, open ocean aquaculture and artificial intelligence can assist commercial-scale decision-making and monitoring;
- **Economic measures**: tools such as certifications can be used to incentivise practice change, stakeholder accountability and transparency within the industry; and
- **Nature-based solutions**: e.g. mangrove restoration, can contribute to coastal protection and biodiversity enhancement, while also providing food security outcomes.

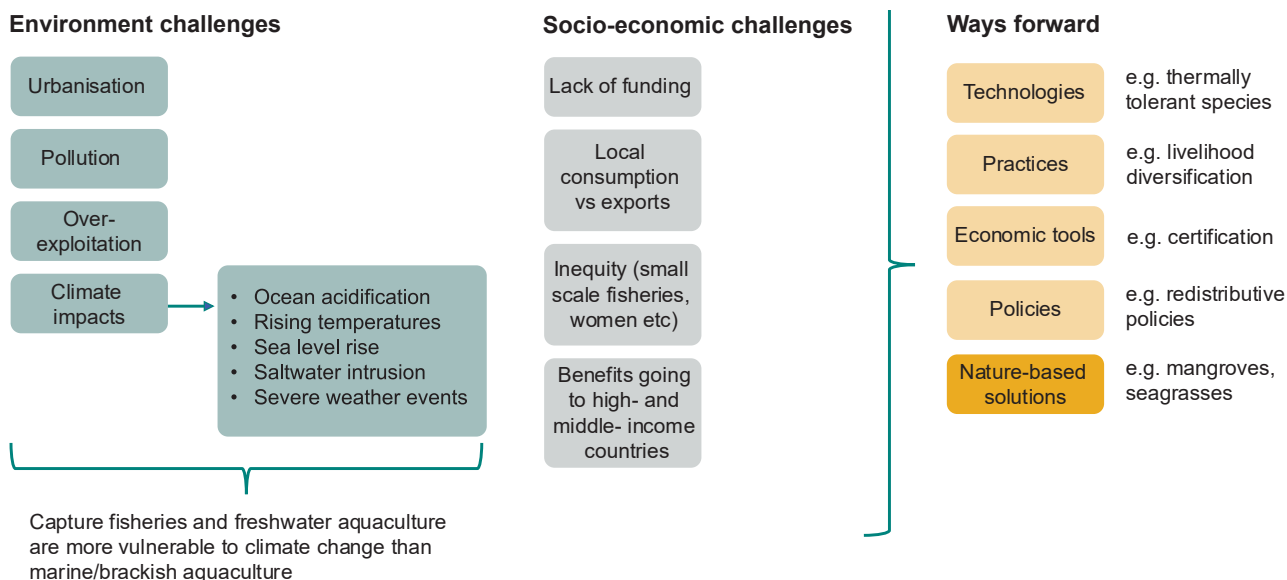


Figure 2: Challenges faced by blue foods

Understanding the links between blue foods and NbS

NbS are increasingly framed as facilitating the protection, sustainable management and restoration of ecosystems to address challenges such as climate change or biodiversity depletion. While NbS have been discussed in relation to land-based food systems (Hrabanski and Le Coq, 2022), the interactions between NbS and blue foods has been less explored. This is surprising, given a large number of blue foods outcomes (e.g., coastal livelihoods and micro-nutrient contributions in the Pacific) are delivered within Marine Protected Areas and broader marine ecosystems (McCarter et al., 2023).

We propose two main framings that link blue foods production activities with NbS. Firstly, NbS can take the form of environmentally oriented actions targeting the conservation or restoration of coastal ecosystems, which can support blue foods. This can be, for example, a locally managed protected area or a community-based fisheries management program that has, as a co-benefit, income generation. Secondly, the explicit management of a blue foods commodity can have the co-benefit of supporting climate resilience and conservation outcomes.

Food security and livelihood outcomes refer to the way ecosystems/blue foods management strategies may constitute a nursery and habitat for marine organisms, which can be harvested for direct consumption or sale.

Conservation outcomes refer to the way ecosystems/blue foods management strategies may constitute a nursery and habitat for marine organisms, therefore enriching biodiversity.

Climate outcomes refer to the way ecosystems/blue foods management strategies may help withstand the environmental effects of climate change, including sea-level rise, increased temperatures, soil erosion, ocean acidification and extreme weather events. Some ecosystems, including seagrasses, have an additional mitigation aspect through carbon sequestration.

Table 1 presents a synthesis of how NbS or blue foods management strategies may deliver food-harvest, conservation and climate outcomes.

Table 1: Outcomes of ecosystem conservation/restoration and blue foods management strategies (The Nature Conservancy, 2021; UNEP, 2016).

| Blue foods-NbS link | Activity | Food security and livelihood outcomes | Conservation outcomes | Climate outcomes |
|---------------------------------------|---|---|--|---|
| Conservation-oriented outcomes | Mangrove conservation or restoration | Availability of fish, crabs, prawns and invertebrates | Habitats and nurseries for fish, crabs, prawns and invertebrates | Facilitates adaptation to sea temperature rise, sea-level rise and extreme events. |
| | Coral reef conservation or restoration | Availability of fish, crabs and invertebrates | Habitats and nurseries for fish, crabs, invertebrates | Facilitates adaptation to sea temperature rise, sea-level rise, ocean acidification and extreme events. |
| | Seagrass conservation or restoration | Availability of fish | Habitats for fish; food for animals | Facilitates adaptation to sea temperature rise, sea-level rise, ocean acidification and extreme events |
| | Coastal wetland conservation or restoration | Availability of fish and shellfish | Fish breeding and nursery, habitat for shellfish and mammals | Facilitates adaptation to sea temperature rise, sea-level rise and ocean acidification |
| | Shellfish reef conservation or restoration | Availability of fish and crabs | Fish, crabs, water filtration | Facilitates adaptation to extreme events |
| | Coastal lagoons conservation or restoration | Availability of fish, crabs, invertebrates | Habitat for fish, crabs and invertebrates | Facilitates adaptation to sea temperature rise, sea-level rise, ocean acidification and extreme events |
| | Food security and livelihood-oriented outcomes | Ecosystem-based aquaculture | Tilapia, freshwater prawns, Mexican blue shrimps, seaweed | Habitat generation |
| Freshwater and coastal fisheries | | Molluscs, freshwater fish, crustaceans | Habitat for marine species, mangrove areas and birds | Facilitates adaptation to sea temperature rise |

3. Research approach

The theoretical framework underpinning the case study approach is grounded in systems thinking, a broad field with extensive histories and methodologies (Reynolds and Holwell, 2020). Using this approach, we sought to focus on the boundaries, feedbacks and influence of specific activities on broader sustainable development outcomes.

To help define the system boundaries and help with our data collection and analysis, a blue foods outcome framework (Figure 3) was developed. The research approach was qualitative and drew on primary and secondary data across sectors (conservation, food security and livelihoods, and climate) and scales (regional, national, subnational and community levels).

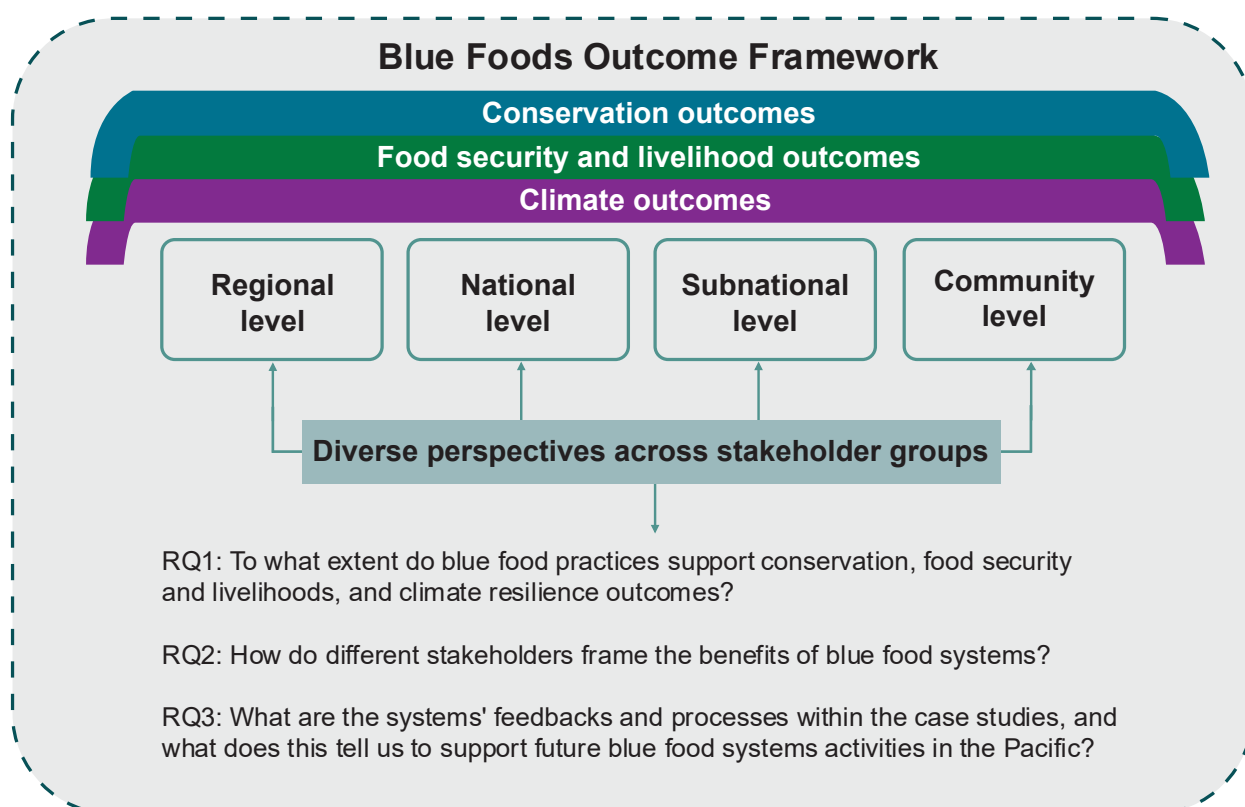


Figure 3: Blue Foods Outcome Framework.

The framework focuses on three possible outcomes of blue foods.

