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An analysis of ecosystem-based adaptations in Pacific Island countries

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Abstract

Pacific Islands Countries and Territories' (PICTs) has one of the richest and most complex ecosystems globally, surrounded by oceans with marine and terrestrial diversity. These diverse ecosystems are essential for the well-being of Pacific Islanders in terms of their livelihoods, food security, recreation and cultural activities; and they are also integral to Islanders' heritage and identity. The well-being and cultural heritage of the Pacific Islanders are under threat from severe climate change-related impacts; and this is further compounded by several non-climate-change related factors such as overfishing and pollution, all negatively impacting the countries' ecosystems. These negative impacts include: ecosystem degradation, loss of ecosystem services, and biodiversity loss. Therefore, a nature-based approach such as ecosystem-based adaptation (EbA) can be a useful tool in adaptation planning for the PICTs. PICTs have identified EbA as a more sustainable way towards addressing the impacts of climate change due to its cost-effectiveness and suitability to the Pacific Islands countries. This is because EbA is a nature-based approach, and its implementation necessitates the involvement of the communities and/or resource

owners. EbA projects in the Pacific region have been piloted in Fiji, Vanuatu, Solomon Islands and Samoa. An analysis of the results from the four Island nations' pilot projects revealed that knowledge integration is a significant factor in decision-making under a social-ecological system where the technical or scientific knowledge and the traditional or indigenous knowledge complement each other and, in many cases, validates the indigenous knowledge. However, as PICTs' economies depend mainly on ecosystem services, both on land and in the ocean for individual and community wellbeing, more research is warranted to further understand how EbA practices best integrate food security and livelihoods.

Keywords: Ecosystem-based Adaptation, Ecosystems, Livelihoods, Food Security, Climate Change, Nature-based Solution

1.0 Introduction

The ecosystem plays a significant role in sustaining livelihoods in Pacific Island Countries and Territories (PICTs). The essential resources and ecosystems on which Pacific islanders rely for nutrition and livelihoods are increasingly under threat. Due to their comparative smallness, geographical remoteness, fragility of ecosystems, and heavy dependence on limited natural resources, PICTs are very vulnerable to the impacts of climate change (Hills et al., 2011). Climate change presents the greatest threat to Pacific Island governments' and territories' environmental, economic, and social sustainability. Climate change already has had devastating effects on coastal and forest ecosystems, oceans, food supplies, and biologically diverse life, especially in small, lower regions where sea levels rise and weather patterns change, which contribute to social and economic disorder (SPREP, 2012).

Ecosystems of PICTs, especially in the urban and agricultural areas, have been swiftly and significantly changing, resulting in reductions in ecosystem health and services such as soil and water quality (Reed, 2005). This deteriorating ecosystem health and services has rapidly affected the growing demands for food, freshwater, timber, fibre, and fuel over the years. As a result, communities' ability to adapt to, and deal with current and expected climate change consequences has been hampered, endangering long-term environmental sustainability and food security (ADB, 2011).

The governments of these nations have identified Ecosystem-based Adaptation (EbA) as a sustainable way to address climate change issues. Most EbA research in the PICTs has protected and conserved marine and coastal resources as adaptive solutions. However, there has been very little research on the benefits of EbA on communities, including food security and sustainable livelihoods (Emerton, 2017). EbA combines a global strategy on utilizing biodiversity and ecosystem services to enable people to adapt to the severe consequences of climate change (UNEP, 2020). It involves sustainable ecosystem management, conservation, and restoration to deliver

services to assist people in adjusting to existing climatic fluctuation and change (IUCN, 2014). An ecosystem-based adjustment helps to reduce susceptibility to both climate and non-climate hazards, and facilitates increased resilience to these. It offers economic and environmental benefits in various ways (Hills et al., 2011).

EbA is increasingly promoted throughout the globe, but its introduction and implementation in the PICTs as a technology supporting adaptation to the impacts of climate change is relatively new (UNEP, 2020). There have been pilot EbA projects in Fiji, Vanuatu, Solomon Islands, and Samoa as adaptation solutions to climate change (Boer et al., 2012). The EbA projects in Taveuni and Macuata (Fiji) by SPREP have not yet been assessed for their effectiveness in delivering benefits, including livelihood and food security. Similarly, in Vanuatu, Solomon Islands, and Samoa, the EbA sites need to be evaluated to ascertain if there are indeed benefits to the communities (SPREP, 2018a).

This paper will present a review of the benefits of EbA in Pacific Island communities. It presents a summary of the benefits at the global level, then moves into evaluating the EbA benefits for PICTs at the community level using some case studies. Finally, the paper provides an insight into the value of indigenous knowledge as the foundation for EbA approaches in PICTs, especially since most of the land, fishing rights and ecosystems are under traditional governance mechanisms.

