Chapter 8

Safeguarding Biodiversity through Indigenous and Local Knowledge for Climate Change Resilience

Authors

Edward Challies, Patila Amosa, Gilianne Brodie, Antoine De Ramon Yeurt, Edgar Pollard, Bindiya Rashni and Hilda Waqa-Sakiti

Tthe Gau iguana *(Brachylophus gau)*, whose habitat is being threatened by climate change. The Gau community in Fiji has initiated a programme to protect this rare species (Photo: POCCA team, 2022).

UC University of Canterbury, Te Whare Wānanga o Waitaha, Christchurch New Zealand

USP The University of the South Pacific

POCCA Pacific Ocean and Climate Crisis Assessment

This research was funded by Aotearoa New Zealand's International Development Cooperation Programme — Ngā Hoe Tuputupu-mai-tawhiti. The views expressed in this research and associated publication are those of the authors and are independent of the New Zealand government.

Abstract

This chapter highlights the fundamental importance of biodiversity to the health and spiritual well-being of the Pacific region and people, and to the health of our planet, especially in the context of climate change. The Pacific is internationally recognised for its vast ocean and exceptional biodiversity which for centuries has sustained life, provided food, medicine, and resources for highly diverse cultural and traditional practices. Addressing and mitigating the impacts of climate change on biodiversity in the Pacific region requires a holistic perspective from terrestrial to freshwater and marine environments, including impacts on areas of both high (hotspot) and low (cool spot) biodiversity in unison with the unique human communities they sustain. The importance of local cultures, practices and Indigenous knowledge in maintaining and building responses to climate impacts, such as the role of 'nature-based' approaches, are discussed. We explore how the interconnected processes of climate change and biodiversity loss threaten balanced social-ecological outcomes on our islands in the Pacific and showcase how climate change responses that are embedded in nature and culture can be led by local communities in partnership with local and national governments. Key policy recommendations and research gaps are also identified, including the need for strengthened connection to the private sector, ecosystem services valuations that clearly reflect the economic value of habitat and biodiversity and a just transition to sustainable economic development via engagement with local communities, business, and industry. Only by working together, fully utilising existing information and understanding each other's perspectives can we reduce ecosystem disruption, achieve integrated biodiversity conservation and foster sustainable climate change resilience.

Glossary of key terms

Biodiversity	A foundational concept for cultural survival and sustainable living, clearly articulated in the Pacific via the concepts of ethnobiodiversity, biospirituality and agrobiodiversity
Conservation	Protection and preservation of biodiversity
Cool spots	Locations with less biodiversity, but where biodiversity is critically important to the livelihoods, culture and social well-being of local people.
Ecological services	Benefits, such as food, shelter, trade and resilience to climate change impacts that are derived from nature
Ethnobiodiversity	'(K)nowledge, uses, beliefs, resource-use systems, conservation practices, taxonomies and language that a given society or community, including the modern scientific community, has for its islands, ecosystems, species, taxa and genetic diversity' (Thaman, 2007a)
Hotspots	Locations with exceptional concentrations of endemic species
Indigenous and Local Knowledge (ILK)	Knowledge, innovations and practices of Indigenous and local communities around the world. Developed from experience gained through time and adapted to the local culture and environment, encompassing knowledge, experience and values possessed by Indigenous societies and passed on from generation to generation through cultural practice and evolution
Nature-based Solutions (NbS)	Climate change responses that work with and enhance nature to help address societal challenges, including climate change. These solutions are grounded in the understanding that healthy ecosystems are crucial for human well-being and resilience. (See IUCN, 2020; SPREP, 2020)

8.1 Introduction

Rapid and dramatic changes in biodiversity and climate globally are having fundamental impacts on social and ecological system function, and threatening livelihoods, wellbeing and resilience around the world (Pörtner et al., 2021). The Pacific Islands region includes internationally recognised biodiversity hotspots (i.e. regions of the world with exceptional concentrations of endemic species). However, these unique areas face a range of anthropogenic pressures ranging from climate change to habitat loss, owing to their small land to sea ratio, high levels of species endemism and vulnerability to invasive predators (Jupiter et al., 2014). Biodiversity in the PICTs is '(a) foundation for cultural survival and sustainable living' (Thaman, 2007a) and this is clearly articulated via the concepts of ethnobiodiversity, biospirituality and agrobiodiversity (Thaman, 2007b; 2008a). Several types of coastal marine and wetland ecosystems (e.g., mangroves, seagrass beds, coral reefs) provide frontline protection from the impacts of climate change such as storm surges, cyclones and sea-level rise (Spalding et al., 2014; Muna et al., 2023). These ecosystems therefore support mitigation of, and adaptation to, climate change impacts for coastal communities (Malhi et al., 2020). Biodiversity loss and climate change resilience are closely interlinked, with a wide range of interrelated drivers spanning local to planetary scales (Maxwell et al., 2016). Increasingly, there is recognition that climate change and biodiversity loss must be addressed in an integrated way with the participation of Indigenous peoples, local communities, and diverse stakeholders (Janif et al., 2016; Mcleod et al., 2019; Popovici et al., 2021). The philosophy of stewardship with a holistic approach that has long been part of the Pacific way of life is underpinning developments in the legal recognition of the rights of nature (Harden-Davies et al., 2020) and thereby reuniting humanity with science and policy.

The impacts of climate change on Pacific biodiversity and ecosystems in general are of significant concern, especially with increasingly severe tropical cyclones in recent years (Wang & Wang, 2023), with their massive destructive impact on Pacific Islands. The resulting loss of biodiversity and damage to ecosystems (terrestrial, freshwater, and marine) have caused considerable stress on Pacific communities. This chapter draws on scientific and community-based research carried out in the area of climate change and biodiversity in the Pacific Islands and examines short-term and long-term consequences for biodiversity and communities in the Pacific region. It keeps the importance of a Pacific context in the foreground, where climate change and biodiversity are framed in Indigenous terms, reflecting the interconnectedness between people and nature (see Efi, 2018) that has existed for centuries.

It is clear that resilience to current and future climate change impacts across all ecosystems in the Pacific needs to focus strongly on significantly reducing anthropogenic environmental degradation and biodiversity loss. Responses that are grounded in local and Indigenous knowledge and practice, and led by Pacific peoples, are essential.

8.2 Biodiversity is culturally and socially embedded in the Pacific

The specific dynamics of climate change and biodiversity loss are geographically varied and responses need to be tailored to local ecological and social-cultural contexts within the exceptionally diverse Pacific. The Pacific Islands region, in many respects, bears the brunt of global climate change due to particular biophysical vulnerabilities and geographic characteristics. However, Pacific cultures and communities are also holders of a wealth of knowledge and practices that are, and will be, essential in addressing climate change impacts in the region and beyond, and impacts on biodiversity in particular.

Pacific communities have co-existed with the natural environment for centuries (McMillen et al., 2014), but these relationships are now threatened by the impacts of climate change and in some cases unsustainable resource use. Climate change impacts in the region include a complex mix of slow- and fast-onset changes, while a wide range of other non-climatic and anthropogenic processes also threaten biodiversity, such as changes in land use, habitat destruction, modification of river flows, freshwater pollution, overexploitation and unsustainable use of resources and invasive species (Hills et al., 2011). Although these threats are non-climatic, they are all potentially exacerbated by climate change impacts, which highlights the interconnectedness of the climate and biodiversity crises.

Pacific peoples, their livelihoods and natural resources are highly interdependent. For example, natural resources are important 'food' and income-generating assets and essential in the treatment of certain health ailments. Women tend to gather seashells near shore for making handicrafts, and lagoon shellfish for food, while men fish more often offshore or harvest specific hardwoods and forest products from within the forests for important cultural uses such as kava bowls or canoes, or for housing materials.

The traditional treatment of certain skin infections and internal health conditions relies on many local plant resources (Weiner, 1970; Whistler, 1992). Environments, communities and resources are highly interconnected across marine, freshwater and terrestrial systems. Approaching biodiversity in the Pacific in the context of climate change therefore demands an integrated ridge-to-reef perspective with Pacific people at its heart (See Fig. 8.1).

The Pacific is as rich in cultural diversity as it is in biodiversity. This is well articulated by the term ethnobiodiversity, which is defined as 'knowledge, uses, beliefs, resource-use systems, conservation practices, taxonomies and language that a given society or community, including the modern scientific community, has for its islands, ecosystems, species, taxa and genetic diversity' (Thaman, 2016, p.6). Thaman (2004b, p. 46) stresses that:

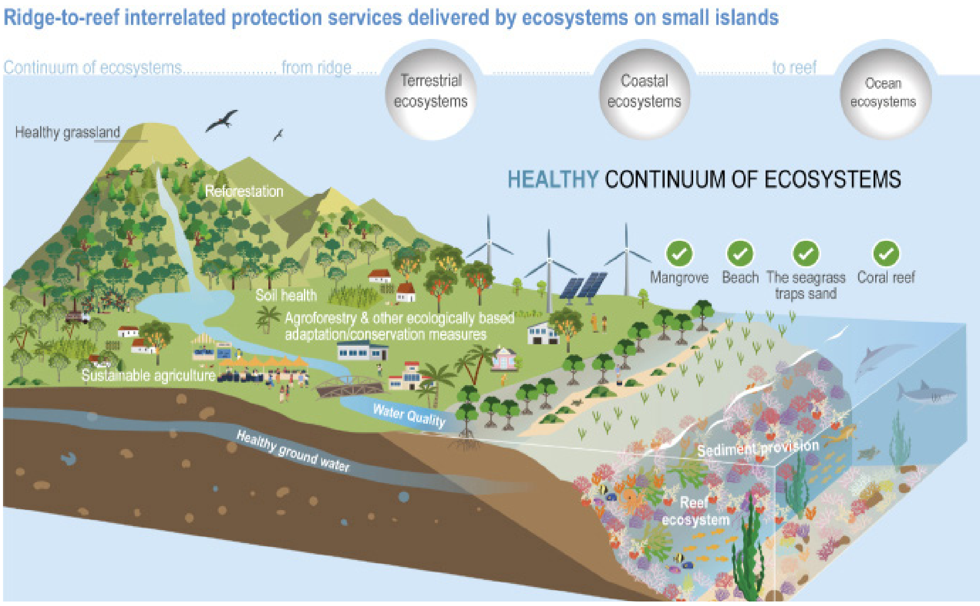


***Figure 8.1**: Ridge-to-reef interrelated protection services delivered by ecosystems on small islands. Source: Mycoo et al., (2022: Fig.15.4)*

this final category or cultural 'level' of atoll biodiversity must be seen as central to the definition of atoll biodiversity itself because, on the atolls, people and their knowledge, traditions and spirituality are seen as inseparable from their marine, terrestrial and freshwater ecosystems (e.g., as embodied in the Melanesia pidgin concepts of kastom/custom or ples/place; the all-encompassing pan-Polynesian concept of land/fonua, fanua, fenua, henua or 'enua, depending on where you are; or the concepts of te aba, in Kiribati and bwirej in the Marshall Islands, all of which encompass land, sea and people), rather than seeing them as separate external entities.

Long before the arrival of modern science and application of formally learnt western knowledge, Indigenous Pacific communities applied their rich Indigenous and local knowledge systems to guide the sustainable use of biodiversity. The cultural value of local biodiversity is an important reason for conservation for future generations, as the ability to apply Indigenous knowledge in-place is essential to maintain cultural practices and identities. The maintenance of vital Indigenous biodiversity knowledge and practices, including the use of totems, may require new ways of passing knowledge from generation to generation (Naikatini, 2024).

For example, tattoos are a significant element of cultural identity in certain Pacific countries such as Samoa (Figure 8.2a), the Marshall Islands, Aotearoa New Zealand and the Cook Islands (Gell, 1996; Hage et al., 1996). The tattoo ink in Samoa is derived from the lama - candle nut tree, *Aleurites moluccanus* (Figure 8.2b) which is burnt to produce soot that serves as the basic ingredient of the ink. Kava drink is associated with a range of societies throughout the Pacific region and is prepared in a special hardwood bowl (tanoa) made from the Pacific teak tree *(Intsia bijuga)* or the Pacific kauri *(Agathis macrophylla)*. For ceremonial purposes in Fiji, the kava bowl cord, of woven coconut fibre, is decorated with large white marine shells (buli leka) of the species *Ovula ovum* (Figure 8.2d), which is laid out along the ground towards the guest of honour. Tapa cloth, originally made for clothing, now plays an important role in traditional ceremonies in Fiji, Samoa, Tonga and Papua New Guinea.

It (tapa) is made from the inner bark of the paper mulberry tree, *Broussonetia papyrifera,* using traditional methods passed along generations orally and through practice (Figure 8.2c). A similar traditional clothing material is the ietoga, or fine mat, woven from the dried leaves of three species of the pandanus plant/tree. In Samoa, fine mats are highly valued in cultural events such as funerals, weddings, bestowals of chiefly title and the cultural practice of ifoga. In the Solomon Islands the Ngali nut tree *Canarium indicum,* endemic to East Melanesia, is a culturally significant plant that carries many dances, stories, recipes and seasonal practices (Figure 8.2e).

Indigenous and local knowledge is therefore an essential component of understanding and maintaining biodiversity in the Pacific. However, unsustainable exploitation of natural resources and biodiversity in the region is related to a gradual loss of traditional knowledge on the significance of particular species (Brodie et al., 2013). There is much value in integrating traditional and modern or scientific knowledge to better understand current impacts of climate change and to foster and develop nature/culture-based approaches to mitigate or adapt to these impacts and nurture biological diversity.