- **Conservation outcomes:** Blue foods systems can incentivise conservation practices, as improved habitat management leads to enhanced species diversity, supporting both food security and livelihood outcomes (Troell et al., 2023). For instance, well managed aquaculture can replace or supplement over-exploited and endangered species by using hatcheries that cultivate the different life stages of aquatic organisms (Froehlich et al., 2017). Additionally, supporting blue foods can create habitats that serve as nurseries for wild species (Le Gouvello et al., 2023), as well as providing these wild species with extra energy sources (Froehlich et al., 2017).
- **Food security and livelihood outcomes:** In PICTs, blue foods play an important nutritional role, with fish accounting for 50-90% of the protein intake of coastal communities (Bell et al., 2009; Wabnitz et al., 2023). The substantial health benefits of blue foods make them crucial to the future health of the Pacific region's growing population. Blue foods also make major socio-economic contributions. This is particularly true for island nations, which

depend more heavily on aquatic food systems than other food systems in terms of consumption, trade and value chain revenue (Wabnitz et al., 2023).

- **Climate outcomes:** Blue foods provide both climate mitigation and adaptation opportunities. For example, compared to terrestrial agriculture, blue foods release less GHG emissions than livestock production systems, while minimising land use/conversion and impacts on freshwater resources (Crona et al., 2023, p.105). Blue foods also represent an opportunity for carbon storage within ecosystems, and protection from climate hazards. For example, mangroves provide a natural buffer to storm and wave inundation and support alternate livelihood options.

Project research questions

The three framework categories and the blue foods systems context were used to develop the following guiding research questions:

1. To what extent do blue foods practices support conservation, livelihoods and food security, and climate resilience outcomes?
2. How do different stakeholders frame the benefits of blue foods systems?
3. What are the systems feedbacks and processes within the case studies, and what does this tell us to support future blue foods systems activities in the Pacific?

Case study selection was purposeful. Scoping interviews were conducted with four researchers and practitioners with knowledge of the blue foods and NbS context in the Pacific. Based on those interviews and desktop research, a set of criteria was developed in partnership with WWF-Australia to identify relevant case studies.

Two case studies were finally selected for the project: i) mangrove oysters in Muanaira and ii) seagrass restoration in Dawasamu. For each case study, a one-day visit included key informant interviews and workshop activities, focus group discussions, rich picture exercises and future visioning activities. Aquaculture and restoration sites were also visited. Key informant interviews and workshop activities overlapped, with most participants taking part in both. See Table 2 for an overview of community participation.

Table 2: Community participants.

| | Mangrove oysters in Muanaira | Seagrass restoration in Dawasamu |
|---------------------------------|-------------------------------------|---|
| Key informant interviews | 4 interviews | 7 interviews |
| Women | 7 women | 8 women |
| Men | 10 men | 6 men |
| Youth | n/a | 2 young men |
| Workshop activities | 4 groups | 5 groups |
| Women | 8 women | 9 women |
| Men | 7 men | 7 men |
| Youth | n/a | 2 young men |

UTS-ISF researchers worked in close partnership with the Ministry of Fisheries to provide access and entry into the community, and the ministry was present at both community visits. SPC technical experts and FNU staff and students worked alongside UTS-ISF researchers to collect data and to help align the study with existing areas of interest in Fiji's blue foods, notably the 2023 Aquaculture Policy and 2024-28 Strategic Development Plan. The study results were coded in NVivo using the three framework categories above. The research was approved by the University of Technology Sydney under ethics program approval number ETH21-6538 for project 22199 under the Institute for Sustainable Futures.

Additionally, once data was coded, the core research team generated causal loop diagrams (CLDs) to paint a systemic picture of the drivers and influences of change for specific blue foods activities. A CLD is a visual tool that helps understand the drivers of change on a specific issue, and the associated impacts of the change taking place. Variables in a CLD are representations of a 'stock' in a system that can change. Relationships between variables are depicted by arrows indicating the direction of influence.

In addition to community visits, five complementary interviews were conducted with 11 interviewees representing regional, national and subnational stakeholders. They included government representatives, NGOs and consultancies.



Muanaira, Fiji home to a mangrove rock oyster project featured as a case study in this report. ©WWF-Pacific

4. Regional and national context

While the PICTs region and communities are highly heterogenous, regional agencies and national governments continue to play an important role in shaping policy and evidence in sustainable development and conservation matters. To contextualise the community-level outcomes from blue foods activities, we first wanted to understand the framing of blue foods by regional agencies and the national government.

Interviews with regional experts and in-country stakeholders working in government, civil society, the private sector and regional organisations informed our framings in relation to blue foods. Branches of government regard blue foods differently, in line with ministerial priorities that change with the national government's agenda. Fiji's Ministry of Fisheries (MoF) and Ministry of iTaukei Affairs were consulted, and their different framings are described below.

Food security, income generation and livelihoods are the MoF's key priorities for investing in blue foods systems, notably in the production and scaling of aquaculture and inshore fisheries industries. A MoF interviewee described major programs of work relating to mariculture and inshore fisheries. This is perceived as a major driver of future incomes and necessary to support demand from Fiji's growing population. Many of the inshore activities blend community livelihood support with research conducted by the MoF and SPC, which is often associated with monitoring, establishing baselines or trials for aquaculture industry development.

Economic returns and benefits were the main reasons given for investment in aquaculture, a major activity with the potential to support income generation and food security for Fiji. The 2024-28 Aquaculture Development Plan has been a major focus for the MoF and will continue to inform sector development into the future. It seeks to increase the value of aquaculture from FJ\$1.1 million to FJ\$132 million by 2028, reduce the value of imported seafood by 70%, and increase export earnings from cultured marine products from FJ\$5 million to FJ\$80 million. Sustainable practices are core to the plan, which prioritises nine key species: black-lip oysters, seaweed, black tiger prawns, Pacific white shrimp, giant river prawns, tilapia, giant clams, rock oysters and Mabe pearls. A MoF interviewee also noted the importance of aquaculture, and MoF's perception that it had multiple future economic benefits. They said that: "New legislation and policy in aquaculture is being developed to establish a framework for aquaculture—at the moment there is nothing supporting the development of the industry".

Overarching MoF policies have a major focus on the blue economy as a livelihood and income generating driver of poverty reduction and fisheries management. In 2024, it launched its 2024-2028 Strategic Development Plan, which it described as a roadmap "to achieving ecological balance, economic growth, and climate resilience in the fisheries sector".

However, while the sector is well known to be vulnerable to extreme weather events, ocean acidification and warming temperatures, strategies to manage climate change are not fully built into the plan's largely economic activities. At present, there is limited integration of climate risks and science across marine policies, despite a growing level of awareness among MoF stakeholders of the need to consider climate change. Climate change is only used five times in the 2024-28 Strategic Development Plan, largely to emphasise vulnerability and industry constraints in coastal fisheries (p.10) and aquaculture sectors (p.13). Research activities are presented as essential to helping understand and address the impacts of climate change.

Considering the limited detail and guidance on climate resilience factors and adaptation strategies within the Strategic Development Plan, it will be challenging to ensure current and future marine industries can manage long-term climate change impacts. A MoF interviewee noted that they were

not using indicators for climate risks yet, but were using seasonal forecasts for spawning, and that while no research had been conducted on the climate impacts on aquaculture commodities, it was “important to ask the questions”. Embedding climate change adaptation and resilience building is therefore an area of opportunity, given the vulnerability of species and infrastructure associated with blue foods.

MoF policy has a strong impact on the sustainability of species, requiring the right balance of conservation and demand for income. An NGO representative interviewed observed that MoF priorities regarding blue foods had changed over the years, depending on the government of the day. “Fiji sea cucumber fisheries were protected [in the past] ... The last government made a decision in consultation with the traditional custodians of resources and kept on opening the sea cucumbers fisheries [for harvesting] until [there was] nearly nothing left. The new government’s Minister of Fisheries Director is a fisheries person, and she has this as a priority [to change],” said the NGO interviewee.

In its National Climate Change Policy (NCCP) 2018-2030, the Fijian Government recognises the central role of fisheries in the provision of livelihoods and food security. It also acknowledges the risks that a range of drivers, including climate change and overfishing, pose to the health of marine ecosystems and Fijian society, due to its high dependence on them. Indeed, the NCCP highlights the importance of utilising governance mechanisms to manage fisheries in a way that ensures both healthy ecosystems and the provision of livelihood opportunities. NbS, notably in the form of locally managed coastal fisheries, are considered a way to achieve that objective. More broadly, they are believed vital to Fiji reaching its mitigation and adaptation targets, especially by providing carbon sinks.

Another ministry that has an interest in the socio-ecological nature of blue foods is the Ministry of iTaukei Affairs. Its framing of blue foods activities was holistic and integrated, touching on all three outcomes. The ministry’s support of sustainable livelihoods recognised the importance of conservation and climate change, which is one of five key priorities within its mandate for looking after the wellbeing of villages. Provincial Conservation Officers implement four programs relating to natural resources, water, climate resilience and disaster risk management. This is organised around the governance structure of Integrated Village Development Plans. iTaukei Affairs works closely through local traditional governance structures and prioritises traditional knowledge regarding natural resources and ecological systems. An iTaukei Affairs interviewee described the more holistic approach to village development, and the tension between conservation outcomes and development activities: “When we are trying to encourage communities to protect their marine area, we need to give them alternative livelihoods. What we witness with communities is that the mindset is to keep separate sustainable development and conservation”.

Integrating conservation outcomes into planning strategies is critical, given the environmental and economic pressures on rural communities. Unsurprisingly, conservation NGOs hold conservation, biodiversity and resilience high in their priorities for the framing of blue foods activities. “We now have a climate change component [in a fish stock management plan] and will let them [community members] know about how climate impacts productivity,” said an NGO interviewee.

Based on their experience of working in diverse communities in Fiji, the NGO interviewee said awareness of climate change impacts was increasing at the community level. This is likely due to a combination of lived experiences of climate impact, and the substantial amount of work that takes place in Fiji in the context of climate change, including donor-funded projects. The NGO stakeholder noted that: “Communities are becoming well informed on the impacts of climate change in their local areas and fishing grounds”.

One business representative emphasised the need to provide alternate livelihood options in parallel with conservation efforts. This speaks to the reality of traditional communities requiring cash for day-to-day life. The NGO interviewee also described examples of blue foods projects that have been able to balance gender-inclusive conservation benefits with income generation, speaking of an oyster farm in Vanua Levu. “In addition to growing pearl oysters for their meat, spat lines act as aggregators for other species, so they [the women in the community] have sea grapes on their collectors (spat lines), which are an additional income source and a food source. This is positive in the sense that the environment is cleaned because oysters are [filter] cleaners. Other species are aggregating, and women are collecting that, and it helps with livelihood, income and it has nutritional value for the community.”