2.0 EbA interventions for ecosystem services

In the sustainable utiliziation of biodiversity and ecosystem services, the EbA interventions are necessary (SPREP, 2020a) to restore, maintain and enhance the capacity of ecosystems to produce services on which local communities depend for their livelihoods and food security (Pearson, 2020). Key EbA interventions for Ecosystem services under threat are as follows:

1. Health and extent of local forests - Abandoned agricultural and cleared land on high elevations to be converted to native forests;
2. Productivity of soil - Agricultural and agroforestry practices to be reviewed and changed to create diverse agro-ecological systems;
3. Riparian function - Effects of terrestrial run-off to the marine environment to be reduced;
4. Biodiversity - Forest conservation expansion, native forest restoration, and reforestation decrease in fragmentation, and invasive species monitoring and agricultural diversity;
5. Protection against storm surges - Coastal system enhancement and mangrove expansion where possible;
6. Freshwater sustainability - Run-off slowing through protection and expansion of forests at high elevation, and increase in cloud and rainwater infiltration to groundwater supply;
7. Food supply sustainability - Crop diversity and aquaculture through potential realisation with action and protection with an improvement of marine resources and habitats; and
8. Income and independence sustainability - Income diversification from cash crops to diversified investment that enhances ecosystems.

3.0 Benefits of EbA in the Pacific Islands

Several studies have demonstrated that there are significant benefits in using EbA approaches in regard to improving food security, enabling ecosystem conservation, sustaining agricultures, and improving livelihoods of communities globally. This is presented in Table 1.

Table 1
Benefits of EbA in the Pacific Island countries

Benefits of EbA	Themes	Key reference
Healthy ecosystems	E, FS	(Singh et al., 2020)
Providing employment and income generation opportunities by supplying the products for household use or sale	L	(Singh et al., 2020)
Supports the availability, access, and use of farmed and wild foods	FS, E	(Charlton, K. 2016)
Strengthening the stability of food systems	FS, E	(Charlton, K. 2016)
Strengthening and conserving the natural functions of the ecosystem	FS, E, L	(Mbow et al., 2019)
New and diversified income opportunities	L	(Emerton, 2017)
Disaster risk reduction, watershed protection, enhanced biodiversity	E	(Emerton, 2017)
Buffers human communities from erosion and flooding	E, L	(Baig et al., 2016)
Barrier beaches, mangroves, and coral reefs are among the natural infrastructure that must be protected and restored.	E, L, FS	(Baig et al., 2016)
Embraces the different cultures and their knowledge about ecosystems	C	(Amend, 2019)
Increased crop yield and steady supply of clean water due to nature-based water conservation measures.	E, FS	(Rossing & Nyman, 2015)
Using indigenous knowledge to revive traditional medicine & healing	E, L	(Thaman, 2000; Pearson, 2020)
Reduces soil erosion resulting in healthier soil	E, FS, L	(Munang et al., 2011)

FS = Food Security; C = Culture; L = Livelihood; E= Ecosystem

3.1 Healthy ecosystems produce healthy foods, and improve livelihoods and resilience

EbA also generates many types of ecosystem co-benefits regarding its services to the communities, by contributing to their improved livelihoods and food security (Emerton, 2017). Management of EbA in a sustainable way also targets the restoration of ecosystems and implementation of conservation programs resulting in social, economic, and cultural benefits for local communities. For example, flood mitigation actions that may have resulted in increased seafood habitation, has provided more ground for recreation, and has provided other beneficial impacts in relation to tourism, providing economic opportunities (IUCN, 2014). Healthy ecosystems and their services are crucial for global food security because they ensure the access, availability and use of cultivated and wild foods while enhancing the food system stability (Mercer et al, 2014). Over the last fifty years, ecosystems have been swiftly and extensively transformed to fulfill increasing needs for food, freshwater, wood, fiber, and fuel, resulting to an accelerated negative impact on the ecosystem health and its services, e.g., soil and water quality (FAO, 2008).

Munang et al (2011) have outlined the application of EbA approaches to better manage ecosystems for food security in the face of climate change. This includes soil management, agricultural biodiversity improvement, and the use of local and scientific knowledge, as well as improved access to new technologies for farmers and the establishment of "payment for ecosystem services" (see paragraph 3.2.3, p. 20).schemes.

Ecosystems offer critical commodities and services that support global and national economies, particularly in developing nations. EbA guarantees that the many products and services that support human activities continue to be delivered in sufficient quantity and quality (Baig et al., 2016). They reduce vulnerabilities caused by other variables, while also providing adaptive choices. As a result, not only can the stresses caused by climate change be mitigated, but productive economic sectors may continue to operate, and livelihoods can be better safeguarded. This implies that, because ecosystems provide environmental, social, and economic advantages, EbA may connect climate adaptation goals with country development needs (FEBA, 2017). Several EbA interventions have been implemented in the PICTs to improve sustainability by changing practices or restoring resources damaged, as shown in Table 2.