Figure 8.2: (a) Traditional tattoo, a significant element of cultural identity in certain Pacific countries. Image: Gese Gese; (b) The lama (candle nut tree, Aleurites moluccanus) which is burnt to produce soot as the basic ingredient of traditional tattoo ink. Image: Malotau Lafolafoga; (c)Preparing tapa cloth and transferring knowledge across generation. Image: Malotau Lafolafoga; (d) Marine shells (buli leka) of the species Ovula ovum used in Fiji for traditional and ceremonial purposes. Image credit: G. Brodie; (e) A traditional Ngali Nut harvesting gathering, where the community comes together to crack the nuts in preparation for feasting, accompanied by songs and storytelling. Image credit: Jones Otafalu.

8.3 Climate change impacts on biodiversity, ecosystems and communities in the region

PICTs are facing multiple impacts of global climate change, including rising sea levels and connected impacts from king tides and storm surges, land loss from inundation and erosion, saltwater intrusion, rising land and sea temperatures, tropical cyclones and floods, ocean acidification, spread of invasive species and sustained droughts and water scarcity (Nurse et al., 2014). These processes produce compounding impacts on environments and communities and threaten biodiversity and ecosystems across a range of land and seascapes on the ridge-to-reef continuum (Delevaux et al., 2018). Impacts vary across island types and by environment, including between rural and urban settings. Interconnected terrestrial, freshwater, and marine ecosystems are impacted in complex ways.

Ecosystems face stress from both slow-onset pressures (e.g., warming) and increasingly frequent and severe shocks (e.g., tropical cyclones and storms). Particularly vulnerable to a range of pressures, for example, are coral reefs, mangroves, seagrass beds and coastal wetlands and montane forests. The region is even starting to witness the loss of entire low-lying islands to sea level rise (e.g., in the Solomons). With respect to ecosystem impacts, in its Sixth Assessment Report, the IPCC (2022, p. 35) noted evidence for changing ecosystem structure, species range shifts, and changes in timing (phenology) across terrestrial, freshwater and ocean ecosystems in small island environments.

The interconnected impacts of climate change on biodiversity can be understood from an integrative 'ridge-to-reef' perspective, which explicitly recognises interaction across terrestrial, aquatic and marine systems, and interwoven bio-cultural diversity. An appreciation of these connections and interdependencies is essential to understanding the pathways and mechanisms via which climate change impacts biodiversity, including complex cascading effects (Goulding et al., 2016), as well as the potential means by which biodiversity conservation and nature- and culture-based approaches can underpin adaptation to and mitigation of climate change. While this chapter examines climate change impacts on terrestrial, freshwater, and marine biodiversity, it does so in the context of a ridge-to-reef perspective, and through specific examples, with a view to maintaining a holistic and integrated understanding of emerging problems and solutions. In addition, we consider temporal dimensions to the challenge of biodiversity conservation in the face of climate change and examine current and short-term impacts as well as anticipated long-term ramifications for Pacific ecologies and peoples.

Biological diversity (or biodiversity), technically defined, encompasses the variability found among all living things, and includes species, ecosystems and genetic material (United Nations, 1992).

In the Pacific region, however, biodiversity encompasses peoples and cultures, as well as the local, traditional and Indigenous knowledge systems that they hold (Thaman, 2004b). Across the Pacific, island states are particularly prone to the impacts of climate change due to their disproportionately large ocean to land ratio within their economic zones. Impacts vary according to the nature of the islands (high volcanic or low atoll; inhabited and developed versus uninhabited and/or isolated). Some effects can be short-term (e.g., extreme weather events such as cyclones, storm surges and king tides) while others have long-term impacts (e.g., ocean acidification and increasing surface seawater temperatures (SSTs)).

Below we describe impacts across different ecosystem types, acknowledging the interconnection between terrestrial systems (including different types of forests, grasslands, farms and gardens), freshwater systems (including creeks, rivers, lakes, streams, swamps and inland wetlands) and marine systems (including intertidal flats, estuaries, bays, lagoons, mangroves, seagrass beds and coral reefs). While we distinguish these ecosystems for the purposes of presenting different impacts, we see them as embedded in highly interconnected social-ecological systems stretching from sky, land or ridge to reef and beyond.

8.3.1 Terrestrial ecosystems

Pacific Islands have a rich and unique biota produced by island biogeographic processes and modified by more recent anthropogenic influences (Jupiter et al., 2014). Terrestrial biodiversity and species endemism per unit area in Oceania are among the highest in the world, with more than half the diversity in independent, developing island nations (Keppel et al., 2012). Island ecosystems are vulnerable to habitat loss, overexploitation, invasive species and pollution.

Studies have documented the exposure of terrestrial ecosystems to climate change impacts such as changes in temperature and precipitation patterns, which weaken the natural adaptive capacity of ecosystems (e.g., Hills et al., 2011; Kumar & Tehrany, 2017; Howes et al., 2018). Any disturbances or disasters such as cyclones, flooding or erosion/landslides render forests more susceptible to invasive species or fires and also lead to loss of habitat (micro-habitats) and ecosystem services (Taylor, 2017). Climate disaster impacts can be worsened by the presence of invasive tree species, which are more vulnerable to high winds and rain and get washed down catchments, blocking rivers or damaging infrastructure (Vissichelli, 2018; Hao et al., 2022). Many of these impacts are exacerbated in places where there are rapidly expanding urban areas or intensifying development and natural resource extraction (Bambrick, 2018).

Terrestrial biodiversity on some islands is more adapted to cyclonic impacts (Burslem et al., 2000). However, with changing climate patterns and more severe and regular cyclones extending out of their traditional zones, many Pacific Islands will struggle with natural recovery.

Increase in mean surface temperatures, along with changes in precipitation patterns can affect ecosystems in several ways including by influencing rates of survival and spread of invasive species (Finch et al., 2021). Additionally, climate change can also lead to an increase in the frequency and intensity of extreme weather events such as cyclones, floods, and droughts which in turn can transport invasive alien species to new areas and decrease the resistance of habitats to invasions (IUCN, 2021).

At the regional level, high-elevation ecosystems such as montane cloud forests are projected to disappear entirely by the year 2100, with corresponding global losses of their endemic biodiversity and connected sub-ecosystems (Taylor & Kumar, 2016). Minter et al., (2018) explain the long-term and far-reaching environmental and social impacts of land clearing and unsustainable logging in high island catchments of the Pacific, and highlight how impacts and effects connect in complex ways across ecosystems and societies. Solutions via well-supported local community practices are highlighted in our KIWA-funded WISH catchment management case study in section four below. Also, given the high degree of connectivity and interaction between terrestrial, freshwater and marine systems in small islands, adverse impacts on ecosystems may result in cascading biodiversity loss across these systems (Hills et al., 2011).

Figure 8.3: Frog *Cornufer guentheri used by communities for food, medicine and magic in parts of the Solomon Islands (Pollard et al., 2015). This species may be threatened by live export for the pet trade, collection for food and logging (IUCN Redlist of Threatened Species, 2012). Image credit: E. Pollard.*

Figure 8.4: Nakauvadra forest and freshwater ecosystems. Image credit: G. Brodie.

Since biodiversity is intrinsically linked to traditional knowledge (Pollard et al., 2015), any loss of biodiversity also risks loss of cultural knowledge and breakdown in cultural practices. There are many examples of this hidden loss of cultural practices playing out across the Pacific. In the terrestrial forests of Malaita in the Solomon Islands, for instance, climate change impacts and other anthropogenic pressures threaten to disrupt multiple traditional uses of the biodiverse frog (see Figure 8.3) and lizard fauna, where seven distinct cultural uses were identified across the themes of human food; trade - barter and exchange; totemic species, considered taboo or sacred to a particular tribe; medicine, curing of ailments; good luck charms, for magic, or sorcery (black magic); folklore, mentioned in cultural stories or myths; and fishing, mainly as bait (Pollard et al., 2015).

Traditional approaches to conservation provide opportunities for ecosystem restoration and protection. In the Pacific, examples of effective protected area management have involved government and non-government organisations working closely with local communities and resource users on integrated approaches to biodiversity protection (Salm & Mcleod, 2008). For instance, the Nakauvadra Community-Based Reforestation Project, led by Conservation International (CI) Fiji, has been working in Ra Province since 2009. The land in Nakauvadra (see Figure 8.4) is owned by communities residing in the adjacent Yaqara Valley. CI has engaged 28 communities to replant trees on 1,135 hectares of important habitat, establishing six community-run tree nurseries, and developing 16 community model farms to improve food security and boost household income for forest resource owners and communities. Another example, highlighted in Box 1, is the conservation efforts of Fiji's rare and endemic cicada, locally known as nanai. The nanai holds cultural significance as a totem to the landowners of Emalu. Through the Fiji REDD+ programme, a large area of the pristine Emalu Forests in the Navosa Province has been protected which is also habitat for the nanai (see Chapter 17 on Climate Finance for how protected areas are used for carbon trading).

Box 1: A Fijian Totem: Nanai - Fiji's rare and endemic cicada

Locally known as nanai, the cicada Raiateana knowlesi is endemic to Fiji. It has a periodic lifecycle (in which the adults are synchronised in their emergence) of eight years. The nanai has the longest periodic lifecycle of any cicada in the southern hemisphere and is found in the Navosa and Serua Provinces. The nanai also holds cultural significance as a totem and a delicacy to a clan in the Navosa Province. Due to its significance, both ecologically and culturally, this species is currently featured on Fiji's $100 bill.

During the nymph stage, the cicada spends most of its lifetime living underground before emerging into the adult stage (aerial life form) towards the end of the eight-year period. The adult survives for 3-4 weeks, during which time it reproduces and lays eggs. The nanai then returns to a sacred pond within the Emalu forest where it eventually dies. The last periodic emergence of the nanai was in 2017. To the people of Emalu, the year of its emergence is revered, and the emergence is a symbol of wealth and prosperity (Watling 1986).

Through the Fiji Reducing Emissions from Deforestation and Forest Degradation (REDD+) Programme, 7,400 ha of Emalu Forest (predominantly pristine forest) is currently leased by the Ministry of Forests and preserved under a 50-year agreement to protect the forest, its unique biodiversity, and in particular the nanai, a totem to the landowners of the Emalu Forest Reserve.

Figure 8.5: *Emerging nanai, a cicada of cultural and ecological significance in Fiji. Image: H. Waqa-Sakiti.*

8.3.2 Freshwater ecosystems

The islands of the Pacific support a diverse range of freshwater wetlands (riverine, lacustrine, springs, brooks, freshwater swamp forests and marshes) (Ellison, 2009). The diversity of freshwater ecosystem types and biotic community structures is at near global maxima in the Indo-Pacific region, towards Papua New Guinea and declines to the east towards Rapanui (Easter Island) with increasing isolation and decreasing island size and age. The biodiversity of aquatic communities is unique in each country, with very high species endemism (national, island and area endemics) due to the habitat isolation that epitomises Pacific Island Countries (Ellison, 2009; Jupiter et al., 2014; Keppel et al., 2014; Nunn et al., 2016). Inhabitants of volcanic high islands are heavily dependent on freshwater systems and surface waters (e.g., rivers, creeks, streams) that deliver a variety of ecosystem services (regulating, provisioning, cultural and supporting services) essential for livelihood sustenance (Rashni, 2021). The biodiversity of fauna found in rivers, creeks and streams reflects the condition of the freshwater system and therefore has potential for biomonitoring. Freshwater invertebrates such as snails, dragonflies and damselflies (Figure 8.6) are particularly useful in this regard because their lifespan is relatively short, and faunal diversity may change with changing environmental conditions. In Fiji, freshwater invertebrate identification and biomonitoring is taught to children via community education activities facilitated by the local conservation NGO NatureFiji - MarequetiViti (NFMV). Beyond their role as indicators of water quality and ecological health, freshwater invertebrates play diverse roles across food webs, and directly benefit human wellbeing. For example, insect predators like damselflies can be an effective biocontrol for mosquitos (Priyadarshana & Slade, 2023), and thereby help to mitigate malaria risk, which is high in parts of the Pacific region (Pollard et al., 2020).

Figure 8.6: *A predatory freshwater damselfly, a useful invertebrate for undertaking freshwater biomonitoring of water quality. Image: copyright Stephen Moore.*

Climate-induced changes to rainfall, temperature, and sea level (Jupiter et al., 2014; Taylor & Kumar, 2016) may all have significant impacts on freshwater ecosystems. Localised climatic drivers such as frequent floods, tropical cyclones and drought lead to degradation in micro-habitat and water quality and can exacerbate waterborne pollution and drive increased water demand (Rashni, 2021; Amosa, 2021). Sea level rise threatens restricted-range and amphidromous/migratory fish species such as eels *(Anguilla mamorata)* (see Figure 8.7). Shifts in distribution may be possible for tolerant, generalist species, but range shifts will be problematic for species with small distributions such as area endemics with patchy distributions (e.g., *Fijidoma maculata*, a monotypic genus with a single species), specialised habitat requirements (large water frogs, Cornufer guppyi), slow dispersal rates, or at high elevations (Jupiter et al., 2014; Taylor & Kumar, 2016).

Some local communities rely on coastal freshwater springs (which have a specialised biodiversity) as their sole drinking water source, or to replace the reticulated system when erosion contaminates the water supply (see Figure 8.8). Sea level rise and coastal inundation have also increased the salinity of spring water and altered associated biodiversity, while in atolls such as Tuvalu, salinisation from inundation has destroyed taro patches, impacting agrobiodiversity.

While these are commonly observed and projected climate threats to insular lotic systems, the actual impacts of climate change on aquatic ecosystems, biodiversity, food web stability and species composition structure remain poorly understood due to understudied taxonomy and nomenclature, scarce data on species ecology and distributions, and lack of fine resolution elevation data for very small remote islands. Additionally, there is a lack of comprehensive assessments on synergistic interactions of climatic and non-climatic threats like micro-habitat loss and invasive species. Investigation of such aspects holds crucial importance for sustainable use and management of freshwater ecosystems to safeguard biodiversity, food security and livelihoods for Pacific communities.