As a regional organisation, SPC champions science and knowledge to support ministries to achieve their policy objectives. The sectoral nature of ministries means many scientific endeavours are targeted at the technological, monitoring and scientific dimensions of blue foods. This is also evidenced in the current regional work SPC is doing on blue foods systems mapping (Wabnitz et al., 2023). SPC interviewees work extensively with government and industry, including farmers and fishers across the Pacific region. As part of their mandate to support national ministries, a current focus is supporting industry to move from semi-commercial to commercial scale and, in doing so, consider overall industry sustainability.

In some countries, where community-based fisheries management has been prioritised, SPC continues to support evidence and data related to this practice. In other contexts, it focuses on supporting industry development. This aligns with the Ministry of Fisheries’ visions for aquaculture, explained earlier. While the MoF’s policy may have limited focus on climate change strategies, SPC brings scientific evidence to more explicitly factor in matters of food security, conservation and climate resilience outcomes. When asked specifically about the extent to which industry stakeholders were considering climate change in their operations, an SPC interviewee observed that demand for climate resilient practices was strong and increasing, in line with awareness of the risks climate change poses to sustainability and productivity, as described in the quotes below.

“A lot of the farmers and industries are asking for the climate smart practices and methods; the demand is coming from the industry.”

“The industry is responding to the warming climate—for example, prawn being grown deeper [due to the] warmer temperatures.”

Summary of national and regional developments in blue foods systems

The field of marine conservation and coastal fisheries industries and aquaculture is well researched throughout the Pacific region. This includes substantial bodies of work on Marine Protected Areas, community-based fisheries management, aquaculture and mariculture systems, and value chain and industry development. This has influenced how communities integrate their traditional management (such as community-based fisheries management) with more recent evidence and experience in economic livelihoods and, to a lesser extent, climate change and resilience building. National ministries (such as Fiji’s Ministry of Fisheries) have clear strategic and policy visions to grow aquaculture industries. This is in response to a series of factors, particularly the pressures of population growth and industrialisation on coastal marine species. While the aquaculture policies set extremely ambitious targets, there is a large opportunity for this industry to grow in a way that supports ocean-based systems and broader ecosystem conservation. Given the heterogenous risks of climate change in Fiji (and broader inshore systems in the Pacific), it is critical that technical agencies SPC and NGOs support ministries and communities to embed climate adaptation and resilience strategies in their blue foods activities.

While the term blue foods is not commonly used, the core activities associated with the concept (eg. aquaculture) and their various outcomes are part of the current approach to marine systems management. However, productivity and income generation are dominant priorities of fisheries ministries. Even when the importance of adaptation and conservation efforts is recognised, it can be challenging to integrate them into the dominant programs and policies.

as Marine Protected Areas (Sievanen et al., 2013). The chief owns the fishing grounds for Muanaira, which includes 10 villages. The qoliqoli is the total fishing area and the kanakana is the subsistence area, along with the immediate shore next to villages, including the mudflats, mangroves, lagoons and reefs. Incomes are generated from the sale of marine species from inshore fisheries and mangroves, including rock oysters and a range of river and inshore fish. At the time of research, rock oysters were being sold for around FJD\$20 per dozen.

Government support has provided Muanaira with solar panels and batteries, water tanks and river-bed protective structures, and covered the cost of dredging parts of the Rewa River (Kinch et al., 2019). Evidence of additional external support is evident in village signage, with SPREP, SPC, USP, Vodafone, Conservation International and China Aid providing support to diverse projects, including beekeeping, pollution control, cyclone recovery and renewable energy (Kinch et al., 2019). This indicates that Muanaira has frequent and ongoing interactions with governments, international aid workers and researchers, differentiating it from more remote Fijian river communities.

Mangrove oysters occur naturally in the Rewa River. The native species (*Saccrostea mordax*) has been harvested traditionally. In the 1970s, the *Crassostrea* species was introduced. Testing done by James Cook University in Australia reveals that the community now harvests three species: *C. bilineata*, *Saccrostea mordax* and *Saccrostea* (non-mordax lineage). In 2018, the Ministry of Fisheries and SPC began working with Muanaira women on a targeted project to establish more formal oyster farms to create a new income stream. Funding from the New Zealand Ministry of Foreign Affairs and Trade (MFAT) enabled the purchase of the oyster baskets, and SPC's technical support enabled villagers to collect the young oysters (spats) to improve production. This program helped establish a community program whereby oysters are managed for income generation and supported the development of studies on the value chains and management components of the mangrove oysters (Kinch et al., 2019, 2019).

Conservation outcomes

Ecosystem health directly benefits livelihoods. Community members strongly recognised the need to conserve and protect mangroves, given the role they play in the growth and productivity of income-producing oysters. For example, community members only harvested older mangroves for firewood and sought to protect younger ones due to their ecological value. A woman interviewed described her understanding of the importance of mangroves: "There are plenty of types of mangroves. The ones they [community members] cut are bigger and inland. Not the ones the oysters stick to. It is illegal to cut mangroves. What they do instead is find the old or rotten ones for firewood".

An interviewee from a regional organisation also confirmed that community members no longer cut mangroves for firewood where juvenile oysters were growing: "Harvesting of the spat is being managed [by the community] through reducing the deforestation of mangroves."

Oyster farm posts (shown in Figure 5) provided the foundation for the growth of seaweed, which creates new habitats for a diversity of marine life. Women in the community described how green seaweed (lumi) was growing on the posts and attracted fish. These new and expanding habitats were adding to the quantity and diversity of fish in the bay where the oyster farm was located.

The image in Figure 6, which was used to discuss the perceived increase in fish species accompanying the growth of oyster production in the river system, shows the system surrounded by fish (see blue square).



Figure 5: Cages the community used for oyster production.



Figure 6: Rich picture of one group in the Rewa River and oyster production system (blue square).

Oyster food safety was an issue identified in relation to historical sewage issues affecting water quality. A sewage contamination event affected the Muanaira environment over 10 years ago and prompted a year-long mandatory pause on all fishing activities, which significantly impacted community livelihoods. While the community noted that the sewage line had been upgraded, it still influenced water quality, fishing and oyster farm location, as described by a woman in the community: “The new sewage line is affecting fish and shellfish. Mangrove oysters were moved toward the mouth of the river because of the sewage line”. One man also noted they were working with a human rights NGO to manage the impacts of the sewage and its effects on local waterways. Managing pollutants has direct implications for the health of the ecosystem and oyster quality, so is important to livelihoods.

Climate outcomes

The climate resilience benefits of mangrove oyster farming in Muanaira were indirect and largely unintentional. Adaptation outcomes were achieved through the planting and protection of mangroves as habitat for growing mangrove oysters. The community has an ongoing mangrove seedling growing system and mangrove replanting program, driven mainly by a desire to support habitat for mangrove oysters. The climate adaptation benefits of mangroves—to build climate buffers—were not a driver for maintaining the habitat.

There was some evidence that recent extreme weather events and impacts on fishing activities had made community members critically aware of climate impacts on marine environments. They had a clear understanding of the impacts on their local fishing grounds, but further action is needed to implement climate resilient practices.

Two community members mentioned the link between mangroves and climate change, namely the ability of mangroves to provide a buffer against storms and to sequester carbon. While the community has a strong sense of ownership of mangrove management, the need to translate high-level climate policies into actionable plans at the community level was highlighted by regional stakeholders—not the community themselves. An NGO interviewee said that while governments are implementing climate resilient policies and strategies, more is needed for communities to take practical action: “There are big gaps between [Government] directives and understanding of communities”. This is a common challenge in Fiji (and other Pacific communities), where national laws and policies often speak to international agreements and climate finance bodies, but are disconnected from the everyday realities of rural community life (UNDP et al., 2021).

Food security and livelihood outcomes

Oyster harvesting in Muanaira is a traditional practice and often seen as women’s work. Community members explained how young girls typically accompany their mothers on harvesting activities from an early age. However, men, extended family members and friends often also joined women to support various activities associated with harvesting the wild oysters, which form part of the traditional diet.

Women invested the income from oyster sales into a range of activities that benefitted community livelihoods. Profits began accruing in 2019 and enabled the purchase of a sewing machine and bed sheets and paid for boat expenses and materials for a path to the village church. Profits also supported children’s school fees and contributed to water tanks for the village. These investments supported daily life and, through the sewing machine and boat expenses, provided assets and the ability to further diversify income and livelihood sources. The sewing machine, for example, continues to be used for crafts and materials that are sold at markets.

The income generation potential of mangrove oysters is constrained by broader market factors. Sales of oysters started out strongly when the project began in 2019, but have since stalled due to changes in customer demand, a lack of marketing and increased competition. Oysters harvested in Muanaira were initially sold to a restaurant in Suva for approximately FJD\$30/dozen over 2019-2020. When COVID-19 hit, sales drastically declined due to border closures and the reduction in international tourists. Since then, women in the village described the challenge of finding and growing new oyster markets. At the time of this study, over a period of approximately three months, the main sales had been 37 dozen oysters (444 individual oysters) to three buyers, with a Suva restaurant being the largest single buyer in 2024. While vendors continue to use their existing networks to sell occasionally and receive orders for specific events (including international workshops and from High Commissions/embassies), there is no consistent oyster demand and guaranteed income for the Muanaira community. This represents a broader market systems

development barrier to the community, but also the Ministry of Fisheries' wider aquaculture ambitions (see the Regional and national context chapter above). According to community members, the challenge is not so much a lack of buyers, but rather the community's inability to understand who the buyers are and to market the products adequately to ensure consistent sales. *Figure 7* shows the discussions being held, and freshly harvested mangrove oysters that the community sells.



Figure 7: Photos from a workshop and harvested mangrove oysters.

The community requires marketing and business skills to reach a broader customer base. Community members reflected that while they had received technical assistance from the Ministry of Fisheries and SPC to establish the oyster farm, there had been limited assistance in product distribution and marketing. This highlights the challenges of approaching blue foods investments from one particular focus (technical and productivity dimensions) while overlooking training and skill building in the commercialisation and market development phase for niche commodities.