Table 2
Key EbA intervention projects in the PICTs

Key EbA interventions	**EbA projects in line with the intervention policies in the Pacific Islands.**	**Key references**
Health and extent of local forests	Fiji, Solomon Islands and Vanuatu - PEBACC project - expansion of native forest at high elevations. Papua New Guinea - *Managed Forests.* This ongoing project attempts to decrease deforestation and forest degradation.	(SPREP, 2018a; SPREP, 2018b; SPREP, 2020a; SPREP, 2020b)

	Samoa – UNDP Project - Adaptation in Sato'alepai and Lelepa Village where reforestation of abandoned agricultural and cleared land has taken place.	(Zari et al., 2019) (UNDP, 2009)
Productivity of soil	Fiji, Solomon Islands and Vanuatu - PEBACC project- agricultural improvement and diversification for productivity and yield associated with different soil amendments and diversified cropping systems. Fiji - Ba, Lautoka, Nadi, Nadroga, and Tavua - Government project expected to deliver environmental benefits, enhanced soil fertility, improved slope, riverbank, and flood zone stability, and conservation of forest areas. Samoa - UNDP project for Adaptation to Flooding and Sea Level Rise and enhanced soil fertility, improved slope, river bank, and flood zone stability, and conservation of forest areas for Fagamolo, Safai Community, Avao, Vaipouli,, Salei'a, Sato'alepai and Lelepa Village.	(SPREP, 2018a; SPREP, 2018b; SPREP, 2020a; SPREP, 2020b) (Pearson, 2020) (UNDP, 2009)
Riparian function	Fiji, Solomon Islands and Vanuatu - PEBACC project - for improving and buffering of ecosystem services for the terrestrial, riparian, coastal and marine environments. Fiji - Vetiver grass nursery - adaptation & use of riparian buffers. Samoa - Tafitoala Village, south coast of Upolu to protect lowland areas from extreme sea surges and coastal erosion, protected by replanting of salt-tolerant coastal plants to create natural barriers along the coastline and reforestation of riparian buffers. Samoa - UNDP project for Adaptation and protection against sea-level rise and coastline protection for Fagamolo, Safai Community, Avao, Vaipouli, and Salei'a.	(SPREP, 2018a; SPREP, 2018b; SPREP, 2020a; SPREP, 2020b) (Terton et al., 2021) (Emerton, 2017) (UNDP, 2009)
Biodiversity	Fiji, Solomon Islands and Vanuatu - PEBACC project - for reforestation, decrease in fragmentation, and diversity in agricultural systems. Fiji - Ridge-2-Reef programme - Ridge-to-reef management of priority water catchments on the two main islands of Fiji to preserve biodiversity, ecosystem services, sequester carbon, improve climate resilience and sustain livelihoods.	(SPREP, 2018a; SPREP, 2018b; SPREP, 2020a; SPREP, 2020b) (Zari et al., 2019) (UNDP, 2009)

	Fiji - Gau Island forest protection. Preservation of cloud forest and coastal habitat using ecosystem-based management, participatory approaches and integrated resource management. Papua New Guinea - Wanang Conservation Area. Lowland rainforest protected area. Community led educational focus. Samoa - UNDP project where agroforestry practices are be reviewed and changed to create diverse agro-ecological systems for Fagamolo, Safai Community, Avao, Vaipouli, Salei'a, Sato'alepai and Lelepa Village.	
Protection against storm surges	Fiji, Solomon Islands and Vanuatu - PEBACC project - for catchment area with Hazard reduction through stormwater regulation and flood control, reducing sedimentation into waterways. Papua New Guinea - Mangrove Rehabilitation - Project to increase the resilience of communities to the negative effects of climate change. Samoa - UNDP project for Adaptation and protection storm surges, sea inundation, and flooding for Fagamolo, Safai Community, Avao, Vaipouli, and Salei'a.	(SPREP, 2018a; SPREP, 2018b; SPREP, 2020a; SPREP, 2020b) (Zari et al., 2019) (UNDP, 2009)
Freshwater sustainability	Fiji, Solomon Islands and Vanuatu - PEBACC project - for protection and expansion of high elevation forests to slow run-off and increase cloud and rainwater infiltration to groundwater supply. Fiji- Wash Programme - Projects focused on delivery of water, sanitation and hygiene promotion assistance. Some aspects of Wash are NbS. Fiji and Samoa - Water and Nature Initiative - Projects focused on good governance, payments for ecosystem services and learning and leadership, with the aim to improve the quality and sustainability of water resources in the region.	(SPREP, 2018a; SPREP, 2018b; SPREP, 2020a; SPREP, 2020b) (Zari et al., 2019)
Food supply sustainability	Fiji, Solomon Islands and Vanuatu - PEBACC project - for protection of marine resources, improvement of habitats and potential for aquaculture, and diversity of crops. Vanuatu - Community Disaster Committee (Futuna) Projects focused on nutrition, food security, working with women in agriculture, and expanding a network of village gardens	(SPREP, 2018a; SPREP, 2018b; SPREP, 2020a; SPREP, 2020b) (Zari et al., 2019)
Income and independence sustainability	Fiji, Solomon Islands and Vanuatu - PEBACC project - for diversification of income from cash crops to other investments through enhanced ecosystems.	(SPREP, 2018a; SPREP, 2018b;