Figure 8.7: Anguilla marmorata (Giant mottled eel). Image: copyright Kinikoto Mailautoka.

Despite the lack of comprehensive national and regional assessments, Pacific researchers have examined links between climate change, anthropogenic activities and the physico-chemical and biological composition of insular lotic systems. A study of rivers in Samoa commonly used by local communities for recreational and domestic activities found high levels of microbial contamination attributed to storm water inflows and fecal waste from nearby livestock, including pigs and free-roaming fowl, coupled with erosion during intense rain events (Amosa et al., 2018). Deforestation and associated soil erosion led to increased sedimentation, reduced water quality and high accretion rates in the Rewa River in Fiji (Carpenter & Lawedrau, 2002). The contamination of freshwater ecosystems from such sources increases their ecological vulnerability and may subsequently reduce or alter biodiversity and ecosystem services provision.

Figure 8.8: *Coastal spring well at Yacata Island in northern Lau, Fiji. Image: copyright Vatuvara Foundation.*

8.3.3 Coastal and marine ecosystems

Relationship between Indigenous Pacific populations and the Ocean

The nature of Pacific Islands, as low-lying reef and high volcanic islands (Nunn et al., 2016) confers specific habitats to each type, with respective attributes of marine biodiversity. The distribution of marine species is shaped by prevailing ocean currents, distance from Indo-Pacific biodiversity hotspots, and the transport of species via island 'stepping stones' (Veron, 1993; N'Yeurt & South, 1997). This means that islands in the broadly-defined eastern Pacific (e.g. French Polynesia, Rapa Nui, the Cook Islands) have a less diverse and more vulnerable fauna and flora compared to their counterparts in the western Pacific (e.g. Vanuatu, the Solomon Islands, Fiji). While this marine biodiversity gradient mostly applies to benthic species such as corals, algae, seagrass and coastal mangroves, it also applies to fishes (Drew & Amatangelo, 2017) and algae (N'Yeurt & South, 1997). Relatively high number of taxa can still occur in easterly localities where there is a wide diversity of habitats, and a pronounced latitudinal distribution of islands (N'Yeurt and Payri, 2010). Human migration patterns across the Pacific also reached westernmost islands first, with remote eastern Polynesia, Hawaii and Aotearoa/New Zealand colonised last by Indigenous populations (Friedlaender & Tucci, 2020). The increasing distance from epicentres of biodiversity from the western to the eastern Pacific islands implies that Indigenous populations in more remote Oceania were faced with fewer subsistence species and the need to conserve more carefully what was available to them. While many early Pacific seafarers took essential crops and domesticated animals – such as taro, bananas, breadfruit, pigs, and chickens – with them on long sea voyages, marine species were not usually part of this strategy (Anderson, 2003).

Dependence on marine and coastal ecosystems for subsistence

Archaeological evidence from Pacific islands , mostly from shell middens, shows that early colonising populations led a hunter-gatherer coastal lifestyle, making extensive use of the available marine biodiversity. Increase in human population may have led to local extinction of species, such as the giant clam *Hippopus hippopus* in the Fiji Islands (Seeto et al., 2011), forcing communities to move inland and take up hunting land-fauna and starting agricultural practices. For people remaining in coastal settlements, marine ecosystems continued to provide the majority of food, although more effort was needed to procure it. Communities developed specialised fishing skills, venturing further out-to-sea, and exploring alternative edible marine species such as intertidal invertebrates and seaweeds (Thomas et al., 2021). Today, in several Pacific islands there remains a strong tradition of consuming seaweed (marine algae), while on other islands the practice appears forgotten (Abbott, 1991; South, 1993; Conte & Payri, 2006; Ostraff, 2006). Indigenous Fishing Knowledge (IFK) has sustained Pacific Islanders for millennia but is now in danger of being lost due to commercialisation of fishing, urbanisation, coastal development, and climate change (Thaman et al., 2017; Kitolelei et al., 2021). Mangrove ecosystems, known for consolidating and filtering coastal sediments as well as providing a nursery area for food species, have been used for subsistence by Pacific Islanders for thousands of years (Baines, 1984). Economic and ecosystem services provided by marine habitats include tourism income, coastal protection, food security and biodiversity reserves (Allemand & Osborn, 2019; Brodie et al., 2020a; Brodie et al., 2020b).

> 'Our native trees are impacted by the imported timber, we're not sure about the details and chemicals, but we notice a big difference, and even with the NZ timber it's not as strong as the wood we have on Niue…these fertilisers and all the chemicals to mix, our soil bears the poison, what happens is, the fertiliser may help to grow one plant, but damages the soil that used to provide nutrients to another plant, native to Niue, we lose what is Niuean and what we're used to'

Community participant
Niue Farmers Association
(POCCA research team interview, 2023)

Receding shoreline in Niue (Photo: POCCA team, 2022).

The threat of Climate Change and demographic change to marine ecosystems

Sea-level rise is considered a threat to coral reefs in the Western and South-Western Pacific Ocean (Morrison & Aalbersberg, 2022). The most likely outcome is more fragile and less diverse coral reef ecosystems (De'Ath et al., 2012). Ongoing impacts of anthropogenic climate change and human population increase will pose significant challenges to Pacific Island peoples who rely heavily on marine ecosystems for their livelihoods (Fache et al., 2019). The UN Decade of Ocean Science for Sustainable Development and State of the Ocean Report (IOC-UNESCO, 2021 & 2022) called for more quantitative data and identified a key challenge as 'Changing humanity's relationship with the ocean' by 'ensuring that the multiple values and services of the ocean for human wellbeing, culture, and sustainable development are widely understood…'. Main anthropogenic threats to Pacific marine ecosystems are seawater temperature increase (von Schuckmann et al., 2023), ocean acidification (Gattuso et al., 2015), overfishing, stronger cyclones, and increasing levels of nitrate inputs to coastal areas from land runoff and wastewater from coastal settlements, industries and resorts. While some evidence points to a capacity for resilience among certain species of corals in heavily polluted urban environments (Lal et al., 2018), repeated stress on ecosystems would exceed their adaptive capacity when facing the combined impact of multiple stressors (Ellis et al., 2019; Benkwitt et al., 2020).

Rising Seawater Surface Temperatures

Rising seawater surface temperatures (SST) in the Pacific region and associated marine heatwaves, habitat disturbance and coral reef bleaching are becoming increasingly common, with records from Samoa, Fiji and Palau (Holbrook et al., 2022). While coral biodiversity associated with extensive reefs can recover from adverse events, repeated bleaching can have disastrous impacts for recovery on isolated reefs, with estimates that 70-80% of global reefs would perish by the end of this century (IPCC, 2018). For larger island countries such as Fiji, with comparatively high reef biodiversity, coral recovery from major bleaching events can be relatively swift – i.e., within 5 years (Sykes & Lovell, 2008). However, for more geographically isolated reef systems, recovery by recruitment could be past a critical level of bleaching stress, especially in light of recent catastrophic heat waves that have impacted coral reefs in the Pacific Islands (Elmer et al., 2016; Bowden-Kerby, 2023). This has major significance for the health of people of such isolated localities, who rely on their reef resources as a protein source.

Ocean acidification

Higher concentrations of atmospheric carbon dioxide due to anthropogenic activities and higher levels of dissolved CO_2 lead to more acidic oceans with a lower pH (Kleypas et al., 2006; Feely et al., 2009). This causes the fragilisation of biodiverse coral reef structures, and decreased resilience of corals, coralline algae and other diverse reef organisms to disturbances (Gattuso et al., 2015; Fabricius et al., 2017). For Pacific Island communities, the most severe impacts would be on coral reefs and coastal invertebrate fisheries, such as molluscs and crabs, with fragilisation of shells, and higher mortality rates at larval stages (Johnson et al., 2016).

Acidification of fish body tissues would lead to lower blood pH and lower metabolic rates (Bell et al., 2011). A decrease in calcified phytoplankton can have effects on the trophic food web of tuna, while lower pH propagates sounds further in the ocean, and a noisier environment could make it harder for schools of tuna to locate prey (Lehodey et al., 2011). The impacts of ocean acidification on biodiversity such as seaweed, are not yet well understood, however negative overall impacts on metabolism, growth and reproduction have been reported for commercially farmed algae in the Pacific, such as Kappaphycus spp. (Largo et al., 2017). Seaweed farms could provide refugia from ocean acidification, due to their buffering effects (Xiao et al., 2021), also reported for mangroves (Camp et al., 2016) and seagrass beds (Ricart et al., 2021), which can reduce local acidity by up to 30%. This may encourage seaweed farming as an alternative income source for Pacific communities and protect seagrass ecosystems, as the combined benefits are substantial to the impacts of climate change on island biodiversity.

Impact of marine pests and invasive species on marine biodiversity

Coral reef biodiversity in the Pacific has been affected by Crown-of-Thorns starfish (COTs) pest outbreaks, with increasing seawater temperatures reported to promote larval settlement (Uthicke et al., 2015; Hue et al., 2020; 2022). Management efforts in the Pacific at the national level are impeded by a lack of quantitative distributional data. A novel approach involving local Pacific communities in citizen science is proposed by Dumas et al., (2020), where outbreaks are reported in real-time via a mobile phone and tablet to a centralised database; reports are then followed by removal campaigns organised under various in-country responses. Removal campaigns as a management strategy are seen as successful in other locations (Matthews et al., 2024). Prominent in recent years have been algal (seaweed) blooms across the Pacific and also the Caribbean Sea (Smetacek & Zingone, 2013; Fidai et al., 2020). In Fiji and Tuvalu, blooms predominantly involve the brown seaweed Sargassum polycystum (see Figure 8.9), and the red seaweed Gracilaria edulis (N'Yeurt & Iese, 2015a, 2015b; Andréfouët et al., 2017). The main drivers of these algal blooms appear to be linked to human population growth and associated coastal activities that generate large nitrate inputs into waterways through, for example raw sewage and industrial and agricultural effluents (Fujita et al., 2013; Iese & N'Yeurt, 2018; Nakamura et al., 2020). Ocean algal afforestation has been identified as a nature-based solution using excess coastal seaweeds to both mitigate rising carbon dioxide levels in the atmosphere as well as excess nitrate in seawater and generating renewable energy for small-island state communities (N'Yeurt et al., 2012; Capron et al., 2020). Over-abundant seaweeds and COTs have also been identified as a good source of organic fertiliser for Pacific subsistence crops (N'Yeurt & Iese, 2015a).

Figure 8.9: Algal bloom of the invasive brown seaweed Sargassum polycystum in Funafuti Lagoon, Tuvalu displacing native biodiversity and causing environmental issues. Image credit: A.D.R. N'Yeurt

Accumulative effect and promoting resilient marine ecosystems

Although ocean warming is seen as the main cause of coral bleaching, ocean acidification, pollution and other stressors create accumulative effect. Coral diseases for example have the potential to degrade coral reefs which are made more susceptible to diseases by their weakened state resulting from numerous cumulative threats. Resilience to current and future climate change impacts in Pacific marine ecosystems should focus strongly on reducing other anthropogenic environmental degradation (Brodie et al., 2020a).

Biodiversity reduction as an indicator of marine system health reflects not only environmental health, but in turn the health of the people who depend on it for physical and mental wellbeing. Many Pacific coastal habitats remain relatively healthy, and efforts at community and national levels seek to build resilience and address direct anthropogenic threats (Morrison & Aalbersberg, 2022).

8.4 Local responses to biodiversity and climate change – working with nature and culture

Climate change continues to threaten the survival of organisms and is expected to dramatically reduce species diversity especially if habitat conditions and the carrying capacity of ecosystems are altered by extreme climate conditions. Research into strategies for the effective conservation of biodiversity has been conducted primarily from a formal scientific perspective separate from the knowledges and practices of local communities. This top-down, less-inclusive approach risks alienating local communities from initiatives for climate resilience and the protection of biodiversity.

Studies (Adom 2016; Ancrenaz et al., 2007) have shown that an inclusive approach to the management and monitoring of ecosystems can lead to the successful preservation of beneficial species and to the sustainability of conservation efforts. Inclusiveness requires leadership by and participation of local and Indigenous communities as the key knowledge-holders in relation to their environment and biodiversity. Hence, Indigenous and Local Knowledge (ILK) is an essential resource to address increasing impacts of climate change on ecosystems in the region and can be integrated with modern science to develop and guide solutions and management decisions on biodiversity conservation and drive climate change responses (Beckford, 2018).

Indigenous people worldwide are custodians or guardians of land, sea and the natural ecosystems that in turn protect and sustain them (McMillen et al., 2014; Liggins et al., 2021). Indigenous (sometimes termed Traditional) knowledge encompasses knowledge, experience and values possessed by Indigenous societies (Ellis, 2005) and is passed on from generation to generation through cultural practice and evolution. This body of largely orally transmitted knowledge underpins traditional environmental management practices (Chunhabunyatip et al., 2022) that work in harmony with natural ecosystems in-place, in a manner akin to Ecosystem-Based Management. The Secretariat of the Convention of Biological Diversity refers to traditional knowledge as:

> knowledge, innovations, and practices of Indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds (Secretariat of the Convention on Biological Diversity, 2019).

ILK typically recognises interdependence and reciprocity between humans and natural resources. Based on long-term lived experience and intergenerational observation of local conditions, ILK informs wise use and management of the environment and supports adaptation to environmental change (Mazzocchi, 2006).