Competition from other producers also creates livelihood risks due to fluctuating prices. The absence of commodity price regulation means that cheaper options are available to consumers. The Fijian Competition and Consumer Commission can regulate the price of certain food items. However, this mainly applies to packaged goods (e.g. butter, salt, rice) and imported fresh produce (such as garlic and onions). No marine commodities are regulated, and this study was unable to identify the source of lower-priced oysters in the market, which one community member estimated were selling for as little as FJD\$7 per dozen.

Community benefits and priorities

Community members described mangrove oyster farming as primarily supporting food security and livelihoods in Muanaira. The oyster farming project was developed with the support of Fiji's Ministry of Fisheries to help the community commercialise its oysters. As such, the primary framing here is one of economic livelihoods. Community members were keen to upscale the mangrove oyster farming activities, with some envisaging the entire bay filled with oyster farms.

Climate change was not an issue identified frequently during community engagement. Only one or two research participants identified it as a driver of the broader changes that people described. Despite being asked about, climate risks were not a dominant focus of conversations during the focus group discussions.

The Muanaira community also stressed the importance of a healthy ecosystem to ensure food provision. For example, men described how more sediment had been transported to the intertidal zone in recent years, blocking one arm of the river and destroying fish habitat: "Around here, there used to be deep pools of water where we used to go fish and now they are filled with mud. There is

no more fish in those areas”. While these observations focus on the impacts of climate change and upstream activities on the health of the river in general, rather than on the mangrove oyster habitat specifically, they illustrate the connections community members drew between ecosystem health and food provision.

Men and women of Muanaira described how their future priorities for the mangrove oysters related to conservation and biodiversity protection. During focus group discussions, they expressed their desire for mangrove oyster sites to support diverse species, serve as feeding grounds and eventually become Marine Protected Areas (MPAs). When asked to identify their future priorities for mangrove oysters, research participants’ votes (Figure 8) favoured MPAs and habitat for other species. MPAs, particularly, were discussed as being a useful management strategy for justifying increased community monitoring and policing of oyster grounds, to reduce the risk of theft. Overall, habitat conservation was also prioritised, given the contribution of fish to livelihoods and food security.

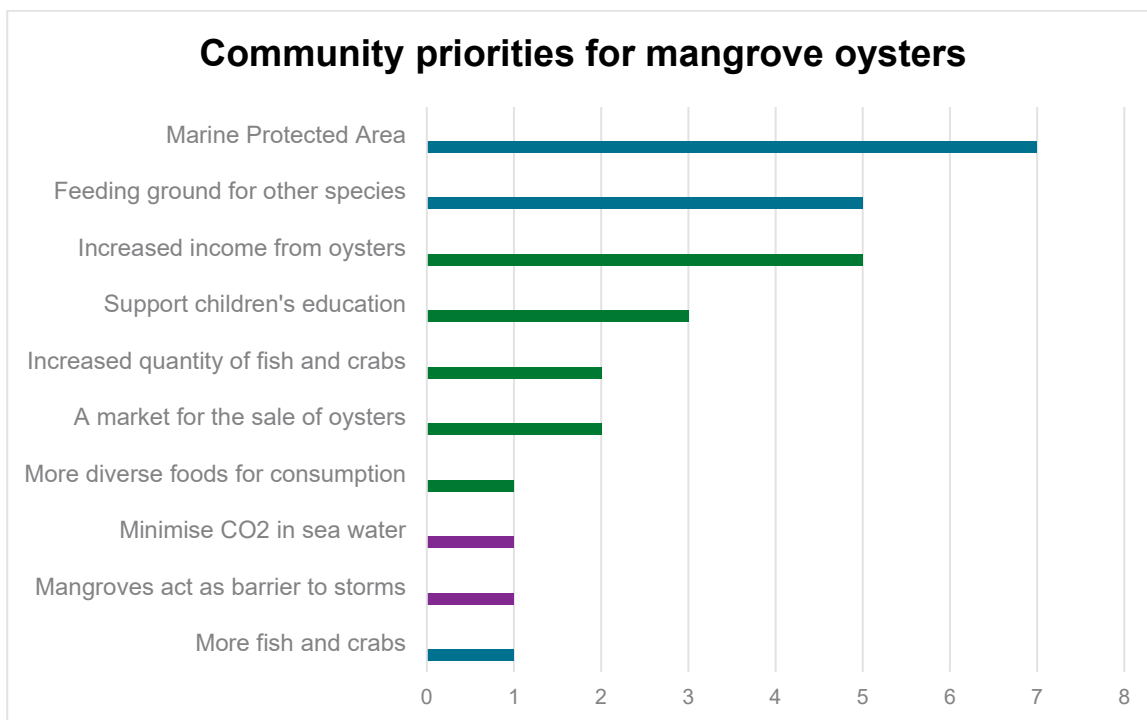


Figure 8: Community priorities for mangrove oysters.

Note: Colours represent the three blue foods outcomes domains, where blue = conservation outcomes, green = livelihood and food security outcomes, and purple = climate resilience outcomes.

Feedback and processes–Causal Loop Diagram analysis

In the system presented below (Figure 9), the variable of interest is the ‘total area dedicated to mangrove oysters’.

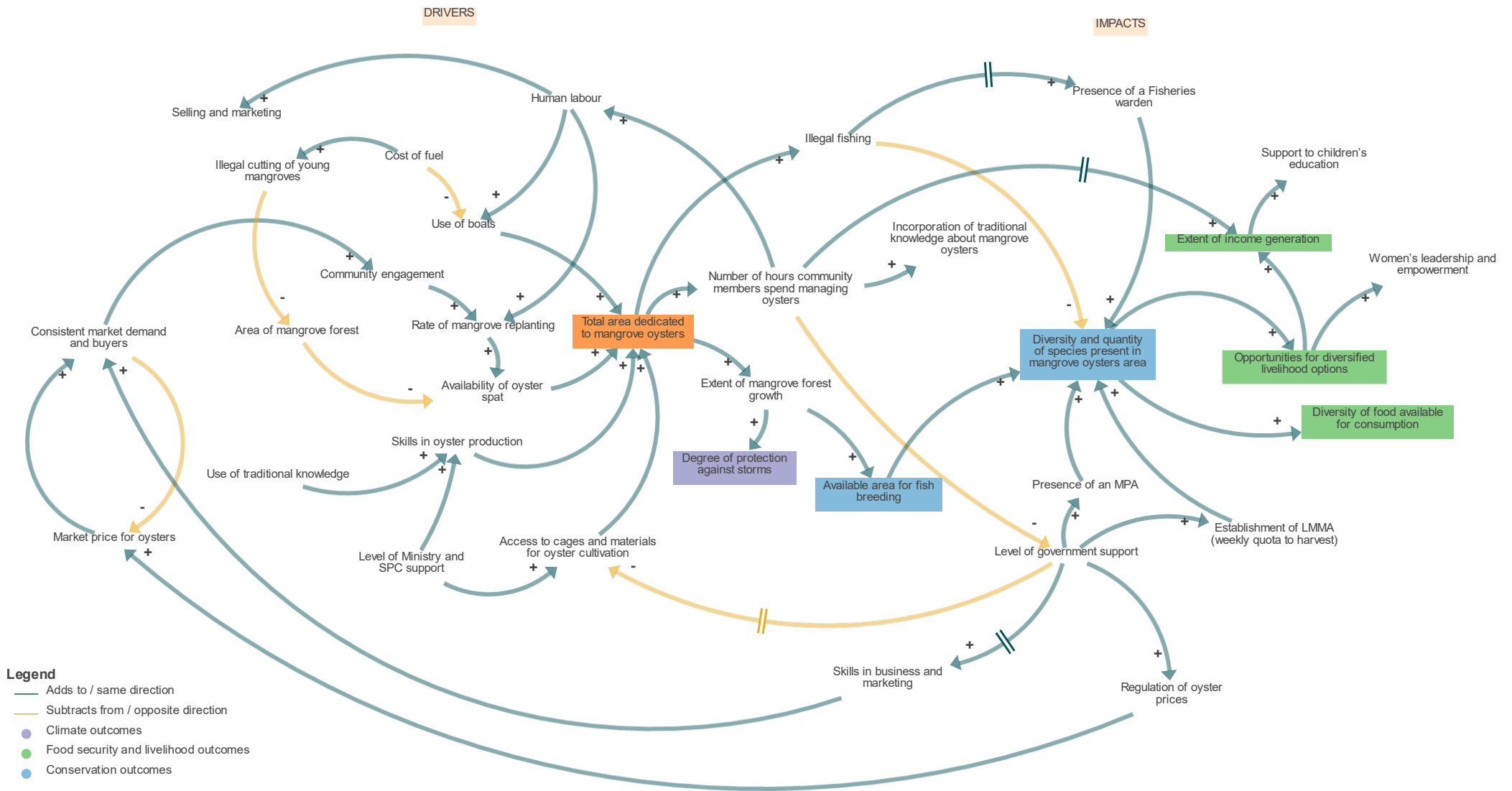


Figure 9: Causal Loop Diagram for the mangrove oysters case study.

Positive (+) arrows indicate an amplifying effect. Negative (-) arrows indicate a dampening effect

Drivers influencing the total area dedicated to mangrove oysters

The left-hand side of the diagram focuses on indirect and direct drivers of change potentially influencing the total area dedicated to mangrove oysters. Several processes amplify or augment a part of the system (green arrows with a + sign), while others (yellow arrows with a – sign) reduce or dampen the variable they are linked with.

The increase in the area dedicated to mangrove oysters depends largely on the availability of and access to a range of material and biological resources. This includes:

- **Access to cages and materials for oyster cultivation**, which have so far been provided by SPC and the Ministry of Fisheries;
- **Skills in oyster production**, which are determined by the presence of traditional knowledge and training and capacity-building from SPC and the Ministry;
- **Availability of oyster spat**, which can be influenced by the rate of mangrove replanting, considering that the spat grows in the mangrove. The rate of replanting can, itself, be influenced by the degree of community engagement. While the Muanaira community may decide to replant mangroves for a range of reasons, the economic opportunities represented by mangrove oyster cultivation may act as an incentive to replant mangroves;
- **Market demand and price**, which can influence how much the community engages and increases their oyster cultivation area, thus creating demand for more oyster spat. Consistent demand for oysters can influence price (through competition) and create incentives for communities to participate in the oyster market;
- **Access to boats and the cost of fuel**: The cultivation and sale of mangrove oysters requires boats to travel to the cultivation area, retrieve the oysters for cleaning and then dispatch them to sale points. This can all be influenced by fuel costs. As the cost of gas for home cooking increases, accelerating demand for firewood, there is also a risk that illegal mangrove cutting might occur;
- **Human labour**: This is a major system requirement, to manage oyster growth, replant, harvest and sell the commodity; and
- **Illegal cutting of young mangroves**, which threatens overall ecosystem health, and can potentially have a long-term impact on the total area of mangrove forest and naturally occurring spat. This can be supplemented by hatchery spat, however mangrove conservation is still threatened by human energy demand pressures.