	Fiji - Kai Project - Improving livelihoods by increasing kai fishery's economic benefits by addressing food safety issues. Tokelau - solar Project - Solar power plants and coconut bio-fuel generators to reduce reliance on imported fuel. *Vanuatu - Nakau Programme.* Reducing exposure to climate-related risks, poverty, and natural disasters by helping indigenous landowners sell carbon offsets and conservation credits instead of timber as a way to deliver economic development to communities. Fiji, Samoa, Solomon Islands, Vanuatu and Tonga - *MESCAL Project* - An IUCN Oceania project to address the key challenges of mangrove management to increase the resilience of the Pacific people to climate change and improve livelihoods. Melanesian countries except for New Caledonia. *REDD+Program* - An integrated framework to reduce carbon emissions from deforestation and valuation of forest ecosystem services.	SPREP, 2020a; SPREP, 2020b) (Zari et al., 2019)

Notwithstanding this body of research, more studies are needed to understand how EbA practices in the PICTs can integrate food security and livelihoods to enhance the knowledge base and support the uptake of good practices in climate change adaptation. The infusion of local knowledge and technical views and cross-cutting initiatives at the local, national and regional levels will significantly assist in integrating food security and livelihoods in EbA practices (Nalau et al., 2018).

4.0 An evaluation of EbA approaches in the Pacific

The degradation and poor governance of ecosystems can reduce the efficacy and impact of food security policies. Given these problems, the development and implementation of food security policies in the Pacific needs to move beyond the conventional focus, to factor in ecosystem-based strategies that integrate interconnected concerns such as climate change, sustainable development, land use planning, EbA, and food security, both at national and local level (Mercer et al. 2014).

In 2015, the Secretariat of the Pacific Regional Environment Programme (SPREP) announced a five-year project funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMU) under its International Climate Initiative (IKI) and named it Pacific Ecosystem-based Adaptation to Climate Change (PEBACC). (SPREP, 2015).

The PEBACC project, commissioned in 2016, was a study of social-ecological systems at different scales in Fiji, Vanuatu, and the Solomon Islands, and it provided a detailed assessment

of these. Referred to as ESRAMs- Ecosystem and Socio-economic Resilience Analysis and Mapping - these assessments aimed to broaden understanding of the linkages between socio-economic and ecological systems and processes in the context of climate change (SPREP, 2018a).

Another BMU-funded IKI project "REDD+ (Reducing Emissions from Deforestation and Forest Degradation) Conservation in Pacific Island Countries" came to an end in March 2021, after more than ten years of readiness support to four Melanesian Island countries, Fiji, Papua New Guinea, Solomon Islands and Vanuatu (Schlein, 2021).

In Fiji at the local level, three communities have been active in the REDD+ initiative, and have made significant contributions to the country's national REDD+ and climate change reporting, where the communities of Draubuta (Emalu) in Navosa, Viti Levu, Navakavu in Navua, Viti Levu, and Drawa in the Cakaudrove province on the island of Vanua Levu have taken a mitigation approach to address the drivers of deforestation and forest degradation (Schlein, 2021). A milestone of crucial importance was achieved by the Fiji Government to conserve forests through the REDD+ project when it signed a long-prepared Emission Reductions Payment Agreement (ERPA) with the World Bank on February 1st, 2021, to commit itself to emission reductions by lowering carbon emissions from deforestation and forest degradation through to 2025 (MOF, 2021).

As part of the REDD+ initiative in Ra province of Viti Levu, a community-based reforestation project began in 2009 (Dayal et al., 2019) and a Mangrove Ecosystem Conservation and Livelihood (MESCAL) project became a component of the REDD+ strategy in Rewa, Ba and Labasa. MESCAL documented mangrove forest biomass and carbon inventory, and part of the Rewa, Ba and Labasa deltas declared as conservation areas to enhance carbon stock (Schlein, 2021). REDD+ sites in Fiji play an important role in enhancing biodiversity by allowing the natural regeneration of native seedlings and saplings and the conservation of unique wildlife habitats, which improves food security and livelihoods in the communities (Dayal et al., 2019).

4.1 Benefits of EbA on Food Security

The Fijian Government's National Adaptation Plan (NAP) has as its main objectives, as food security, optimal land use, development, and the expansion of the agriculture sector... A range of ecosystem-based adaptation (EbA) options has been outlined and mapped for Taveuni, Fiji. The alternatives include various ecological restoration and conservation initiatives that are required to put Taveuni on a more sustainable development path favouring food security (Reddy, 2018). Taveuni Island has seen the overuse of fragile soil resources for commercial agriculture over the decades, with far-reaching ecological and social repercussions for communities, rendering them more vulnerable to climate change. The SPREP (2018) synthesis report states that Taveuni residents have relied on intensive taro cultivation since the1990s, which has resulted in soil degradation and unsustainable land-use practices (see paragraph 4, p. 2).