More specific to biodiversity is the concept of Traditional Ecological Knowledge (TEK), which encompasses knowledge, skills and customary practices developed over hundreds of years through Indigenous people's direct interaction with the environment (Gupta, 2020). As highlighted by Kitoleilei et al., (2021) for Indigenous fishing communities in Fiji, it is critical to include ILK (or in this case IFK, Indigenous Fishing Knowledge) to preserve the status of ecologically and culturally important keystone species for the site-specific management of marine and other fisheries. Article 8 (j) of the Convention on Biological Diversity (CBD) (1992) acknowledges a link between Indigenous and local community traditions and knowledge that are relevant for the conservation and sustainable use of biological diversity. This is further strengthened by the 2022 Global Biodiversity Framework, which acknowledges the important roles and contributions of Indigenous peoples and local communities as custodians of biodiversity and partners in its conservation, restoration, and sustainable use. GBF implementation must ensure recognition of Indigenous rights, knowledge (including traditional knowledge associated with biodiversity), innovations, worldviews, and values, and ensure practices of Indigenous peoples and local communities are respected, documented, and preserved. This must occur with the free, prior, and informed consent of Indigenous people, including through their full and effective participation in decision-making in accordance with relevant national legislation and international instruments, including the United Nations Declaration on the Rights of Indigenous Peoples, and human rights law. Enabling Indigenous-led and designed conservation initiatives should foster the capacity of local communities to take ownership of and maintain long-term sustainability of such efforts. Recent efforts in this area in the Pacific region have been encouraging, for instance the CARE Principles for Indigenous Data Governance (Collective benefit, Authority to control, Responsibility, Ethics; Carroll et al., 2020), and have included the traditional ownership of genetic biodiversity (Liggins et al., 2021).

Cultural practices, knowledge and views of local communities can be powerful conservation tools and must be reflected in biodiversity policies and strategies (Adom, 2016). Also, researchers must comply with local protocols to ensure mutual understanding and expectations with local communities (Malsale et al., 2018).

One possible mechanism for enabling Pacific approaches to biodiversity protection and ecosystem restoration is in the development of nature- and culture-based approaches, which draw on TLK to work with nature and communities to adapt to and mitigate climate change impacts. The International Union for Conservation of Nature (IUCN) has defined 'Nature-based solutions' (NbS) as 'actions to protect, sustainably manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits' (Cohen-Shacham et al., 2016). The IUCN Global Standard for Nature-based solutions, developed in 2020, provides best practice parameters for the development of NbS, and has been contextualised to reflect environmental and cultural diversity in the Pacific via priority actions explicitly detailed in the Pacific Islands Framework for Nature Conservation and Protected Areas 2021 – 2025 (SPREP, 2021) endorsed by Pacific leaders.

Furthermore, NbS harness the capacity for biodiversity and ecosystem services to reduce vulnerability and build resilience to climate change. The focus of nature-based approaches in a Pacific context is concerned with the 'intactness' of social-ecological systems, including people and targeting multiple co-benefits – mitigating and adapting to climate change, conserving biodiversity, sustaining cultural practice, and building community resilience. Thus, nature-based strategies have potential to contribute to effective responses to climate change and impacts of biodiversity and communities in the Pacific. There is considerable scope to strengthen Nature-based approaches in the region which is why it is an explicit thematic working group area in the Pacific Island Roundtable for Nature Conservation (PIRT).

8.5 Case studies

The case studies (1-5) highlight a range of nature-based interventions focused on climate change mitigation and adaptation, disaster risk reduction and resilience to natural hazards undertaken through projects or programmes focusing on: forest conservation and restoration, riparian zone rehabilitation, catchment management (ridge-to-reef approach) and sustainable forest or fisheries management. These will further assess the benefits, effectiveness and barriers of these interventions and the sustainability of the project at the community level.

8.5.1 Case study 1: Forest and Protected Area Management

Implemented in Fiji, Samoa, Vanuatu and Niue, a five-year GEF-PAS project led by the Food and Agricultural Organisation of the United Nations (2012-2017) aimed to strengthen biodiversity conservation by mitigating forest and land degradation. Its developmental objective was to enhance the sustainable livelihoods of local communities living in and around existing or potential protected areas. The project has worked at the interface of these two objectives in the four countries with a range of activities structured within six technical components: 1) policy and legal reform; 2) extension and consolidation of the protected area network; 3) strengthening capacity for protected area and community-based conservation management; 4) developing mechanisms for sustainable protected areas financing; 5) sustainable use of biodiversity; and 6) sustainable land management in forest margins. The project was designed with the objective to assist the countries to achieve the Aichi targets of the Convention of Biodiversity, and in particular to contribute to the target to protect at least 17% of each country's terrestrial area. These actions also contribute to the more recent Global Biodiversity Framework targets agreed in 2022 which acknowledge the imperative issue of limited resource availability and capacity.

"In my day, there were so many different native birds, we knew each bird by its colours and the specific trees they would build their nests on…,but what happened we began to notice our native birds disappear, we hardly see them, it's either the mynah bird has preyed on the native birds, or the mynahs have taken over their habitats. So much of the richness of our language originates from our observations and nature of our native birds"

Community participant
Neiafu
Samoa
(POCCA research team interview, 2023)

The Masamasa-Falelima National Park in Samoa which is home to protected native birds. Extreme weather patterns are threatening their habitat (Photo: POCCA team, 2022).

8.5.2 Case study 2: Watershed management for healthy ecosystems and people

The multi-donor Kiwa Initiative, launched in 2020, aims to strengthen the resilience of Pacific ecosystems, economies, and communities at national and regional scales by establishing a central hub for projects that promote Nature-based Solutions (NbS). NbS are defined within the initiative as 'actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively.' A programme supported within the KIWA initiative is the Watershed Interventions for Systems Health (WISH) in Fiji, which is a collaborative effort between governments, academics, and non-government organisations to address the threat to coastal and freshwater ecosystems via targeted up-stream' interventions, with local communities, to prevent, detect and respond to water-related diseases such as typhoid, dengue and leptospirosis and mitigate degradation of natural resources (Wakwella et al., 2023). The specific objective of Kiwa Initiative is to target nature-based solutions for climate change adaptation in the Pacific while mainstreaming gender equality and a human-rights-based approach. Globally, women remain poorly represented in climate negotiations (Gonda, 2019) and in leading solutions to urgent conservation challenges in climate and biodiversity loss. This bias is evidenced by a large case-study for understanding inequity for women in the conservation sector, focused on The Nature Conservancy (TNC) and including staff at offices within the Pacific (James et al., 2023).

8.5.3 Case study 3: Organic marine fertiliser community projects

As populations and demand for food are increasing in the Pacific Islands, soils are increasingly depleted as well as impacted by climate change and sea-level rise. At the same time, rising temperatures exacerbate algal blooms and the spread of marine pests such as Crown-of-Thorns starfish *(Acanthaster spp.)* and seaweeds such as *Sargassum polycystum* and *Gracilaria edulis* (N'Yeurt & Iese, 2015a). This community project, involving two local farming communities on Beqa Island, Fiji, is led by the Pacific Blue Foundation (PBF) and the University of the South Pacific's Centre for Environment and Sustainable Development (PaCE-SD). It aims to develop simple and sustainable uses for these resources as fertilisers (soil conditioners) that can be produced and utilised by coastal Pacific Island communities to reduce dependency on imported chemical (NPK) fertilisers. This work is based on research examining the use of starfish (Griffin, 2018) and seaweeds (Soreh, 2022) as organic fertilisers on a selected range of Pacific food crops. The research suggests that organic fertilisers derived from these pest species can substitute for chemical NPK fertilisers and provide essential trace elements found in seawater. Use of these locally available species would reduce the environmental impact from excess nutrients currently entering coastal areas from the use of excessive chemical fertilisers.

8.5.4 Case study 4: Palolo worm, *Eunice viridus*, as a coral reef health indicator and cultural tradition

Palolo 'spawn' (epitoke) is a seasonally harvested traditional seafood delicacy in Samoa (see Figure 8.10), and several other Pacific Island countries, and its emergence is linked to environmental factors such as the lunar cycle. It is the terminal reproductive part (eggs or sperms) of the worms that are released twice a year, making palolo 'rising' season a culturally significant time in Samoa and other Indigenous Pacific Islanders (Lee, 2022). Coral reefs, the palolo worm's habitat, are considered under threat from climate change impacts such as ocean acidification and human activities. Large numbers of worm harvesters walking on corals is also thought to add disturbance pressure in addition to potential over-harvesting. The price of palolo has increased but there is limited documentation of current harvesting practices, loss of traditional practices and fisher attitudes. Lee (2022) found evidence that local people had shifted towards western paradigms over traditional knowledge and values, and developed a preference towards buying overfishing, leading to higher demand with no increasing supply.

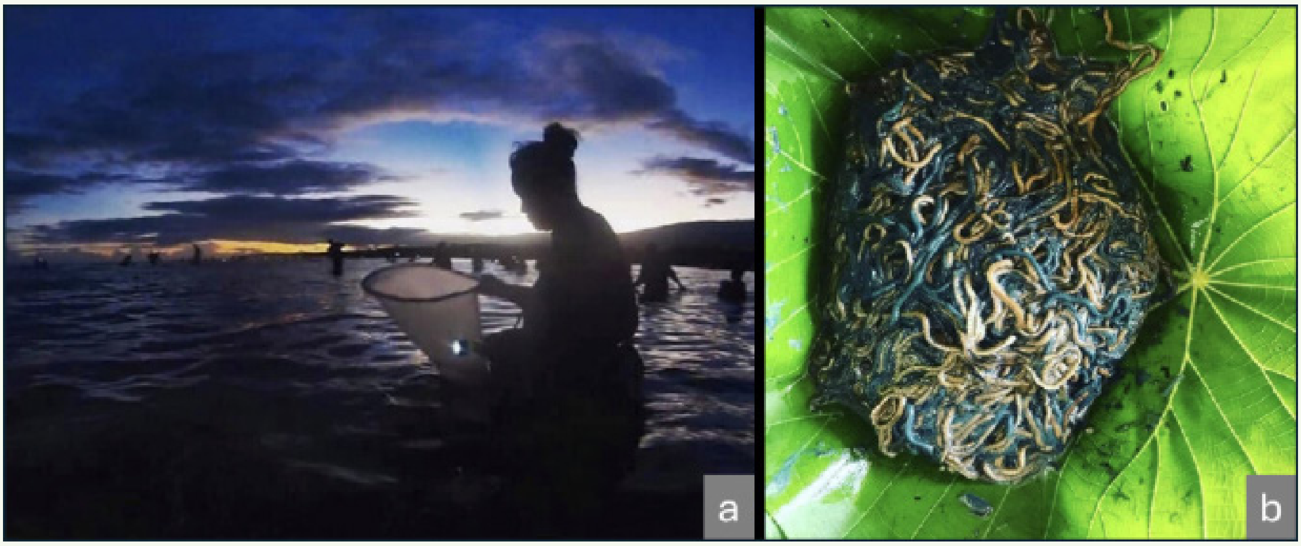


***Figure 8.10**: (a) Palolo harvest, Samoa. (b) Collected palolo worms (epitoke). Image credit: F.P. So'oalo*

8.5.5 Case study 5: Atoll biodiversity cool spots: the role of women, communities & diverse marine resources in sustaining nearshore fisheries

As per Thaman (2004a & 2008b), this atoll case study reflects the concept of biodiversity 'cool spots' i.e., remote atolls may have less diversity than high islands close to large mainland 'hotspots' - particularly on land - but their biodiversity is critically important to the livelihoods, culture and social well-being of the people living there.

In many Pacific Small Island developing states marine resource use is dominated by the high economic return of tuna, however the value and importance of small scale fisheries, with direct relevance to human well-being, food and nutrition security, should not be marginalised within the 'blue economy' dialogue (Brodie et al., 2020b). Healthy, biodiverse ecosystems such as normally found within atoll lagoons, support sustainable provision of ecological and economic services such as food, shelter, trade, and resilience to climate change impacts. Additionally, in many South Pacific countries women are the major fishers of shellfish and other nearshore invertebrate fisheries (Fay-Sauni & Sauni, 2005).

Nearshore fisheries, such as te bun cockles in Kiribati lagoons for example, are considered important food sources during times of hardship and for those that cannot fish offshore. Some families may rely solely on nearshore marine resources for protein and these resources are vital for the nutritional livelihoods of low socio-economic families (Fay et al., 2007). Overfishing then becomes a major issue in urban areas and sustainability of resources declines. Human development and climate change impacts influence coastal stability and the health of nearshore lagoon habitats in Kiribati (Brodie et al., 2020b; Tabunawati, 2024). Community education via school curricula and promotion of community-based conservation, in ways meaningful to different stakeholder groups, in combination with national policies that provide solutions to urban migration is the way forward.

"There is still time, still hope, for the people of Vunisavisavi, our community does not plan to go down without a fight. We must be resilient, plant more trees and reduce the burning and cutting of trees. This is a special place, we will do everything we can to make sure our future generation have the same benefits that we enjoyed, growing up near the ocean on royal ground"

Meredani Koco
Vunisavisavi
Cakaudrove
Fiji
(POCCA research team interview, 2023)

Demonstrating the impact of saltwater inundation in Vunisavisavi Village, Fiji (Photo: POCCA team, 2022).