Impacts from changes in the total area dedicated to mangrove oysters

The right-hand side of the diagram focuses on the potential changes in the system that would eventuate if the total area dedicated to mangrove oysters were to increase. This is not fully realised yet, due to limited market opportunities. These impacts reflect the potential trajectory for Muanaira communities if opportunities for oyster sales increased and operations were scaled. They include:

- **Conservation impacts**: If the total area dedicated to mangrove oysters increased, the extent of mangrove forest may also increase, which could expand breeding grounds for fish and increase the diversity and quantity of species present;
- **Changing role of government**: As the number of community members working in the oyster system increases and the system moves towards commercialisation, the role of government changes. The community indicated the system would need to be regulated and monitored more closely, through the establishment of an MPA and/or Locally Managed Marine Area

(LMMA), to balance livelihood and biodiversity outcomes. As the government steps back from subsidising the industry (mainly through the provision of cages), its role changes from that of an industry catalyser to a regulatory authority that helps to support the industry and community (e.g. regulation of oyster prices). Government can also turn its focus towards developing the marketing and business development skills of community members, so they can increase and diversify their customer base;

- **Food security and livelihood impacts:** Income generation can occur when there is a consistent market for the product. This link has a time delay in the diagram (two lines), indicating that it would take time for income to consistently grow. The community believes this is possible, as it has happened in the past. The species diversity enabled by a healthier ecosystem can have direct food security benefits, as the community can consume and sell different marine species. This has flow-on effects for education, women's leadership and food nutrition; and
- **Climate:** The increase in the extent of the mangrove forest could provide protection against storm surges.



Mangrove oysters harvested in Muanaira ©WWF-Pacific

6. Seagrass restoration in Dawasamu case study

Overview

Case study two focused on a seagrass restoration pilot project in Dawasamu district, in the Tailevu Province at the eastern end of Viti Levu, Fiji (Figure 10).

This pilot is part of the MACBLUE project commissioned by the German Federal Ministry for Environment, Nature Conservation, Nuclear Safety and Consumer Protection and implemented by the German Corporation for International Cooperation GmbH (GIZ), Fiji National University (FNU), The Pacific Community (SPC) and the Secretariat of the Pacific Regional Environment Programme (SPREP) since 2019. The project aims to facilitate the protection and restoration of seagrass ecosystems in the Pacific through a range of research and applied activities, including the development and scaling-up of best management practices. The project is implemented in four countries: Fiji, Papua New Guinea, Solomon Islands and Vanuatu.

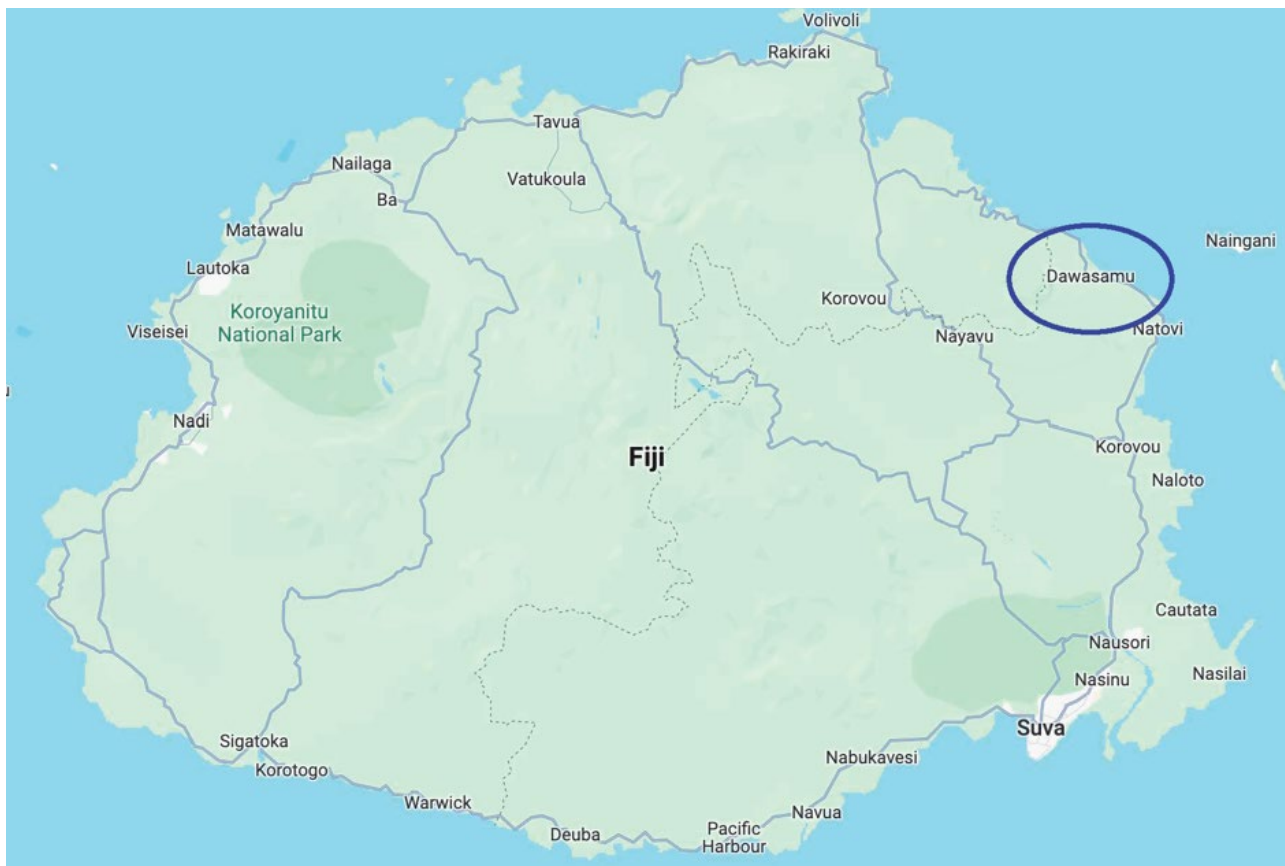


Figure 10: Location of the Dawasamu district, Viti Levu, Fiji.

In the Pacific region, seagrasses are thought to cover 1,446.2 square kilometres (McKenzie et al., 2021a). They are often found near mangroves and coral reefs, and these three ecosystems complement one another. Seagrasses and mangroves absorb sediments from the land to enable reef growth, while the reef protects seagrasses and mangroves from waves and currents (Singh et al., 2021). Seagrass meadows are also thought to absorb carbon, prevent coastal erosion, and provide habitat and nurseries for a range of species, including threatened sea turtles, dugongs and seahorses, and economically significant species, notably molluscs and crustaceans (Singh, 2019; 2022).

Seagrasses are threatened by a range of processes, including extractive activities, infrastructure development, aquaculture, fishing and climate change (Singh, 2019). The exact geographical spread of seagrass ecosystems in the Pacific, as well as the pace and scale of degradation is uncertain. However, it is estimated that by 2100, Pacific islands could lose 5 to 20% (McKenzie and Yoshida, 2020), or even 35% (Singh, 2019) of the seagrasses present today. This would have substantial food security impacts, given the habitat contributions seagrass meadows make, and the associated livelihood benefits they provide to communities.

Improving the state of seagrass ecosystems is dependent on a combination of upland and catchment level interventions, combined with coastal zone restoration. While a strong lever of action is to reduce the impacts of land-based activities on seagrasses, there are also opportunities to use nature-based or ecosystem-based approaches to protect and restore seagrasses (Singh, 2019; Singh et al, 2021).

The seagrass restoration project started in July 2023. Seagrasses were surveyed by FNU researchers in the villages of Silana and Nataleira, where four species were identified. Replanting activities occurred in 2023 in Nataleira, where seagrass meadows were the most degraded. At the time of the research, the plantings were immature, and the monitoring of survival rates was ongoing. As such, the insights provided by community members reflect their hopes for the future benefits of restoration, based on their knowledge of the benefits provided by seagrasses in other areas (i.e. Silana) or in the past.

Community members mentioned a range of climate impacts affecting their farming and fishing activities, including sea-level rise, unpredictable weather patterns and cyclones, which can be accompanied by flooding. Community members cultivate a broad range of root crops, vegetables and fruits, and catch fish and seafood (Table 3). They also sell surplus from both land and sea-based activities through the market. This is the main source of income for the village. Residents increasingly rely on shops for food, including tinned food, chicken, rice, potatoes, noodles, flour, salt, sugar, oil, garlic, cakes and toiletries.

Table 3: Land and sea food items harvested by the community.

| Root crops | Vegetables | Fruits | Fish | Seafood |
|--------------|--------------|------------------|-----------------------------|------------------|
| Cassava | Cabbage | Banana | Barracuda | Giant clam |
| Sweet potato | Capsicum | Breadfruit | Grouper | Lobster |
| Taro | Cucumber | Coconut | Mullet | Mud crab |
| Yam | Leafy greens | Malay rose apple | Netley | Mussels |
| | Long bean | Mango | Parrot fish | Octopus |
| | Pumpkin | Plantain | Rabbitfish | Saltwater prawns |
| | Spinach | | Sardines | Sea cucumbers |
| | Tomato | | Snapper | Sea snails |
| | | | Spanish mackerel | Squid |
| | | | Trevally | Lumi (seaweed) |
| | | | Trochus | |
| | | | (Coral) Trout | |
| | | | Tuna (Skipjack, Yellow fin) | |

Fishing activities are conducted by men, women and youth, with men and young men more likely to go offshore to fish. Line fishing, diving, spearfishing, gleaning and net throwing and net dragging are the main fishing methods used in Nataleira. Community members reported they have noticed a decline in fish diversity in inshore fisheries. The fishing effort (time spent fishing, distance travelled) and its associated costs (e.g. fuel cost) have substantially increased over the past decade. Women used to free-dive near the shore, when seagrass and marine species were abundant, but this activity now occurs too far from shore. Several explanations for fish depletion were put forward, including:

- Overfishing, due to fishermen from out of the area being licensed to fish within the community’s fishing grounds;
- More intensive fishing practices (like the use of larger nets);
- Environmental degradation due to Cyclone Winston (i.e. coral destruction) and the local quarry activities (i.e. high-water turbidity); and
- Changes in weather patterns.