Investing in EbA approaches can improve land management and increase livelihood options while empowering communities; it can also protect or restore terrestrial and marine resources. Some of the measures trialled during an evaluation of soil nutrient management project

in Taveuni were the usage of green manure, longer fallow period, and organic fertilizers, which worked well alongside the initiative with better quality planting materials to improve the quality and yield of taro.(Nisha et al., 2014). Macuata Province is the first province in Fiji to have a provincial Natural Resource Management Strategy (NRMS) facilitated by WWF. It has an active support program to the customary fishing grounds ("iqoliqoli") along much of Macuata Province's coastline. Government and conservation stakeholders view the largest qoliqoli (Qoliqoli Cokovata) as a priority entry point in having the entire Great Sea Reef system established as a Ramsar Wetlands Site (SPREP, 2018a).

In Port Vila, Vanuatu, the communities started the Tagabe riparian corridor's regeneration, restoration, protection of coastal vegetation, and intensification of home gardens. There were also mangrove restoration initiatives in Erakor and Pango and green space set up in Central Port Vila (SPREP, 2018). In the Solomon Islands, the EbA implementation plan, following prioritization in Barana and Queen Elizabeth Park rehabilitation and restoration, works on the Mataniko River and its tributaries to provide land stability around the river banks and provision for food (SPREP 2018c). Rehabilitating upper elevation farms with diversified crops through agroforestry in Lavena and protected marine resources in Waitabu, Waitabu Marine Park, Taveuni leads to better food security (SPREP, 2018).

4.2 Benefits of EbA on Livelihood

The EbA projects conducted in Fiji, Vanuatu, the Solomon Islands, and Samoa resulted in positive impacts for the communities' livelihoods. - The more fertile land meant a better harvest that could be sold to earn more income and improve the living standards. The intensification of home gardens was the main focus of the project to increase the extent and productivity of home gardens to help maintain and improve food and cooking fuel security for communities in Greater Port Vila and to build resilience to climate change. Ecosystem-based approaches for climate change adaptation in the Greater Port Vila area have the potential to increase the resilience of communities and ecosystems, supporting the alleviation of poverty and improved community health and wellbeing (SPREP, 2018a). A sustainable housing development is also considered in this project. Planting strongly scented flowers amongst the vegetables to keep away insect pests in the Barana Park, Solomon Islands, also provided opportunities for the women in the community to engage in flower arrangement businesses as an alternative for income and sell for their income generation (SPREP, 2018c). This intervention had two advantages, firstly, the use of chemical-free pesticides, and secondly, it benefited the livelihoods of the communities as an alternative for income generation.

4.3 Benefits of EbA on Ecosystem Functions

To restore and protect coastal vegetation, particularly mangrove habitats, along with critical parts of the greater Port Vila coastline the EbA project includes replanting and regenerating areas where mangroves and other crucial coastal tree species have been depleted, and implementing policy to

strengthen the protection of mangrove habitat at the urban, provincial, and national levels (Mackey et al., 2017). There was a strategic introduction of multi-value trees and vegetation to Port Vila's key urban areas and coastal environments. The project educated the people about using trees species, providing tangible resources (including food), increasing vital urban ecosystem services, and acting as a seed bank to safeguard vulnerable species against climate change (SPREP, 2018).

4.4 Benefits of EbA on Culture

EbA has always been present in the Pacific, where traditional knowledge has been used to predict the weather, crop harvesting seasons, fish spawning seasons, and for other purposes. But these practices have been slowly fading, and have been left undocumented in many cases. The projects conducted by SPREP/PEBACC & UNDP in the four Pacific Island Countries have allowed the communities to revive and practice their traditional knowledge in their daily living (SPREP, 2018a; UNDP, 2009). There has been a noticeable rise in the number of medicinal plants showing up in Barana Park, Solomon Islands which used to be the native plants. The village elders had the opportunity to use these plants to prepare herbal plants for family use and to sell to the people in other areas of the island (Iroga, 2020).

5.0 Need for more inclusion of traditional knowledge and indigenous communities in EbA interventions in the Pacific

Consideration and inclusion of traditional and indigenous knowledge of communities in the conceptualisation, formulation, implementation and sustainability of EbA is crucial for PICTs. Traditional and indigenous knowledge and culture are essential components of biodiversity (SPREP, 2012) since these facilitate functioning ecosystems that supply oxygen, clean air, water, pollination of plants, pest control, wastewater treatment, and many ecosystem services (SOE, 2016). Indigenous knowledge refers to knowledge of indigenous communities. Local knowledge refers to knowledge of local people who may or may not be indigenous, but in both cases have detailed environmental knowledge based on personal and collective experiences of their local environments (Nalau et al., 2018). The four islands where the EbA interventions were piloted are diverse in culture and traditional knowledge, which are intricately linked to livelihoods (SOE, 2016). Cultural practices and traditional knowledge have enabled these Island nations to survive with knowledge passed down over many generations (Nalau et al., 2018). Gaps appear in the knowledge base in each of the pilot projects for the four Island nations. Existing knowledge is an important factor in determining the successful and effective implementation of EbA (McVittie et al., 2017). The PICTs are highly vulnerable to climate change, prompting global concern about their future. A lot of funding has been made available to assist or intervene with climate change adaptation programs. But despite extensive funding and interventions through technical knowledge, programs have not been successful as indigenous and local knowledge requires better integration into the programme interventions and greater participation by the local communities in

decision-making so they can take responsibility for the programmes implemented (Pearson et al., 2020).