8.6 Policy gaps and recommendations

The majority of nations in the Pacific are long-standing signatories to the global climate, ocean and biodiversity framework conventions such as the United Nations Framework Convention on Climate Change, the United Nations Convention on the Law of the Sea and the Convention of Biological Diversity (CBD) plus targets in the Global Biodiversity Framework (GBF). The GBF is a key context shift that recognises the lack of resources and capacity to improve policy and drive conservation, and specifically provides support to developing countries to do this. Agenda 2030 and the Sustainable Development Goals include Target 14.2, which aims to sustainably manage and protect marine and coastal ecosystems. Additionally, for Small Island developing States (SIDS), the SAMOA Pathway (UN General Assembly, 2014) recognises the critical nature of 'healthy, productive and resilient oceans and coasts' via Article 53. These policy instruments all recognise the vital need for ocean and marine protection but may sometimes lack explicit recognition of the value of biodiversity and holistic approaches to environmental management needed on islands. Biodiversity policy and governance however must put Pacific peoples and cultures at the heart of efforts to conserve biodiversity and build climate resilience, and this is strongly reflected in the 2050 Strategy for the Blue Pacific Continent which provides a regionally developed overarching framework to advance the region's goals via seven key thematic areas, which include emphasis on climate change and disasters, people centered development and ocean and the natural environment (PIFS, 2022).

At a national level in Pacific SIDS, the funding and human resources available to plan, implement and successfully monitor and evaluate progress via national government agencies is limited, and in some developing countries there may be very few staff working on biodiversity related reporting. This capacity gap is acknowledged in the GBF, which seeks to provide assistance under Target 19. At a regional level this capacity gap is also partially addressed through the willingness of Pacific nations to work together via regional policy development forums led by agencies such as the Pacific Forum Secretariat (PIFS) and the Office of the Pacific Ocean Commissioner (OPOC). These arrangements facilitate regional governance and policy frameworks such as Pacific Island Regional Ocean Policy (PIROP – see Vinceet al., 2017), Framework for a Pacific Oceanscape (FPO, 2012) and continued regional dialogue via the Pacific Ocean Alliance and associated Council of Regional Organisations of the Pacific (CROP) agency forums which unite Pacific based agencies, such as Forum Fisheries Agency (FFA), Secretariat of the Pacific Regional Environment Programme (SPREP), Pacific Community (SPC), and the University of the South Pacific (USP). This regional approach results in directly relevant collaborative forums like the Pacific Islands.

Conference on Nature Conservation and Protected Areas aims to foster partnership development through the Pacific Island Roundtable for Nature Conservation (PIRT) and its thematic working groups. PIRT partnerships produce government endorsed, strategic frameworks specifically focused on nature conservation, and addressing biodiversity loss i.e.,the Pacific Islands Framework for Nature Conservation and Protected Area 2021-2025 (SPREP, 2021), which identifies the key regional priorities for action via extensive consultation.

These priorities include transformative action, conservation and ecosystem management, livelihood and heritage, broad strategic guidance and the region's response to threats.

The importance of reducing biodiversity loss is well recognised by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019). The global loss of biodiversity and genetic diversity is the largest and longest known planetary function crisis boundary (Rockström et al., 2009; Steffen et al., 2015) and as argued above, this crisis is particularly pronounced in the Pacific. It is concerning therefore that climate change and ocean associated policies across the Pacific have, until recently, been poorly connected to biodiversity policies and regulations because of a lack of effective communication and integration across national management agencies. In acknowledgement of this disjuncture in recent years there has been concerted effort to mainstream biodiversity, and a recognition that biodiversity is a key foundation for environmental and community resilience to the impacts of climate change. In several PICTs such as the Solomon Islands and Fiji, we have seen the emergence of new national integrated ocean policies that sit under or alongside climate change policies in an economic framework. These emerging policies strive to create an enabling environment for increased cooperation and dialogue with environmental managers that recognises the vital need for policy and regulations that strengthen sustainable environmental practices and include human development in balance with nature. As detailed by Harden-Davies et al., (2020) the development of a new international legally binding instrument for the conservation and sustainable use of marine biodiversity beyond national jurisdiction (BBNJ agreement) was developed (and adopted in June 2023) as part of the United Nations Convention on the Law of the Sea. They argue that '(l)egal recognition of rights of nature is emerging worldwide as a fresh imperative to preserve ecological integrity, safeguard human wellbeing, broaden participation in decision-making and give a voice to nature' (Harden-Davies et al., 2020, p. 1).

Various policy frameworks also emphasise 'Nature-Based Solutions (NbS)' and promote climate adaptation solutions that work with nature and thereby also deliver biodiversity outcomes. However, just how effective these can be in the face of policy that enables extractive industries such as mining and logging, and how they work in concert with Environmental Impact Assessment (EIA) legislation, remains to be seen. Certainly, there is a challenge for most Pacific Island countries to balance economic development imperatives and conservation of natural resources and ecosystems. The National Climate Change Policies, Green Growth Framework, Integrated Coastal Management Plan Framework and National Disaster Risk Reduction Policies for some of the PICs provide an enabling policy framework at the national level. The National Adaptation Plan (NAP) also provides an opportunity to elaborate and firmly embed ecosystem-based adaptations and NbS as climate change adaptation and mitigation strategies. While ecosystem- based and nature-based approaches are likely an essential element of integrated responses to climate change and biodiversity loss, it is essential in the Pacific context that policies and implementing these approaches in the region put Pacific people at the centre of decision-making and learn from culturally embedded practices and traditional and Indigenous environmental knowledge of the Pacific.

There is potential for Pacific Island countries to take a lead role is shaping global policy and practice around market-based approaches to biodiversity and climate change.

The risks and opportunities surrounding payments for ecosystem services (PES) schemes and carbon or biodiversity credits, for example, are particularly important for the Pacific. On one hand these mechanisms could leverage significant private finance for conservation, while on the other hand Pacific countries will need to control the terms of these projects in order to safeguard the interests of local communities. Some private standards are beginning to reflect integrated approaches. For example, Plan Vivo (a global voluntary carbon standard) has launched a biodiversity standard, and there is a growing understanding that in the PES business there is a need to look 'beyond carbon'. Programmes and projects integrating additional layers, such as biodiversity and even community/culture/ Indigenous standards are likely to enter the market as understanding of the importance of Indigenous Pacific ecosystems and the wide-ranging services that they provide becomes clear to the global community.

Moving forward will therefore require revision and updating of existing laws, policy lens shifts to include emphasis on Indigenous peoples and knowledge and adequate tracking of the effectiveness of new integrated ocean and climate policies in safeguarding biodiversity. These regional priority issues will be influenced by pressures from demographic change, changing consumption patterns, and economic development imperatives. A clear example is the need for policy to confront and address resource extraction such as commercial mining, forestry, and fishing. Deep-sea mining with its risk of impacts on biodiversity (Niner et al., 2018; Paulus, 2021) is highly controversial in the Pacific with countries such as; Nauru Kiribati, Cook Islands and Tonga exploring the potential economic benefits because of their existing overreliance on single source revenue (Farran, 2022). The increase in global demand for electric cars and devices has contributed to the clamor for rare metals, much of which is found on the Pacific Ocean seabed. Deep-sea mining impacts are predicted to occur beyond the immediate mining area and therefore mining by one country may impact waters of a different nation (Luick, 2022).

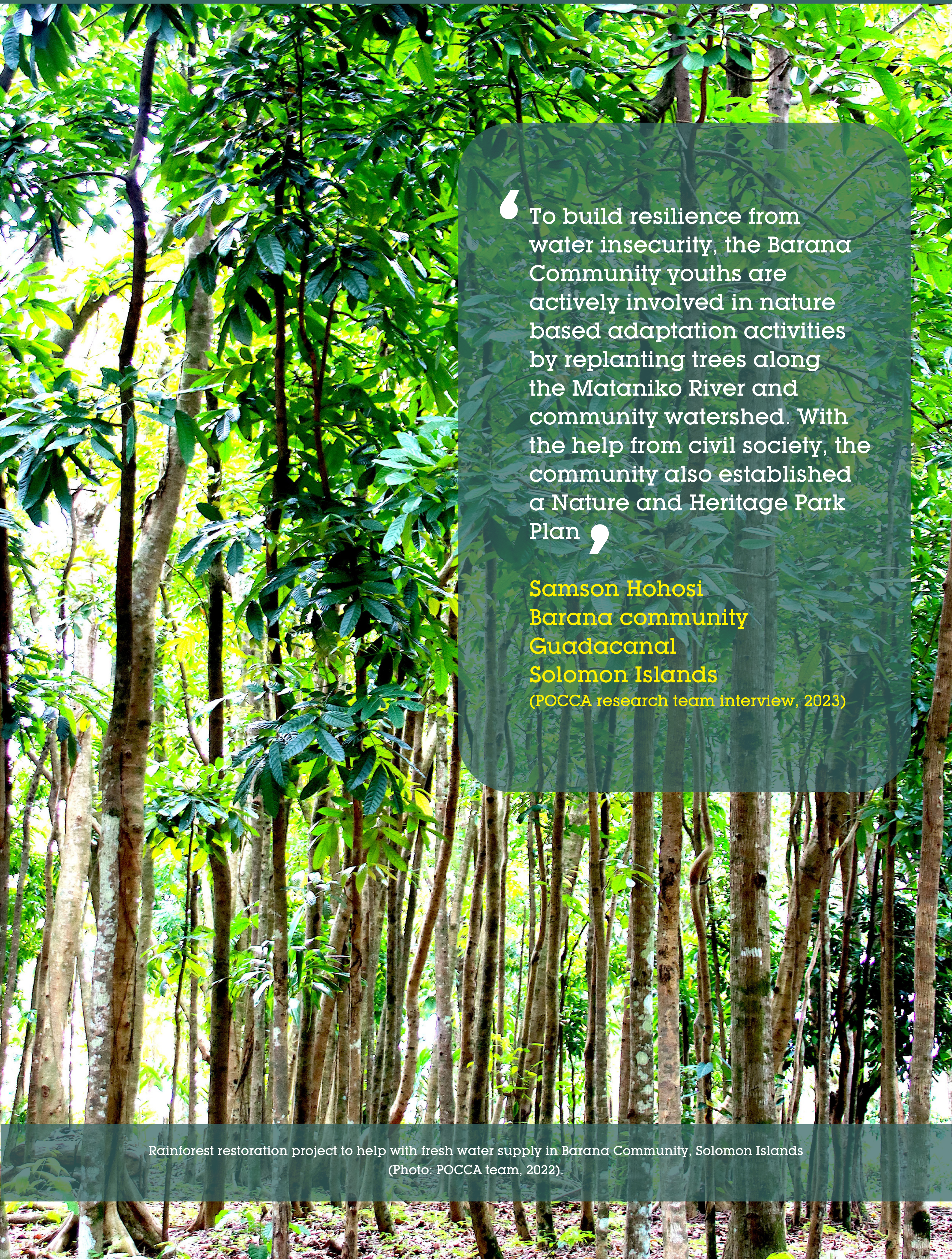
As detailed by Blasiak et al., (2019), there is a need for greater transparency and coherence in funding for sustainable and healthy oceans. Private and philanthropic finance could also play a greater role, provided this can be governed so as to balance immediate community needs against longer term outcomes. Strengthened protection for biodiversity and improved communication to a wider range of critical stakeholders, including the private sector, will be required. This must be reflected in broad enabling policies for sustainable systems that include more explicit inclusion in national and provincial policy, and this in turn will need to link to associated development cooperation and bilateral trade agreements.

The endorsement of the 2050 Strategy for the Blue Pacific Continent by Pacific Islands Forum leaders in July 2022 provides an 'overarching blueprint to advance Pacific regionalism… articulating the region's long-term vision, values and key thematic areas and strategic pathways….'Amongst the seven key thematic areas is emphasis on climate change and disasters, people centered development, ocean and the natural environment (PIFS, 2022).

8.7 Conclusion

Biodiversity is culturally and socially embedded in the Pacific and is valued by humans in a wide variety of ways, many of which cannot be easily quantified or expressed in monetary terms. For example, healthy diverse marine, freshwater and terrestrial habitats are all places that give families quality time together and bring wellness and peace of mind to the human spirit. These places create lasting memories of tranquillity and an appreciation of the special role of nature in our lives that needs to be seen and experienced by the next generation. We need to find solutions and resilience to climate change as currently these special places are slowly being lost and degraded over time.

Resilience to climate change via active conservation of biodiversity is an urgent task, not only for PICTs, but also for the global community. Enhancing biodiversity, by recognising its value and prioritising its conservation and restoration, can directly build resilience to climate change impacts now and into the future. These solutions combine nature-based interventions with Indigenous and local knowledge and practice to influence policy for climate resilience and the preservation of culturally and economically important biodiversity. Environmental policy and governance must put Pacific peoples and cultures at the heart of efforts to conserve biodiversity and build climate resilience. Legislation needs to acknowledge the role of both Indigenous and scientific knowledge systems in protecting biodiversity. Hence, a review of existing environmental regulations and a new vision of resilient ecosystem conservation which incorporates Indigenous and local knowledge, working in harmony with Western science, will go a long way in protecting Pacific Island biodiversity in the 21st century and beyond.



"To build resilience from water insecurity, the Barana Community youths are actively involved in nature based adaptation activities by replanting trees along the Mataniko River and community watershed. With the help from civil society, the community also established a Nature and Heritage Park Plan"

Samson Hohosi
Barana community
Guadacanal
Solomon Islands
(POCCA research team interview, 2023)

Rainforest restoration project to help with fresh water supply in Barana Community, Solomon Islands (Photo: POCCA team, 2022).

References

Abbott, I. A. (1991). Polynesian uses of seaweed. In P. A. Cox & S. Bannack (Eds.), *Islands, plants, and Polynesians* (pp. 135-145). Dioscorides Press.

Adom, D. (2016). Inclusion of local people and their cultural practices in biodiversity conservation: Lessons from successful nations. *American Journal of Environmental Protection, 4*, 67-78.

Allemand, D., & Osborn, D. (2019). Ocean acidification impacts on coral reefs: From sciences to solutions. *Regional Studies in Marine Science, 28*, 100558. https://doi.org/10.1016/j.rsma.2019.100558.