Conservation outcomes

Community members largely acknowledged the role of seagrass meadows as feeding grounds and habitat for marine species. Youth group members described seagrass restoration as a beneficial activity that would “provide room for marine organisms”, and said that seagrasses overall provide habitat for fish, turtles, molluscs and other species valuable to the community (Table 4). Community members hoped that seagrass restoration would lead to an increase in the quantity and diversity of marine species close to shore.

Table 4: Species that can be found in seagrasses, as identified by community members.

Note: This list is provided for illustrative purposes and is not exhaustive. As Fijian terms for species may correspond to various species in the Linnean classification systems, there may be discrepancies between the Fijian and Linnean terms.

| | |
|--------------------|---|
| Echinoderms | <ul style="list-style-type: none"> • Dairo (sand fish or <i>Mefriafyla scabra</i>) |
| Fish | <ul style="list-style-type: none"> • Busa (barred garfish, <i>Hemirhamphus far</i>) • Cucu (juvenile goldsaddle goatfish, <i>Parupeneus cyclostomus</i>) • Daniva (goldspot herring, <i>Herklotsichthys quadrimaculatus</i>) • Kabatia (emperor, <i>Lethrinus semicinctus</i>) • Malea (tilapia, <i>Oreochromis spp.</i>) • Nuqa (rabbit fish, <i>Siganus spp.</i>) • Qitawa (crescent perch, <i>Therapon jarbua</i>) • Saga (bluefin trevally, <i>Caranx melampygus</i>) • Stingrays • Walu (Spanish mackerel, <i>Scomberomorus commerson</i>), • Sharks • Mullet • Nethili • Matu (<i>Gerres spp.</i>) • Kake (<i>Lutjanus spp.</i>) |
| Molluscs | <ul style="list-style-type: none"> • Golea (stromb, <i>Strombus gibberulus</i>) • Kaibakoko (hardshell clam, <i>Periglypta puerpera</i>) |

| | |
|----------|---|
| | <ul style="list-style-type: none"> • Yaga (spider conch, <i>Lambis lambis</i>) |
| Reptiles | <ul style="list-style-type: none"> • Turtles |
| Seaweed | <ul style="list-style-type: none"> • Lumi |

Improved water quality was also considered a potential benefit of seagrass restoration. Youth participants noted that in Silana, where seagrasses are healthy, water quality is better. While they acknowledged that other factors may be at play, including siltation due to the quarry activity, they observed that removing seagrass was making the sand “unstable”, which could lead to increased water turbidity.

Land-based activities—notably quarry work upstream of the river that flows into the ocean near Nataleira, the use of pesticides in agriculture and rubbish dumping—were often described as a source of environmental degradation and an impediment to seagrass restoration. A women’s group mentioned that the community filed a complaint about the quarry activities but did not receive a response. Others, however, noticed that quarry activity had slowed in 2024, but it is unclear if operations have fully stopped. One group of men also mentioned the existence of a Ridge to Reef³ agreement, signed in 2005, that aims to account for the interconnectedness of terrestrial and marine ecosystems, including the impacts of land-based activities, like farming inputs, on the marine environment. However, information about this agreement and the areas it applied to were not handed down to the younger generation. Figure 11 is a visual representation by a men’s group of the proximity of the quarry (left-hand side) to the fishing grounds and seagrass meadows.

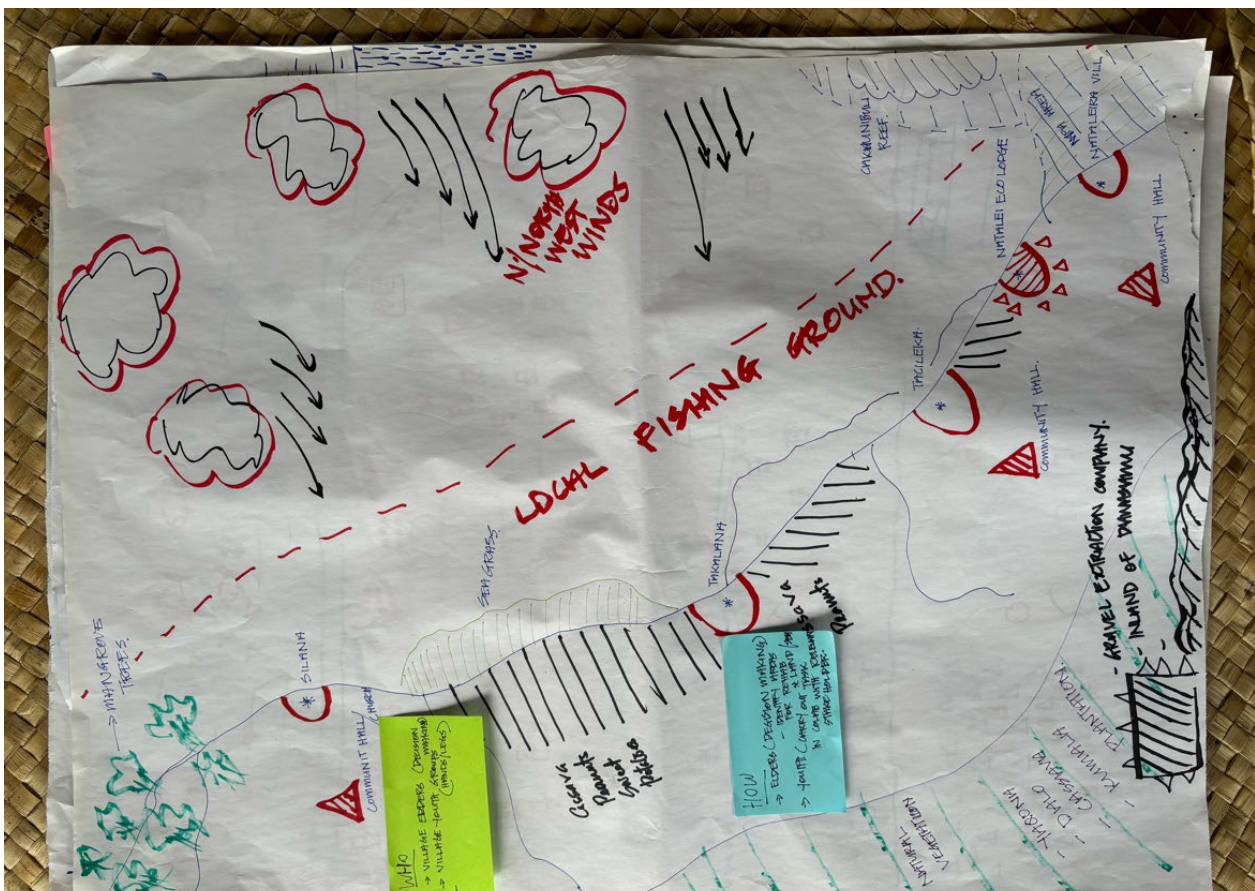


Figure 11: Picture of the community, coastal system and quarry in relation to seagrass restoration.

³ The Reef to Ridge program was initiated by the Global Environment Facility. It involved a range of UN agencies (UNDP, FAO, UNEP) and was implemented in several Pacific Island Countries and Territories. In Fiji, SPC and the Ministry of Forestry played a central role in the on ground implementation of the program.

Fishing activities were also noted as having the potential to affect seagrass restoration. Several community members suggested fencing off the area or reducing the boating presence in areas under restoration.

Scaling up community engagement in seagrass planting and monitoring was considered essential to its restoration. At the time of our visit, community involvement in the project was relatively limited. While participants were aware of the conservation project and supported it, they often acknowledged that they had not been directly involved in replanting activities. They showed interest in being involved in future replanting activities, with a women's group highlighting the importance of ensuring it is not a "one-time thing". Several community members suggested that seagrass restoration activities become part of communal or youth work, and youth participants from Silana agreed. They mentioned that they already planted mangroves and would be interested in extending this to seagrasses. Finally, community members expressed an interest in furthering the collaboration with organisations implementing the seagrass restoration activities (i.e. FNU, LMMA network).

Food security and livelihood outcomes

Seagrass restoration could lead to positive food security and income benefits by increasing the availability of fish and seafood for both direct consumption and sale. Youth participants explained that fishing activities often occur near seagrasses, due to the higher concentration of fish. A women's group drew a direct correlation between the presence of seagrass and food security and livelihood benefits: "Seagrass brings more fish. More fish is available to eat and sell". In general, all community members reflected on the 'past', when seagrass meadows were healthier and fishing required less effort. Women talked about the ability to simply dive near the land, allowing them to harvest required seafoods for daily subsistence. The area is now relatively murky and has low species diversity.

Seagrass restoration could reduce community dependence on purchasing food items and reinforce the barter system. A women's group mentioned that if they were able to catch more fish, they would "eat more fish rather than go and buy to the store" and contribute to the traditional bartering system. The loss of seagrasses, due to human and climatic factors, thus risks eroding traditional practices and exacerbating a situation where food security is increasingly dependent on purchased food items, some of which may have lower nutritional values and contribute to the growth in non-communicable diseases.

Seagrass restoration could also reduce the time and costs of fishing. Community members mentioned that they travel increasingly far to find fish. If seagrass restoration were to increase fish populations closer to shore, fishing would require less effort and less fuel.

Seagrass restoration could be integrated into existing ecotourism activities at the ecolodge in Nataleira. A women's group suggested that the presence of seagrass could become "part of the [touristic] activities to go and snorkel to see the seagrass". Restoration activities, themselves, could become a source of income if the community was paid to replant seagrasses.

However, the benefits of seagrass restoration could be neutralised by overfishing. A men's group mentioned that "economic benefit would come [with seagrass restoration]. But [it would] create a big challenge because people overfish". Several explanations for overfishing were given, including the provision of fishing licences to fishermen outside Nataleira, as well as growing food demands as Nataleira's population increases. It was suggested that a community management plan, developed in collaboration with the Ministry of Fisheries, may be needed to support sustainable inshore management.