5.1 Case Study: Fiji

In Fiji, like other Pacific Islands, there is a significant dependence on the ecosystem to deliver goods and services to the communities. These goods and services are essential to the livelihoods of local communities and food security, and therefore, it is vital to enhance resilience to climate change (Nalau et al., 2018). The Itaukei (Indigenous Fijian) communities have sustainably managed their ecosystems over time, and this indigenous knowledge and experiences can enable future ecosystem-based adaptation options that are more sustainable and effective. Therefore, it is essential to understand, respect, and utilize Indigenous knowledge for managing and protecting local ecosystems as part of the communities' climate change adaptations (Pearson et al., 2020). Under the Fijian vanua (land) and iqoliqoli (river and marine) system, the communities have customary stewardship, resulting in environmental conservation as a duty of care. However, due to the loss of indigenous and traditional knowledge of the environment, the traditional decision-makers are misinterpreting the traditional rights and obligations in terms of the community conserved areas and customary tenure resulting in their areas being exploited unsustainably (Govan et al., 2009). The iTaukei people and their knowledge and traditions are considered integral to all terrestrial, freshwater, and marine ecosystems (i.e., as part of the vanua and iqoliqoli), rather than separate external entities (Thaman, 2000). Previous studies in Fiji have demonstrated the ability of iTaukei communities to identify changes in their ecosystems and to ensure the maintenance of their livelihoods and food security (Pearson, 2020). One example is the use of indigenous knowledge passed down over the years, which can be used to determine the presence and behaviour of sharks, and on the basis of which ecological predictions can be made (Rasalato et al., 2010). Based on their indigenous knowledge, some communities could make a prediction or forecast bad weather or cyclones from which farmers would make changes to their planting and harvesting plans. The communities would also plan to store food and water while strengthening their houses to withstand predicted harsh weather conditions (McNamara and Prasad, 2014).

5.2 Case Study: Samoa

Samoa uses community strength, local knowledge, and participatory effort to secure livelihoods, for which ecosystems and their services are essential. This, therefore, enables the EbA approaches to be effectively used to address food security and other issues. Traditional and indigenous knowledge plays a significant role in developing participatory planning processes to reduce climate vulnerability for coastal communities and ecosystems (Daly et al., 2010). Gender also plays a vital role in the type of indigenous knowledge possessed in Samoa. Quite different to most PICTs, in Samoa, the women have exceptional knowledge in the beautification for farmland and which types of plants to grow, which can potentially impact the food security and livelihood of the

communities (Nalau et al. 2017). Community-based resources are effectively managed to enhance food security and livelihood using village by-laws for the overall administration, which also plays a significant role in protecting the ecosystems and its services. One such example is that the indigenous knowledge of "Tabus" is elevated in effect to a subordinate law to protect fishing rights and areas (Boer and Clarke., 2012) where conservation and management of the fishery resources may include restrictions on fish sizes, bans on certain fishing gear or methods, and closures of fishing seasons or areas (Govan et al. 2009).

In Samoa, family, reciprocity, and social relationships all have a fundamental role in how climate adaptation takes place, which is why there is a greater focus for adaptation programs to be channelled through the Matai (non-indigenous) councils and centred on indigenous values of fa'asamoa (indigenous or the Samoan way) (Parsons, 2015).

5.3 Case Study: Solomon Islands

Solomon Islands indigenous ecological knowledge and customary tenure may be integrated (Aswani & Hamilton, 2004) with the traditional management of resources to maintain customary conservation practices as follows:

- Sacred sites in which movement into, and within these sites was usually restricted to certain people with indigenous knowledge about conservation. These sites then automatically served as unofficial protected sites;
- Social prohibitions, which are prohibitions or restrictions on the consumption of certain species, in order to protect ecosystem resources; and
- Serial or sequential prohibitions, which rotated farming areas and limited access to some groups for harvesting resources, which enabled the regeneration of ecological resources (Sulu, 2004).

The indigenous ecological knowledge in resource management is key to the conservation process, as for example, in the case of the bumphead parrotfish (Bolbometopon muricatum) in the Roviana Lagoon, Western Solomon Islands, which is successfully protected along with other species to ensure food security (Aswani & Hamilton, 2004). Another example is the production of vanilla which is grown in drier areas on the Guadalcanal Plains where local villagers' use indigenous and traditional knowledge to cure the quality of vanilla, thus ensuring sustainable production by maintaining the soil quality, whist at the same time enhancing this livelihood and food security (Bourke et al, 2006).