Amosa, P. (2021). Water availability and access in the Pacific. In W. Leal Filho, A. M. Azul, L. Brandli, A. Lange Salvia, & T. Wall (Eds.), *Clean water and sanitation* (pp. 1-11). Encyclopedia of the UN Sustainable Development Goals. Springer International Publishing. https://doi.org/10.1007/978-3-319-70061-8_179-1.

Amosa, P., Latu, F., Imo, T., & Vaurasi, V. (2018). Preliminary water quality evaluation of the Vaisigano River, Samoa. *International Journal of Advances in Science, Engineering and Technology, 6*, 49-54. https://doi.org/IJASEAT-IRAJ-DOI-14832.

Ancrenaz, M., Dabek, L., & O'Neil, S. (2007). The costs of exclusion: Recognizing a role for local communities in biodiversity conservation. *PLoS Biology, 5*, e289. https://doi.org/10.1371/journal.pbio.0050289.

Anderson, A. J. (2003). Initial human dispersal in remote Oceania: Pattern and explanation. In C. Sand (Ed.), *Pacific archaeology: Assessments and prospects* (pp. 71-74). Nouméa: Service des Musées et du Patrimoine.

Andréfouët, S., Payri, C., Van Wynsberge, S., Lauret, O., Alefaio, S., Preston, G., Yamano, H., & Baudel, S. (2017). The timing and the scale of the proliferation of Sargassum polycystum in Funafuti Atoll, Tuvalu. *Journal of Applied Phycology, 29*, 3097-3108.

Bambrick, H. (2018). Resource extractivism, health and climate change in small islands. *International Journal of Climate Change Strategies and Management, 10*(2), 272-288.

Baines, G. B. K. (1984). Mangrove resource management in a Pacific island nation: Fiji. *Proceedings of the Asian Symposium on Mangrove Environment Research and Management*, 728-739.

Beckford, C. (2018). Climate change resiliency in Caribbean SIDS: Building greater synergies between science and local and traditional knowledge. *Journal of Environmental Studies and Sciences, 8*(1), 42–50. https://doi.org/10.1007/s13412-017-0440-y.

Bell, J. D., Johnson, J. E., Ganachaud, A. S., Gehrke, P. C., Hobday, A. J., Hoegh-Guldberg, O., Le Borgne, R., Lehodey, P., Lough, J. M., Pickering, T., Pratchett, M. S., & Waycott, M. (2011). Vulnerability of tropical Pacific fisheries and aquaculture to climate change: Summary for Pacific Island countries and territories. *Secretariat of the Pacific Community*.

Benkwitt, C. E., Wilson, S. K., & Graham, N. A. J. (2020). Biodiversity increases ecosystem functions despite multiple stressors on coral reefs. *Nature Ecology & Evolution, 4*, 919-926. https://doi.org/10.1038/s41559-020-1203-9.

Bhagwan, J. (2023). Pacific Council of Churches opening prayer. Pacific Ocean Climate Crisis Assessment (POCCA) *2nd Authors Meeting. Re-imagining climate crisis resilience and Pacific Indigenous knowledge*. 14th June 2023, Tanoa International Hotel, Nadi, Fiji.

Blasiak, R., Wabnitz, C. C., Daw, T., Berger, M., Blandon, A., Carneiro, G. & Wiegler, K. (2019). Towards greater transparency and coherence in funding for sustainable marine fisheries and healthy oceans. *Marine Policy, 107*, 103508. https://doi.org/10.1016/j.marpol.2019.103508.

Bowden-Kerby, A. (2023). Coral-focused climate change adaptation and restoration based on accelerating natural processes: Launching the 'Reefs of Hope' paradigm. *Oceans, 4*, 13-26. https://doi.org/10.3390/oceans4010002.

Brodie, G., Brodie, J., Maata, M., Peter, M., Otiawa, T., & Devlin, M. (2020b). Seagrass habitat in Tarawa Lagoon, Kiribati: Service benefits and links to national priority issues. *Marine Pollution Bulletin, 155*, 111099. https://doi.org/10.1016/j.marpolbul.2020.111099.

Brodie, G., Holland, E., N'Yeurt, A. D. R., Soapi, K., & Hills, J. (2020a). Seagrasses and seagrass habitats in Pacific small island developing states: Potential loss of benefits via human disturbance and climate change. *Marine Pollution Bulletin, 16*0, 111573. https://doi.org/10.1016/j.marpolbul.2020.111573.

Brodie, G., Pikacha, P., & Tuiwawa, M. (2013). Biodiversity and conservation in the Pacific Islands: Why are we not succeeding? In *Conservation Biology: Voices from the Tropics* (pp. 181–187). https://doi.org/10.1002/9781118679838.ch21.

Burslem, D. F. R. P., Whitmore, T. C., & Brown, G. C. (2000). Short-term effects of cyclone impact and long-term recovery of tropical rain forest on Kolombangara, Solomon Islands. *Journal of Ecology, 88*(6), 1063-1078. https://doi.org/10.1046/j.1365-2745.2000.00505.x.

Camp, E. F., Suggett, D. J., Gendron, G., Jompa, J., Manfrino, C., & Smith, D. J. (2016). Mangrove and seagrass beds provide different biogeochemical services for corals threatened by climate change. *Frontiers in Marine Science, 3*, 52. https://doi.org/10.3389/fmars.2016.00052.

Capron, M. E., Stewart, J. R., N'Yeurt, A. D. R., Chambers, M. D., Kim, J. K., Yarish, C., Jones, A. T., Blaylock, R. B., James, S. C., Fuhrman, R., Sherman, M. T., Piper, D., Harris, G., & Hasan, M. A. (2020). Restoring pre-industrial CO2 levels while achieving Sustainable Development Goals. *Energies, 13*(18), 4972. https://doi.org/10.3390/en13184972.

Carpenter, C., & Lawedrau, A. (2002). Effects of forestry activities on surface water quality in the Pacific region: A case study of the Rewa River catchment, Fiji Islands. *International Forestry Review, 4*(4), 307–309. https://doi.org/10.1505/ifor.4.4.307.17446.

Carroll, S. R., Garba, I., Figueroa-Rodríguez, O. L., Holbrook, J., Lovett, R., Materechera, S & McLean, J. (2020). The CARE principles for Indigenous data governance. *Data Science Journal, 19*, 43. https://doi.org/10.5334/dsj-2020-043.

Chunhabunyatip, P., Sasaki, N., Grünbühel, C., Kuwornu, J. K. M., & Tsusaka, T. W. (2022). Influence of Indigenous spiritual beliefs on natural resource management and ecological conservation in Thailand. *Sustainability, 10*(8), 2842. https://doi.org/10.3390/su10082842.

Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). *Nature-based solutions to address global societal challenges*. IUCN.

Conte, E., & Payri, C. E. (2006). Present day consumption of edible algae in French Polynesia: A study of the survival of pre-European practices. *Journal of the Polynesian Society, 115*, 77-93.

De'Ath, G., Fabricius, K. E., Sweatman, H., & Puotinen, M. (2012). The 27-year decline of coral cover on the Great Barrier Reef and its causes. *Proceedings of the National Academy of Sciences of the United States of America, 109*(44), 17995–17999. https://doi.org/10.1073/pnas.1208909109.

Delevaux, J. M. S., Whittier, R., Stamoulis, K. A., Bremer, L. L., Jupiter, S., Friedlander, A. M & Goodman, M. (2018). A linked land-sea modeling framework to inform ridge-to-reef management in high oceanic islands. *PLOS ONE, 13*(3), e0193230. https://doi.org/10.1371/journal.pone.0193230.

Drew, J. A., & Amatangelo, K. L. (2017). Community assembly of coral reef fishes along the Melanesian biodiversity gradient. *PLOS ONE, 12*(10), e0186123. https://doi.org/10.1371/journal.pone.0186123.

Dumas, P., Fiat, S., Durbano, A., Peignon, C., Moutham, G., Ham, J & Adjeroud, M. (2020). Citizen science, a promising tool for detecting and monitoring outbreaks of the crown-of-thorns starfish Acanthaster spp. *Scientific Reports, 10*, 291. https://doi.org/10.1038/s41598-019-57251-8.

Efi, Tui Atua Tupua Tamaese Ta'isi Tupuola Tufuga. (2018). Le fuia, le fuia, e tagisia lou vaelau 'Starling, starling, we pine for your nimbleness': Towards a Samoan Indigenous framing of responsibility for climate change. *Pacific Studies, 41*(1/2), 15-25.

Ellis, J. I., Jamil, T., Anlauf, H., et al. (2019). Multiple stressor effects on coral reef ecosystems. *Global Change Biology, 25*, 4131–4146. https://doi.org/10.1111/gcb.14819.

Ellis, S. C. (2005). Meaningful consideration? A review of traditional knowledge in environmental decision making. Arctic, 66–77.

Ellison, J. C. (2009). Wetlands of the Pacific Island region. *Wetlands Ecology and Management, 17*(3), 169-206. https://doi.org/10.1007/s11273-008-9097-3.

Elmer, F., Rogers, J. S., Dunbar, R. B., Monismith, S. G., Bell, J. J., & Gardner, J. P. A. (2016). Influence of localized currents, benthic community cover, and composition on coral recruitment: Integrating field-based observations and physical oceanographic modeling. *Proceedings of the 13th International Coral Reef Symposium*, Honolulu, 101-142.

Fabricius, K. E., Noonan, S. H. C., Abrego, D., Harrington, L., & De'Ath, G. (2017). Low recruitment due to altered settlement substrata as primary constraint for coral communities under ocean acidification. *Proceedings of the Royal Society B: Biological Sciences, 284*, 20171536. https://doi.org/10.1098/rspb.2017.1536.

Fache, E., Dumas, P., & N'Yeurt, A. D. R. (2019). An interdisciplinary overview of some climate-related narratives and responses in the Pacific. *Journal de la Société des Océanistes, 149*, 199-210.

Farran, S. (2022). Deep-sea mining and the potential environmental cost of 'going green' in the Pacific. *Environmental Law Review, 24*(3), 173-190.

Fay, L., Vuki, V., Sauni, S., & Tebano, T. (2007). Anadara fishing supports urban households in Tarawa, Kiribati and Suva, Fiji. *SPC Women in Fisheries Information Bulletin, 17*, 19-26.

Fay-Sauni, L., & Sauni, S. (2005). Women and the Anadara fishery: A case study in south Tarawa, Kiribati. In I. Novaczek, J. Michell, & J. Veitayaki (Eds.), *Pacific voices: Equity and sustainability in Pacific Island fisheries* (pp. 65–79). University of the South Pacific, Institute of Pacific Studies.

Feely, R. A., Doney, S. C., & Cooley, S. R. (2009). Ocean acidification: Present conditions and future changes in a high-CO2 world. *Oceanography, 22*(1), 36-47.

Fidai, Y. A., Dash, J., Tompkins, E. L., & Tonon, T. (2020). A systematic review of floating and beach landing records of Sargassum beyond the Sargasso Sea. *Environmental Research Communications, 2*(12), 122001. https://doi.org/10.1088/2515-7620/abcc2c.

Finch, D. M., Butler, J. L., Runyon, J. B., Fettig, C. J., Kilkenny, F. F., Jose, S & Amelon, S. K. (2021). Effects of climate change on invasive species. In T. M. Poland et al. (Eds.), *Invasive species in forests and rangelands of the United States* (pp. 57-83). Cham: Springer.

FPO. (2012). Framework for a Pacific Oceanscape – *Our sea of islands, our livelihoods, our Oceania: A catalyst for implementation for ocean policy*. Retrieved from Forum Secretariat.

Friedlaender, J. S., & Tucci, S. (2020). Human migrations: Tales of the Pacific. *Current Biology, 30*(23), R1469–R1499. https://doi.org/10.1016/j.cub.2020.11.008.

Fujita, M., Suzuki, J., Sato, D., Kuwahara, Y., Yokoki, H., & Kayanne, H. (2013). Anthropogenic impacts on water quality of the lagoonal coast of Fongafale Islet, Funafuti Atoll, Tuvalu. *Sustainable Science, 8*, 381-390.

Gattuso, J.-P., Magnan, A., Billé, R., Cheung, W. W. L., Howes, E. L., Joos, F., Allemand, D., Bopp, L., Cooley, S. R., Eakin, C. M., Hoegh-Guldberg, O., Kelly, R. P., Pörtner, H.-O., Rogers, A. D., Baxter, J., Laffoley, D., Osborn, D., Rankovic, A., Rochette, J., Sumaila, U. R., Treyer, S., & Turley, C. (2015). Contrasting futures for ocean and society from different anthropogenic CO2 emissions scenarios. *Science, 349*(6243), aac472. https://doi.org/10.1126/science.aac472.

Gell, A. (1996). *Wrapping in images: Tattooing in Polynesia*. Oxford Studies in Social and Cultural Anthropology - Cultural Forms. Oxford: Oxford University Press.

Gonda, N. (2019). Re-politicizing the gender and climate change debate: The potential of feminist political ecology to engage with power in action in adaptation policies and projects in Nicaragua. *Geoforum, 106*, 87–96. https://doi.org/10.1016/j.geoforum.2019.07.020.

Goulding, W., Moss, P. T., & McAlpine, C. A. (2016). Cascading effects of cyclones on the biodiversity of Southwest Pacific islands. *Biological Conservation, 193*, 143-152. https://doi.org/10.1016/j.biocon.2015.11.022

Griffin, S. (2018). Evaluation of biogas and fertilizer production from *Acanthaster cf. A. solaris* (Crown of Thorns Starfish). (Master's thesis, Pacific Centre for Environment and Sustainable Development, The University of the South Pacific, Suva, Fiji).

Gupta, B. (2020). Traditional knowledge and biodiversity: Emerging issues. *Harnessing Nature Magazine, 2*(3), 24–26.