Climate outcomes

Community members believed climate change and land-based activities (the local quarry activities and use of chemicals on agricultural land) were, in large part, responsible for seagrass depletion. A men's group mentioned that "man-made climate leads to depletion of seagrass", while a youth participant discussed more specific consequences of climate change, such as wave strength and water temperature: "I think because of stronger waves and water being hotter, less seagrass is present". The youth group also mentioned that restored seagrass could play a role in climate resilience by reducing shoreline erosion.

While there is increasing interest and emerging evidence of the blue carbon benefits of seagrass ecosystems (Singh et al., 2022), this is a technical field and not of direct interest or relevance to the community. As donors increase their focus on blue carbon research and eventual access to growing blue carbon markets, it will be important to ensure communities are across the associated governance and financial dimensions, to ensure equitable access to international carbon markets.

Community benefits and priorities

Community members predominantly framed the role of seagrass restoration in terms of its interconnected conservation, food security and livelihoods outcomes. For example, restored seagrass meadows may increase habitat available to marine species, which is a conservation outcome in itself. Complementing this, restored meadows will also give community members the opportunity to source food for consumption or sale, and reduce the time and money spent on fishing. The main consideration then becomes to balance these two types of outcomes through sustainable inshore management, which the men's group highlighted as a priority.

In contrast, the role of seagrass in climate resilience was less discussed. A comment from the women's group illustrates how seagrass is mainly considered fish habitat, while other ecosystems are seen as having a role in climate resilience: "Seagrass brings more fish, and mangroves keep the strong waves from coming to the village". The role of seagrass in reducing shoreline erosion, and not their part in carbon capture (widely put forward in academic and policy circles), was the main climate resilience role granted to seagrass meadows. While the direct food security, livelihood and conservation benefits of seagrass restoration were prioritised by communities, they may strategically mobilise the carbon capture argument in the future, to access funding for restoration.

Community members identified a range of priorities regarding seagrass ecosystems (see Figure 12). These include:

- **Enhancing livelihood**, with 10 community members prioritising the integration of seagrass in their existing ecotourism business (i.e. an ecolodge). Interestingly, only two community members identified the contribution of seagrass to food consumption ('greater consumption of fish') as a priority, while food consumption was a central topic of discussion during the focus group. This discrepancy may be explained by the fact that as seagrass restoration progresses, its role in food consumption may naturally increase, while its integration into ecotourism activities may require more proactive measures and greater community coordination and governance;
- **Improved water quality**, notably through seagrass replanting activities. During the focus group discussion, several participants mentioned being involved in other restoration activities such as coral reefs restoration (also mentioned as a priority) and mangrove replanting. As seagrasses, mangroves and coral reefs play complementary roles, supporting activities that take a holistic approach to ecosystem restoration and build momentum for other restoration activities may be a fruitful approach. A second

conservation priority appears to be around reducing the negative impacts of pollution and fishing activities (i.e. boat damage) on seagrass; and

- **Furthering community involvement in seagrass restoration activities:** Community members identified education and the integration of replanting in day-to-day activities through community programs as potential strategies to increase engagement. The emphasis placed on community involvement echoes the observation made by community members that while their involvement in seagrass restoration had until now been minimal, they were willing to change that.

The limited emphasis put on climate resilience is also reflected in the priorities established by communities (Figure 12). Erosion control was put forward by only three community members.

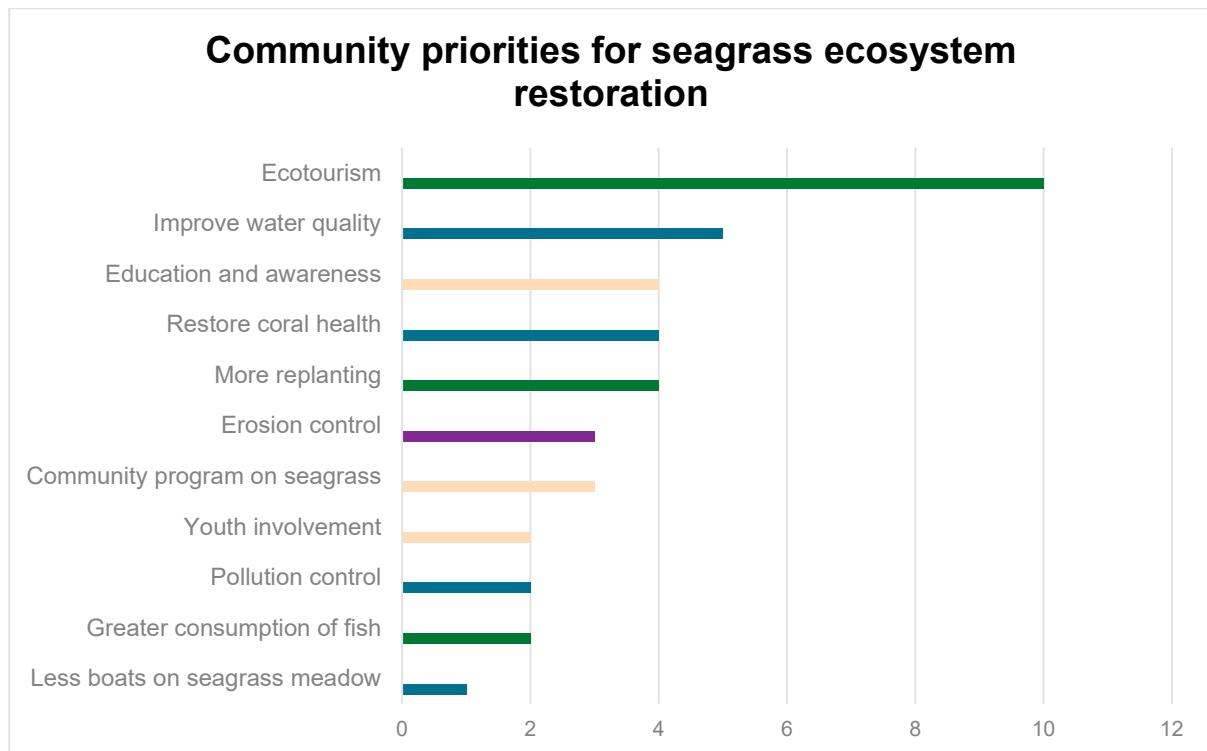


Figure 12: Community priorities for seagrass ecosystem restoration.

Note: Colours represent the three blue food outcomes domains, where blue = conservation outcomes, green = livelihood and food security outcomes, and purple = climate resilience outcomes. The colour orange has been added for priorities that did not directly speak to the three outcomes.

Feedback and processes – Causal Loop Diagram analysis

In the system presented below (Figure 13), the variable of interest is the ‘total area of thriving seagrass ecosystem’, which includes both the seagrass itself and all aquatic species it shelters.

Drivers influencing the total area of thriving seagrass ecosystem

The left-hand side of the diagram focuses on indirect and direct drivers of change potentially influencing the total area of thriving seagrass ecosystem. Several processes amplify or augment a part of the system (green arrows with a + sign). While others (yellow arrows with a – sign) reduce or dampen the variable they are linked with.

The rate of replanting is a major driver of the thriving seagrass ecosystem. The drivers affecting this are linked to the collaboration and coordination that occurs in the community as well as between researchers and community members, and how replanting and monitoring activities are integrated into community programs and traditional practices.

The survival rate is a major influencer of seagrass restoration. It is affected by three factors:

- **Water quality and land-based activities:** This relates to run-off from agricultural land and impacts of extractive activities, notably the establishment, in 2016, of aggregate material processing. While the quarry activities are under review, the water quality and environmental impacts may affect the survival rate of seagrasses;
- **Intensity of fishing methods:** Fishing activities (e.g. dragging nets) may lead to localised impacts on the seagrass planted; and
- **Climate impacts (i.e. rise in sea water temperature, cyclones and storms):** These are macro-drivers that influence the conditions in which seagrass ecosystems can thrive. They are beyond the control of communities and government but are important drivers of change in the system, which may affect survival rates.

Finally, the presence/absence of a diversity of marine species can impact the total area of thriving seagrass ecosystems. This is influenced by the number of marine species withdrawn from the environment. This number can vary due to food demand in the community, the type of fishing equipment used, as well as the issuing of fishing licences to fishers from outside the community.

Impacts from changes in the total area of thriving seagrass ecosystems

The right-hand side of the diagram focuses on the perceived potential changes to the system that would eventuate if seagrass ecosystems thrive. While these are not yet realised, the community highlighted the nascent state of seagrasses and reflected on the historical prevalence of species in the immediate coastal areas to comment on future impacts. These include:

- **Conservation and species diversity, and subsequent links to fishing effort:** This includes increased species diversity in the coastal zone. This is perceived to reduce the fishing effort in terms of fuel costs and time spent in deeper water fishing;
- **Food security and livelihood impacts:** The eventual increase in species diversity and ecosystems would enable greater access to fishing activities in inshore areas. This would have direct impacts on incomes, diets and traditional bartering systems. A higher abundance of marine biodiversity can also potentially boost ecotourism and offer greater income; and
- **Climate:** The presence of seagrasses may reduce coastal erosion, which can be worsened by the effects of climate change.