5.4 Case Study: Vanuatu

Tropical forest ecosystems have played a very important role in Vanuatu, as Ni-Vanuatuan's have always used ecosystems and its services to enhance their livelihoods and food security. The indigenous knowledge, known as 'kastom', is centre to the traditional ways that communities

regulate use of, and access to their natural resources (Regenvanu et al. 1997). The indigenous knowledge is also very strongly embedded in the Tannese society, where three types of knowledge are used for leadership purposes. The 'Suatu' knowledge is used for conflict resolution, networks, and relationships; the 'Iaramara' knowledge being for the overall community welfare and traditional knowledge (stories); and the 'Tipunus' knowledge being expertise for gardens, including the development of, and learning about flora, fauna, and weather (Mackey et al., 2017).

Gender also plays a major role in the types of indigenous knowledge used and passed down. Men and women in Vanuatu hold precise knowledge of climate change adaptation, which impacts on livelihood-related practices. Men generally have weather-related traditional knowledge passed on by the ancestors, which served as early warning indicators in influencing the planting seasons and predicted yield or harvest for food security purposes. On the other hand, women did work regarded as more women-specific, like gardening, animal grazing, fetching drinking water, firewood, and preparing food (Nalau et al., 2017).

Based on a detailed analysis on EbA in Vanuatu, the indigenous knowledge of staple crops and livestock varieties is key to the EbA strategy to establish a diverse and successful agricultural system (Mackey et al., 2017). The EbA strategy was to conserve the diverse agricultural landscapes, enhance livelihoods and ensure food security, with the following indicators: size of agricultural farmland per farmer; diversity of income per household; level of poverty amongst the community; and diversity of food sources and the rate of nutrition and malnutrition.

6.0 Conclusion and Recommendations

Healthy ecosystems and their services are critical for global food security because they support optimal and sustainable land use while also strengthening food system stability and providing access to farmed and wild foods. EbA techniques may be cost-effective and economically advantageous to societies, and they can be the best way to adapt to climate change. Increasing ecosystem resilience through conservation and sustainable management offers natural protection against severe climate change occurrences. For example, while a seawall can be an option, well-conserved and restored mangroves are not only less expensive, but their total co-benefits greatly outweigh those of the seawall. This intervention can boost resilience by providing storm protection, improving people's livelihoods, and offering other social and economic advantages such as ways to generate more income for the household. Livelihood impacts show the changes in means and access to the material and non-material necessities to have a stable, secure, and decent quality of life. EbA contributes to resilience and adaptation.

More studies are needed to understand how EbA practices in the PICTs can integrate the communities' traditional and indigenous knowledge to enhance the overall knowledge base, and support the uptake of good practices and ownership in climate change adaptation. The infusion of local knowledge and technical views and cross-cutting initiatives at the local, national and regional levels will significantly assist in integrating food security and livelihoods in EbA practices by

increasing agricultural and livestock production. This integration can also improve natural resource management, as well as contribute to expanding income-generating opportunities at the household and community levels.

References

ADB, 2011. Climate change and food security in the Pacific. Rethinking the options. Mandaluyong City, Philippines: Asian Development Bank.

Aswani, S & Hamilton, R. 2004. Integrating indigenous ecological knowledge and customary sea tenure with marine and social science for conservation of bumphead parrotfish (Bolbometopon muricatum) in the Roviana Lagoon, Solomon Islands. Environmental Conservation. 31. 69 - 83. 10.1017/S037689290400116X

Baig, S. P., Rizvi, A., Josella, M., Palanca-Tan, R. 2016. Cost and Benefits of Ecosystem-Based Adaptation: The Case of the Philippines. Gland. Switzerland: IUCN. viii + 32pp.

Boer, B and Clarke, P. 2012. Legal frameworks for ecosystem-based adaptation to climate change in the Pacific islands. SEP. Apia, Samoa.

Bourke, R.M., McGregor, A. Allen, M.G. Evans, B.R. Mullen, B.F. Pollard, A.A. Wairiu, M. and Zotalis, S. 2006. Solomon Islands Smallholder Agriculture Study Volume 1 Main Findings and Recommendations. AusAID

Charlton, K. 2016. Food security, food systems, and food sovereignty in the 21st century: A new paradigm required to meet Sustainable Development Goals Article in Nutrition & Dietetics. DOI: 10.1111/1747-0080.12264. University of Wollongong

Daly, M.; Poutasi, N.; Nelson, F. and Kohlhase, J. 2010. Reducing the Climate Vulnerability of Coastal Communities in Samoa. J. Int. Dev. 22, 256–281.

Dayal, S. Shah, S. Bhat, J. 2019. Forest Conservation through REDD+ in Fiji Islands. Department of Forestry, College of Agriculture, Fisheries & Forestry, Koronivia Campus, Fiji National University, Republic of Fiji Islands. Indian Forester

Emerton, L. 2017. Valuing the Benefits, Costs, and Impacts of Ecosystem-based Adaptation Measure.s A sourcebook of methods for decision-making. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

FAO. 2008. An Introduction to the Basic Concepts of Food Security. The Four Dimensions Of Food Security. The EC - FAO Food Security Programme, European Union.