Hage, P., Harary, F., & Milicic, B. (1996). Tattooing, gender and social stratification in Micro-Polynesia. *The Journal of the Royal Anthropological Institute, 2*(2), 335-350. https://doi.org/10.2307/3034099.

Hao, M., Aidoo, O. F., Qian, Y., Wang, D., Ding, F., Ma, T & Borgemeister, C. (2022). Global potential distribution of *Oryctes rhinoceros*, as predicted by boosted regression tree model. Global Ecology and Conservation, 37, e02175. https://doi.org/10.1016/j.gecco.2022.e02175.

Harden-Davies, H., Humphries, F., Maloney, M., Wright, G., Gjerde, C., & Vierros, M. (2020). Rights of nature: Perspectives for global ocean stewardship. *Marine Policy, 122*, 104059. https://doi.org/10.1016/j.marpol.2020.104059.

Hills, T., Brooks, A., Atherton, J., Rao, N., & James, R. (2011). *Pacific Island biodiversity, ecosystems and climate change adaptation: Building on nature's resilience*. Retrieved from https://www.sprep.org/attachments/Publications/000931_PIBioEcoCCAdaptation.pdf.

Holbrook, N. J., Hernaman, V., Koshiba, S., Lako, J., Kajtar, J. B., Amosa, P., & Singh, A. (2022). Impacts of marine heatwaves on tropical western and central Pacific Island nations and their communities. *Global and Planetary Change, 208*, 103680. https://doi.org/10.1016/j.gloplacha.2021.103680.

Howes, E. L., Birchenough, S., & Lincoln, S. (2018). Effects of climate change relevant to the Pacific Islands. *Pacific Marine Climate Change Report Card*. Commonwealth Marine Economies Programme.

Hue, T., Chateau, O., Lecellier, G., Kayal, M., Lanos, N., Gossuin, H., Adjeroud, M & Dumas, P. (2020). Temperature affects the reproductive outputs of coral-eating starfish Acanthaster spp. after adult exposure to near-future ocean warming and acidification. *Marine Environmental Research, 162*, 105164. https://doi.org/10.1016/j.marenvres.2020.105164.

Hue, T., Chateau, O., Lecellier, G., Marin, C., Coulombier, N., Le Dean, L., Gossuin, H., Adjeroud, M., & Dumas, P. (2022). Impact of near-future ocean warming and acidification on the larval development of coral-eating starfish *Acanthaster cf. solaris* after parental exposure. Journal of Experimental Marine Biology and Ecology, 548, 151685. https://doi.org/10.1016/j.jembe.2021.151685.

Iese, V., & N'Yeurt, A. D. R. (2018). *Final report for seaweed monitoring survey in Tuvalu*. Funafuti: Ministry of Environment, Government of Tuvalu.

IOC-UNESCO. (2021). *The United Nations Decade of Ocean Science for Sustainable Development (2021–2030) Implementation Plan*. Paris: UNESCO. (IOC Ocean Decade Series, 20). Available at: https://unesdoc.unesco.org/ark:/48223/pf0000377082?14=null&queryId=459ef876-bc02-4f0b-b542-4ff2f943372e
.

IOC-UNESCO. (2022). *State of the Ocean Report. Pilot edition*. Paris: IOC-UNESCO. (IOC Technical Series, 173).

IPBES. (2019). *Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2019) Status and Trends – Nature (Chapter 2.2)*. Global Assessment on Biodiversity and Ecosystem Services. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services from IPBES-7.

IPCC, (2018). *Global Warming of 1.5°C.An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* (Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)).

IUCN. (2020). *IUCN Global Standard for Nature-based Solutions: A user-friendly framework for the verification, design and scaling up of NbS*. Gland: IUCN (International Union for Conservation of Nature).

IUCN. (2021). *Invasive alien species and climate change*. Gland: IUCN (International Union for Conservation of Nature).

James, R., Fisher, J. R., Carlos-Grotjahn, C., Boylan, M. S., Dembereldash, B., Demissie, M. Z & Butt, N. (2023). Gender bias and inequity holds women back in their conservation careers. *Frontiers in Environmental Science, 10*, 1056751. https://doi.org/10.3389/fenvs.2022.1056751.

Janif, S. Z., Nunn, P. D., Geraghty, P., Aalbersberg, W., Thomas, F. R., & Camailakeba, M. (2016). Value of traditional oral narratives in building climate-change resilience: Insights from rural communities in Fiji. *Ecology and Society, 21*(2). https://doi.org/10.5751/ES-08100-210207.

Johnson, J., Bell, J., & Gupta, A. S. (2016). *Pacific Islands ocean acidification vulnerability assessment*. Apia: SPREP.

Jupiter, S., Mangubhai, S., & Kingsford, R. T. (2014). Conservation of biodiversity in the Pacific Islands of Oceania: Challenges and opportunities. *Pacific Conservation Biology, 20*(2), 206-220. https://doi.org/10.1071/PC140206.

Keppel, G., Morrison, C., Meyer, J. Y., & Boehmer, H. J. (2014). Isolated and vulnerable: The history and future of Pacific Island terrestrial biodiversity. *Pacific Conservation Biology, 20*, 136-145.

Keppel, G., Morrison, C., Watling, D., Tuiwawa, M. V., & Rounds, I. A. (2012). Conservation in tropical Pacific Island countries: Why most current approaches are failing. *Conservation Letters, 5*, 256–265. https://doi.org/10.1111/j.1755-263X.2012.00255.x.

Kitolelei, S., Thaman, R., Veitayaki, J., Breckwoldt, A., & Piovano, S. (2021). Na Vuku Makawa ni Qoli: Indigenous Fishing Knowledge (IFK) in Fiji and the Pacific. *Frontiers in Marine Science, 8*, 684303. https://doi.org/10.3389/fmars.2021.684303.

Kleypas, J. A., Feely, R. A., Fabry, V. J., Langdon, C., Sabine, C. L., & Robbins, L. L. (2006). *Impacts of ocean acidification on coral reefs and other marine calcifiers: A guide for future research*. Report of a workshop held 18–20 April 2005, St. Petersburg, FL, sponsored by NSF, NOAA, and the U.S. Geological Survey.

Kumar, L., & Tehrany, M. S. (2017). Climate change impacts on the threatened terrestrial vertebrates of the Pacific Islands. *Scientific Reports, 7*(1), 5030. https://doi.org/10.1038/s41598-017-05257-w.

Lal, R., Kininmonth, S., N'Yeurt, A. D. R., Riley, R. H., & Rico, C. (2018). The effects of a stressed inshore urban reef on coral recruitment in Suva Harbour, Fiji. *Ecology and Evolution, 8*, 11842-11856. https://doi.org/10.1002/ece3.4641

Largo, D. B., Chung, I. K., Phang, S.-M., Gerung, G. S., & Sondak, C. F. A. (2017). Impacts of climate change on Eucheuma-Kappaphycus farming. In A. Hurtado, A. Critchley, & I. Neish (Eds.), *Tropical seaweed farming: Trends, problems and opportunities* (pp. 121-129). Cham: Springer.

Lee, E. L. (2022). Caviar of the Pacific: Palolo fishing today and its association with coral reef health. *Independent Study Project (ISP) Collection*, 3561. https://digitalcollections.sit.edu/isp_collection/3561.

Lehodey, P., Brill, R. W., Nicol, S., Senina, I., Calmettes, B., Pörtner, H. O., Bopp, L., Ilyina, T., Bell, J. D., & Sibert, J. (2011). Vulnerability of oceanic fisheries in the tropical Pacific to climate change. In J. D. Bell, J. E. Johnson, & A. J. Hobday (Eds.), *Vulnerability of tropical Pacific fisheries and aquaculture to climate change* (pp. 941). Nouméa: Secretariat of the Pacific Community.

Liggins, L., Noble, C., & The Ira Moana Network. (2021). The Ira Moana Project: A genetic observatory for Aotearoa's marine biodiversity. *Frontiers in Marine Science, 8*, 740953. https://doi.org/10.3389/fmars.2021.740953.

Luick, J. (2022). Blue peril: *A visual investigation of deep-sea mining in the Pacific*. Technical Note, Austides Consulting. https://dsm-campaign.org/wp-content/uploads/2022/09/Blue-Peril-Technical-Paper.pdf.

Malhi, Y., Franklin, J., Seddon, N., Solan, M., Turner, M. G., Field, C. B., & Knowlton, N. (2020). Climate change and ecosystems: Threats, opportunities and solutions. *Philosophical Transactions of the Royal Society B, 375*, 20190104. https://doi.org/10.1098/rstb.2019.0104.

Malsale, P., Sanau, N., Tofaeono, T. I., Kavisi, Z., Willy, A., Mitiepo, R., Lui, S., Chambers, L. E., & Plotz, R. D. (2018). Protocols and partnerships for engaging Pacific Island communities in the collection and use of traditional climate knowledge. *Bulletin of the American Meteorological Society, 99*(12), 2471–2489. https://doi.org/10.1175/BAMS-D-17-0163.1.

Matthews, S. A., Williamson, D. H., Beeden, R., Emslie, M. J., Abom, R. T., Beard, D. & Quincey, R. (2024). Protecting Great Barrier Reef resilience through effective management of crown-of-thorns starfish outbreaks. *PLoS ONE, 19*(4), e0298073. https://doi.org/10.1371/journal.pone.0298073.

Maxwell, S. L., Fuller, R. A., Brooks, T. M., & Watson, J. E. (2016). Biodiversity: The ravages of guns, nets and bulldozers. *Nature, 536*(7615), 143-145. https://doi.org/10.1038/536143a.

Mazzocchi, F. (2006). Western science and traditional knowledge. *EMBO Reports, 7*(5), 463–466. https://doi.org/10.1038/sj.embor.7400693.

McLeod, E., Bruton-Adams, M., Förster, J., Franco, C., Gaines, G., Gorong, B. & Williams, A. (2019). Lessons from the Pacific Islands: Adapting to climate change by supporting social and ecological resilience. *Frontiers in Marine Science, 6*, 289. https://doi.org/10.3389/fmars.2019.00289.

McMillen, H. L., Ticktin, T., Friedlander, A., Jupiter, S. D., Thaman, R., Campbell, J., Veitayaki, J., Giambelluca, T., Nihmei, S., Rupeni, E., Apis-Overhoff, L., Aalbersberg, W., & Orcherton, D. F. (2014). Small islands, valuable insights: Systems of customary resource use and resilience to climate change in the Pacific. *Ecology and Society, 19*(4), 44. https://doi.org/10.5751/ES-06937-190444.

Minter, T., Orirana, G., Boso, D., & van der Ploeg, J. (2018). *From happy hour to hungry hour: Logging, fisheries and food security in Malaita, Solomon Islands*. Penang, Malaysia: WorldFish. Program Report: 2018-07.

Morrison, R. J., & Aalbersberg, W. G. L. (2022). Anthropogenic environmental impacts on coral reefs in the western and south-western Pacific Ocean. In J. Zhang, T. Yeemin, R. J. Morrison, & G. H. Hong (Eds.), *Coral reefs of the Western Pacific Ocean in a changing Anthropocene* (pp. 7-24). Cham: Springer.

Muna, L. R., Brodie, G., Singh, A., Hills, J., Wandres, M., & Damlamian, H. (2023). Understanding ecosystem services for climate change resilience in coastal environments: A case study of low-canopy sub-tidal seagrass beds in Fiji. *Frontiers in Marine Science, 10*, 1184568. https://doi.org/10.3389/fmars.2023.1184568.

Mycoo, M., Wairiu, M., Campbell, D., Duvat, V., Golbuu, Y., Maharaj, S., Nalau, J., Nunn, P., Pinnegar, J., & Warrick, O. (2022). Small islands. In H.-O. Pörtner, D. C. Roberts, J. T. Poloczanska, M. D. Morecroft, V. M. T. M. H. Field, & T. M. Brönnimann (Eds.), *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 2043–2121). Cambridge: Cambridge University Press.

Naikatini, A. N. (2024). *Behavioural ecology and traditional knowledge of Fiji's forest birds* (Doctoral dissertation). University of the South Pacific.

Nakamura, N., Kayanne, H., Takahashi, Y., Sunamura, M., Hosoi, G., & Yamano, H. (2020). Anthropogenic anoxic history of the Tuvalu Atoll recorded as annual black bands in coral. *Scientific Reports, 10*, 7338. https://doi.org/10.1038/s41598-020-63578-4.

Niner, H. J., Ardron, J. A., Escobar, E. G., Gianni, M., Jaeckel, A., Jones, D. O. & Gjerde, K. M. (2018). Deep-sea mining with no net loss of biodiversity—an impossible aim. *Frontiers in Marine Science, 5*, 53. https://doi.org/10.3389/fmars.2018.00053.

N'Yeurt, A. D. R. (1995). Meristotheca procumbens P. Gabrielson et Kraft (Gigartinales, Solieriaceae): An edible seaweed from Rotuma Island. *South Pacific Journal of Natural Sciences, 14*, 243-250.

N'Yeurt, A. D. R., Chynoweth, D. P., Capron, M. E., Stewart, J. R., & Hasan, M. A. (2012). Negative carbon via ocean afforestation. *Process Safety and Environmental Protection, 90*, 467-474.

N'Yeurt, A. D. R., & Iese, V. (2015a). Marine plants as a sustainable source of agri-fertilizers for Small Island Developing States (SIDS). In W. G. Ganpat & W.-A. Isaac (Eds.), *Impacts of climate change on food security in Small Island Developing States* (pp. 280-311). Hershey: IGI Global. https://doi.org/10.4018/978-1-4666-6501-9.ch010.