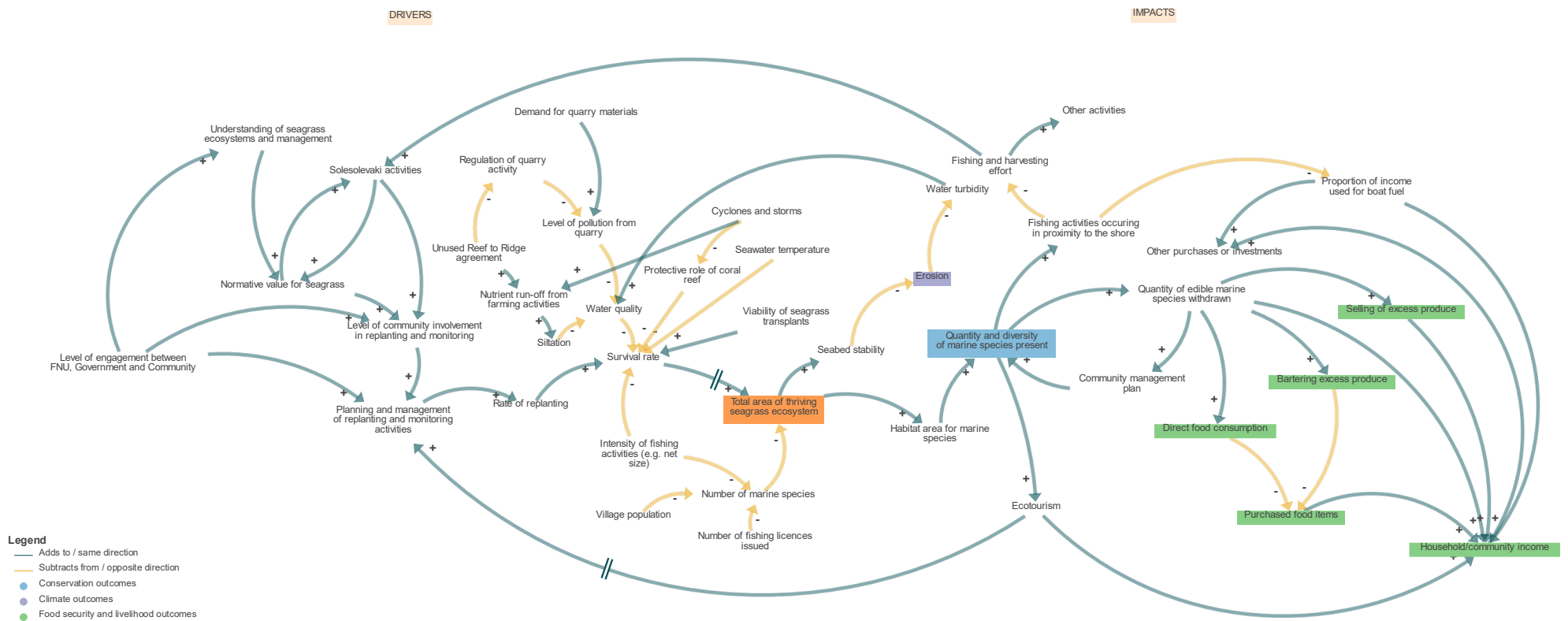


Figure 13: Causal Loop Diagram for the seagrass restoration case study.

Positive (+) arrows indicate an amplifying effect. Negative (-) arrows indicate a dampening effect

7. Implications for blue foods systems as nature-based solutions

This study has explored the extent to which two blue foods activities—an open ocean aquaculture and a restoration program—support different types of outcomes. These outcomes complement the major objectives of land-based NbS approaches, which often aim to balance multiple outcomes. The activities undertaken help us bring a systems-thinking perspective to the often disciplinary and technical approaches associated with marine ecosystems, climate change and food security activities. Analysis and participatory activities provided insights from communities and regional experts on how blue foods activities support different types of conservation, food security and livelihoods, and climate outcomes.

Here, we summarise two main sets of contributions from this study, to support researchers and conservation NGOs working to link blue foods activities to NbS practices and outcomes.

Framing blue foods systems as an NbS and supporting traditional practices

The recent blue foods assessment provided globally salient insights into the economic, environmental and human nutrition contributions they make. The macro-scale nature of this assessment provides much-needed evidence to justify investment in sustainable and equitable blue foods systems. At the Pacific level, efforts are continuing to support fisheries and aquaculture studies and policy development, including a regional blue foods assessment. These studies, while essential, risk missing the crucial voices and experiences of rural communities undergoing climate change and blue foods system transformations, often in negative directions due to competing pressures.

This study has provided complementary evidence to two existing case studies where efforts are being made to support livelihoods and conservation. The added value of this study is a framework for analysis and participatory community engagement that helps link blue foods activities to various NbS outcomes. With growing finance and interest in NbS in the Pacific region, it is critical to ensure that community voices are captured in national and regional directions and investments, including fisheries and aquaculture.

The Pacific is a unique region of the world, where population pressures, limited land, abundant but threatened ocean resources and climate change intersect. The region is also home to deep beliefs and knowledge linking nature and society, and home to Indigenous and traditional knowledge systems that continue to influence every-day blue foods management. The growth in NbS investment and policy to maximise blue foods productivity needs to continue to include the multi-generational understandings of ecosystems and societal change to ensure effective future management.

Co-benefits outcome framework and managing trade-offs

Blue foods systems offer major co-benefits to rural communities, natural environments and ecosystems. Adopting a blue foods systems perspective to manage marine and aquaculture production is an important transition from the traditional marine science, fisheries biology and economic productivity lenses frequently applied to blue foods. A systems lens facilitates the clear articulation of the multiple benefits that can be achieved and helps draw linkages between environmental health, livelihoods and climate resilience. There is growing urgency to strengthen

the adaptive capacity of people and ecosystems, and growing interest in blue carbon and mitigation efforts from NbS interventions in marine areas. This makes the blue foods systems approach relevant to institutions seeking to connect marine activities to broader outcomes related to climate change.

A core dimension of systems thinking is the balancing of trade-offs and identifying them through the application of systems thinking methodologies. Causal Loop Diagrams, for example, help identify how different drivers influence the specific change being sought. They also help think through the various pathways of change that can jeopardise long-term outcomes. No system is perfectly balanced, and thus understanding how feedbacks and processes influence change can help design effective interventions.

Implications for nature-based solutions investments

The NbS space is highly complex, nuanced and driven by well-established metrics and indicators. The Pacific's unique socio-ecological context, which combines traditional practices with the market economy in a changing climate, requires careful consideration of how everyday resource management might contribute to NbS outcomes. This study has sought to provide evidence of how existing blue foods activities—one naturally occurring and one supported by human intervention—can support various NbS outcomes. The findings indicate that conservation, food security and livelihoods, and climate resilience are supported in different ways, depending on the type of blue foods activity.

As efforts are made to adapt and mitigate climate change, we must ensure equity in livelihoods and that conservation outcomes do not minimise economic benefits to people. NbS practices often mirror traditional, pre-globalisation ecosystem management activities in many of the world's coastal and riverine environments. They have formalised metrics and indicators that support planning and the financing of NbS activities, notably in relation to land-based carbon markets. Blue foods activities have been practised traditionally for millennia but are now undergoing radical transformations and are subject to multiple pressures. A blue foods systems approach offers a way to explicitly link marine and aquaculture activities to the different outcomes being sought through NbS investments.

Blue foods systems will continue to play a critical role in livelihoods, nutrition and conservation, yet face growing climatic and population pressures. The systems approaches used in this study, combined with participatory engagement with local communities, can support decision-making that takes a holistic and integrated approach to maximising conservation, livelihoods and food security, and climate resilience.

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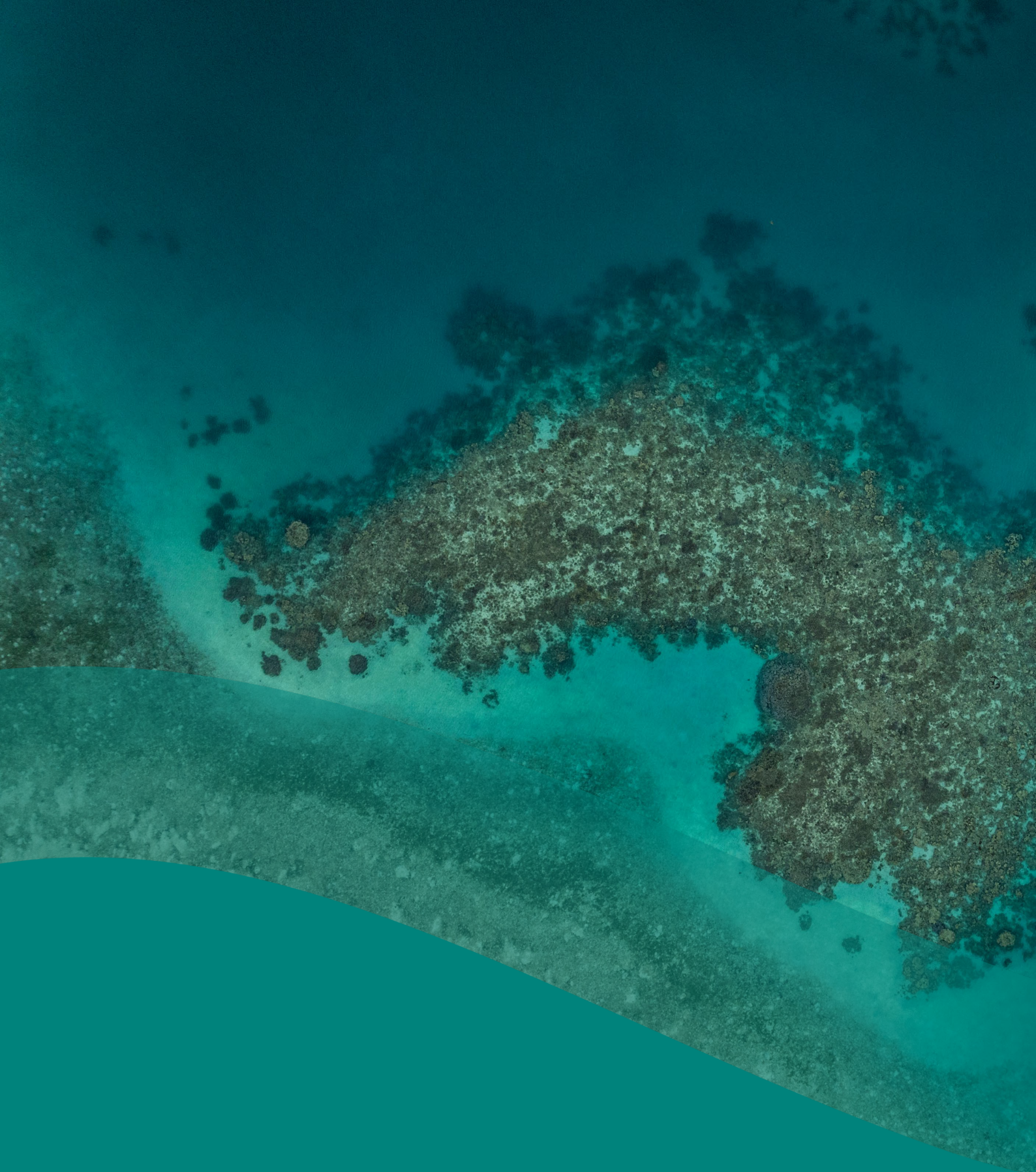
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