N'Yeurt, A. D. R., & Iese, V. (2015b). The proliferating brown alga Sargassum polycystum in Tuvalu, South Pacific: Assessment of the bloom and applications to local agriculture and sustainable energy. *Journal of Applied Phycology, 27*(5), 2037-2045. https://doi.org/10.1007/s10811-015-0572-4.

N'Yeurt, A. D. R., & Payri, C. E. (2010). Marine benthic algal flora of French Polynesia. III. Rhodophyta, with additions to the *Chlorophyta and Phaeophyceae. Cryptogamie, Algologie, 31*, 1-205.

N'Yeurt, A. D. R., & South, G. R. (1997). Biodiversity and biogeography of marine benthic algae in the Southwest Pacific, with special reference to Rotuma and Fiji. *Pacific Science, 51*(1), 18-28. https://doi.org/10.1353/psc.1997.0001.

Nunn, P. D., Kumar, L., Eliot, L. I., & McLean, R. F. (2016). Classifying Pacific islands. *Geoscience Letters, 3*(1), 7. https://doi.org/10.1186/s40562-016-0041-8.

Nurse, L. A., McLean, R. F., Agard, J., Briguglio, L. P., Duvat-Magnan, V., Pelesikoti, N., Tompkins, E., & Webb, A. (2014). Small islands. In V. R. Barros et al. (Eds.), *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 1613-1654). Cambridge: Cambridge University Press.

Ostraff, M. (2006). LIMU: Edible seaweed in Tonga, an ethnobotanical study. *Journal of Ethnobiology, 26*(2), 208-227. https://doi.org/10.2993/0278-0771(2006)26(208:LESITA)2.0.CO;2.

Pacific Islands Forum Secretariat (PIFS). (2022). *2050 Strategy for the Blue Pacific Continent*. Suva: PIFS. https://www.forumsec.org/2050strategy/.

Paulus, E. (2021). Shedding light on deep-sea biodiversity—a highly vulnerable habitat in the face of anthropogenic change. *Frontiers in Marine Science, 8*, 667048. https://doi.org/10.3389/fmars.2021.667048.

Parmesan, C., Morecroft, M. D., Trisurat, Y., Adrian, R., Anshari, G. Z., Arneth, A., Gao, Q., Gonzalez, P., Harris, R., Price, J., Stevens, N., & Talukdarr, G. H. (2022). Terrestrial and freshwater ecosystems and their services. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 197–377). Cambridge: Cambridge University Press. https://doi.org/10.1017/9781009325844.004.

Pollard, E. J., MacLaren, D., Russell, T. L., & Burkot, T. R. (2020). Protecting the peri-domestic environment: The challenge for eliminating residual malaria. *Scientific Reports, 10*(1), 7018. https://doi.org/10.1038/s41598-020-74004-7.

Pollard, E. J. M., Thaman, R., Brodie, G., & Morrison, C. (2015). Threatened biodiversity and traditional ecological knowledge: Associated beliefs, customs, and uses of herpetofauna among the 'Are'Are on Malaita Island, Solomon Islands. *Ethnobiology Letters, 6*(1), 99-110. https://doi.org/10.14237/ebl.6.1.2015.778.

Popovici, R., Moraes, A. G. d. L., Ma, Z., Zanotti, L., Cherkauer, K. A., Erwin, A. E. & Prokopy, L. S. (2021). How do Indigenous and local knowledge systems respond to climate change? *Ecology and Society, 26*(3). https://doi.org/10.5751/ES-12481-260327.

Pörtner, H. O., Scholes, R. J., Agard, J., Archer, E., Arneth, A., Bai, X., Barnes, D. & Yu, K. (2021). Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change. Bonn: IPBES secretariat. https://doi.org/10.5281/zenodo.4659158.

Priyadarshana, T. S., & Slade, E. M. (2023). A meta-analysis reveals that dragonflies and damselflies can provide effective biological control of mosquitoes. *Journal of Animal Ecology, 92*(8), 1589-1600. https://doi.org/10.1111/1365-2656.13846.

Rashni, B. (2021). Freshwater biomonitoring: An ecosystem-based approach (EBA) for building climate-resilient communities in Fiji. In M. Mukherjee & R. Shaw (Eds.), *Ecosystem-Based Disaster and Climate Resilience* (pp. 483-500). Singapore: Springer. https://doi.org/10.1007/978-981-15-8467-3_25.

Ricart, A. M., Ward, M., Hill, T. M., Sanford, E., Kroeker, K. J., Takeshita, Y., Merolla, S., Shukla, P., Ninokawa, A. T., Elsmore, K., & Gaylord, B. (2021). Coast-wide evidence of low pH amelioration by seagrass ecosystems. *Global Change Biology, 27*, 2580-2591. https://doi.org/10.1111/gcb.15594.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin III, F. S., Lambin, E., Lenton, T. M. & Folke, C. (2009). Planetary boundaries: Exploring the safe operating space for humanity. *Ecology and Society, 14*(2). https://www.ecologyandsociety.org/vol14/iss2/art32/.

Salm, R. V., & McLeod, E. (2008). Climate change impacts on ecosystem resilience and MPA management in Melanesia. In S. J. Leisz & J. B. Burnett (Eds.), *Climate Change and Biodiversity in Melanesia* (pp. 7-20). Honolulu: Bishop Museum Technical Report (42).

Secretariat of the Convention on Biological Diversity. (2019). *Traditional Knowledge and the Convention on Biological Diversity*. The Secretariat of the Convention on Biological Diversity. https://www.cbd.int/doc/publications/8j-brochure-en.pdf.

Secretariat of the Pacific Regional Environment Programme. (2021). *Pacific Islands framework for nature conservation and protected areas 2021-2025*. Apia: Secretariat of the Pacific Regional Environment Programme.

Seeto, J., Nunn, P. D., & Sanjana, S. (2011). Human-mediated prehistoric marine extinction in the tropical Pacific? Understanding the presence of Hippopus hippopus (Linn.1758) in ancient shell middens on the Rove Peninsula, southwest Viti Levu Island, Fiji. Geoarchaeology: A*n International Journal, 27*(1), 2-17. https://doi.org/10.1002/gea.20364.

Smetacek, V., & Zingone, A. (2013). Green and golden seaweed tides on the rise. *Nature, 504*(7478), 84. https://doi.org/10.1038/504084a.

Soreh, C. T. (2022). Assessing the effects of liquid seaweed extracts from *Sargassum polycystum and Gracilaria edulis* on selected agricultural crops (Master's thesis). Pacific Centre for Environment and Sustainable Development, The University of the South Pacific, Suva, Fiji.

South, G. R. (1993). Seaweed resources of the South Pacific Islands. In A. T. Critchley & M. Ohno (Eds.), *Seaweed Resources of the World* (pp. 146-155). Kanagawa International Fisheries Training Centre & Japan International Cooperation Agency.

Spalding, M. D., Ruffo, S., Lacambra, C., Meliane, I., Hale, L. Z., Shepard, C. C., & Beck, M. W. (2014). The role of ecosystems in coastal protection: Adapting to climate change and coastal hazards. *Ocean & Coastal Management, 90*, 50-57. https://doi.org/10.1016/j.ocecoaman.2013.09.007.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R. & Schellnhuber, H. J. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science, 347*(6223), 1259855. https://doi.org/10.1126/science.1259855.

Sykes, H.R., & Lovell, E.R. (2009). A cause for optimism: identification of threats and resiliency on Pacific reefs through establishment of a long-term reef monitoring network in Fiji: the Fiji Coral Reef Monitoring Network (FCRMN).

Tabunawati, T. (2024). Comparison of seagrass meadow health and function in Abaiang and Tarawa lagoons in Kiribati (MSc thesis). PACE-SD, University of the South Pacific.

Taylor, S. (2017). Impacts of climatic and oceanic processes on the threatened terrestrial vertebrates of the Pacific region. *GeoResJ, 13*, 1-8. https://doi.org/10.1016/j.grj.2017.07.001.

Taylor, S., & Kumar, L. (2016). Global climate change impacts on Pacific Islands terrestrial biodiversity: A review. *Tropical Conservation Science, 9*(1), 203-223. https://doi.org/10.1177/194008291600900113.

Thaman, R. R. (2004a). Cool spots under threat: The conservation status of atoll biodiversity and ethnobiodiversity in the Pacific Islands. In K. G. Lee & H.-M. Tsai (Eds.), *Changing Islands – Changing Worlds: Proceedings of Islands of the World VIII* (pp. 60-64). Taipei: International Small Islands Studies Association (ISISA).

Thaman, R. R. (2004b). Sustaining culture and biodiversity in Pacific Islands with local and Indigenous knowledge. *Pacific Ecologist, Autumn-Winter*(7 & 8), 43-48.

Thaman, R. R. (2007a). Biodiversity, ethnobiodiversity and biospirituality: A foundation for cultural survival and sustainable living on small islands. *The Pacific Journal of Theology Series 2, 38*, 70-84.

Thaman, R. R. (2007b). Island biodiversity and ethnobiodiversity: Conservation, sustainable use and equitable sharing of biodiversity and ethnobiodiversity as a foundation for sustainable island life. In H.-M. Tsai (Ed.), *Proceedings of the Inaugural Meeting of the IGU Commission on Islands: 'Island Geographies' International Conference, 29 October-3 November 2007, Taiwan University, Taipei, Taiwan* (pp. D.4.1-D.4.34).

Thaman, R. R. (2008a). Pacific Island agrobiodiversity and ethnobiodiversity: A foundation for sustainable Pacific Island life. Biodiversity: *Journal of Life on Earth, 9*(1 & 2), 102-110.

Thaman, R. R. (2008b). Atolls – the 'biodiversity cool spots' vs hot spots: A critical new focus for research and conservation. *Micronesica, 40*(1/2), 33-61.

Thaman, R. R. (2016). Atolls of the tropical Pacific Ocean: Wetlands under threat. In C. M. Finlayson, G. R. Milton, R. C. Prentice, & N. C. Davidson (Eds.), *The Wetland Book* (pp. 1-25). Dordrecht: Springer.

Thaman, B., Thaman, R., Balawa, A., & Veitayaki, J. (2017). The recovery of a tropical marine mollusk fishery: A transdisciplinary community-based approach in Navakavu, Fiji. *Journal of Ethnobiology, 37*(3), 494. https://doi.org/10.2993/0278-0771-37.3.494.

Thomas, A., Mangubhai, S., Fox, M., Meo, S., Miller, K., Naisilisili, W., Veitayaki, J. & Waqairatu, S. (2021). Why they must be counted: Significant contributions of Fijian women fishers to food security and livelihoods. *Ocean & Coastal Management, 205*, 105571. https://doi.org/10.1016/j.ocecoaman.2021.105571.

UN Environment Programme. (2019). Biodiversity (Chapter 6). In *Global Environment Outlook – 6: Healthy Planet, Healthy People*. UN Environment Programme.

UNESCAP. (2019). *Ocean Cities Regional Policy Guide*. Bangkok: UNESCAP.

UN General Assembly. (2014). Resolution adopted by the General Assembly on 14 November 2014, 69/15. *SIDS Accelerated Modalities of Action (SAMOA) Pathway*. A/RES/69/15, United Nations.

United Nations. (1992). *Convention on Biological Diversity*. New York: United Nations.

Uthicke, S., Logan, M., Liddy, M., Francis, D., Hardy, N., & Lamare, M. (2015). Climate change as an unexpected co-factor promoting coral-eating seastar (Acanthaster planci) outbreaks. *Scientific Reports, 5*, 8402. https://doi.org/10.1038/srep08402.

Veron, J. E. N. (1993). *Corals of Australia and the Indo-Pacific*. Honolulu: University of Hawaii Press.

Vince, J., Brierley, E., Stevenson, S., & Dunstan, P. (2017). Ocean governance in the South Pacific region: Progress and plans for action. *Marine Policy, 79*, 40-45. https://doi.org/10.1016/j.marpol.2017.02.018.

Vissichelli, M. (2018). *Invasive species impacts on federal infrastructure*. National Invasive Species Council Secretariat. Washington, DC.

Von Schuckmann, K., Minière, A., Gues, F., et al. (2023). Heat stored in the Earth system 1960–2020: Where does the energy go? *Earth System Science Data, 15*, 1675–1709. https://doi.org/10.5194/essd-15-1675-2023.

Wakwella, A., Wenger, A., Jenkins, A., Lamb, J., Kuempel, C. D., Claar, D., Corbin, C., Falinski, K., Rivera, A., Grantham, H. S., & Jupiter, S. D. (2023). Integrated watershed management solutions for healthy coastal ecosystems and people. *Cambridge Prisms: Coastal Futures, 1*, p.e27.

Wang, H., & Wang, C. (2023). What caused the increase of tropical cyclones in the western North Pacific during the period of 2011–2020? *Climate Dynamics, 60*(1), 165-177.

Watling, D. (1986). *Mai Veikau: Tales of Fijian Wildlife*. Watling, D., & Rolls, I. Suva, Fiji.

Weiner, M. (1970). Notes on some medicinal plants of Fiji. *Economic Botany, 24*, 279–282. https://doi.org/10.1007/BF02860662

Whistler, A. (1992). *Polynesian Herbal Medicine*. W. Arthur Whistler.

Xiao, X., Agustí, S., Yu, Y., Huang, Y., Chen, W., Hu, J., Li, C., Li, K., Wei, F., Lu, Y., Xu, C., Chen, Z., Liu, S., Zeng, J., Wu, J., & Duarte, C. M. (2021). Seaweed farms provide refugia from ocean acidification. *Science of the Total Environment, 776*, 145192. https://doi.org/10.1016/j.scitotenv.2021.145192.

UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

USP
THE UNIVERSITY OF THE SOUTH PACIFIC

POCCA
Pacific Ocean and Climate Crisis Assessment