FEBA. 2017. Making Ecosystem-based Adaptation Effective: A Framework for Defining Qualification Criteria and Quality Standards. FEBA technical paper developed for UNFCCC-SBSTA 46. Friends of Ecosystem-based Adaptation. GIZ, Bonn, Germany, IIED, London, UK, and IUCN, Gland, Switzerland. 14 pp.

Govan, H. Tawake, A., Tabunakawai, K. George, S. Alefaio, S. Troniak, S. Maltali, T. Tafea, H. Walton, H. Bartlett, C. Jenkins, A. 2009. Community Conserved Areas: A review of status & needs in Melanesia and Polynesia. In press. ICCA regional review for CENESTA /TILCEPA /TGER /IUCN/ GEF-SGP.

Green, W. 2019. Terrestrial food production systems and food choices. Amazing world of science with Mr. Green. Accessed 28 February 2020. https://www.mrgscience.com/ess-topic-52-terrestrial-food-production-systems-and-food-choices.html/

Hills, T. Brooks, A. Atherton, J. Rao, N. and James, R. 2011. Pacific Island biodiversity, ecosystems and climate change adaptation: building on nature's resilience. Apia. Samoa: SPREP.

Iroga, R. 2020. Barana Nature and Heritage Park demonstrating ecosystem based adaptation. SBMonline. Accessed 27 September 2021. https://sbm.sb/2020/04/07/barana-nature-and-heritage-park-demonstrating-ecosystem-based-adaptation/

IUCN, 2014. Ecosystem-based Adaptation: Concept, Principles and Options. Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. UNEP. UNDP.

Mackey, B. Ware, D. Nalau, J. Sachin, O. Fleming, C.M.V. James, C.R. Connolly, R. Hallgren, W. Buckwell, A. 2017. Vanuatu Ecosystem and Socio-economic Resilience Analysis and Mapping (ESRAM). Apia, Samoa: SPREP. 100pp.

Mbow, C., C. Rosenzweig, L.G. Barioni, T.G. Benton, M. Herrero, M. Krishnapillai, E. Liwenga, P. Pradhan, M.G. Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu, 2019: Food Security. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.

McNamara, K.E. & Prasad, S.S. 2014. Coping with extreme weather: communities in Fiji and Vanuatu share their experiences and knowledge. Climatic Change 123(2):121-132.

McVittie, A. Cole, L. Wreford, A. 2017. Assessing Adaptation Knowledge in Europe: Ecosystem-Based Adaptation. Final Report. Ecofys. Project number: DESNL16057.

Mercer, J., Kurtis, T., Kelman, I., Mavrogenis, S. 2014. Ecosystem-Based Adaptation for Food Security in the AIMS SIDS: Integrating External and Local Knowledge. Sustainability. doi:10.3390/su6095566. ISSN 2071-1050

MOF, 2021. Emalu REDD+ Pilot Site. The REDD+ Unit. Ministry of Forestry. Colo-i-Suva Forestry Station, Suva. Accessed 30 September 2021. http://fijireddplus.org/about-redd/emalu-redd-pilot-site/

Munang, R. Thiaw, I & Rivington, M. 2011. Ecosystem Management: Tomorrow's Approach to Enhancing Food Security under a Changing Climate. Sustainability. 3. 937-954. 10.3390/su3070937.

Nalau, J. Becken, S. Loehr, J. Parsons, M. Brown, C. Mackey, B. 2018. The Role of Indigenous and Traditional Knowledge in Ecosystem-Based Adaptation: A Review of the Literature and Case Studies from the Pacific Islands. VOL - 10. DO - 10.1175/WCAS-D-18-0032.1. JO - Weather, Climate, and Society.

Nisha, S. Prasad, S. & Bhat, J. 2014. Evaluation of soil nutrient management practices of taro farmers' in Taveuni, Fiji. The South Pacific Journal of Natural and Applied Sciences, 32, 61-68. 10.1071/SP14010

Parsons, M. 2015. Continuity and change: Indigenous Australia and the imperative of adaptation. Applied Studies in Climate Adaptation. Wiley, 281–288. doi.org/10.1002/9781118845028.ch31.

Pearson, J. 2020. The Role of Local and Indigenous Knowledge in Ecosystem-Based Management and Adaptation: A Case Study of iTaukei Communities in Bua Province, Vanua Levu Island, Fiji. PhD thesis, The University of Queensland.

Pearson, J. McNamara, K.E. Nunn, P.D. 2020 iTaukei Ways of Knowing and Managing Mangroves for Ecosystem-Based Adaptation. In: Leal Filho W. (eds) Managing Climate Change Adaptation in the Pacific Region. Climate Change Management. Springer, Cham. https://doi.org/10.1007/978-3-030-40552-6_6.

Rasalato, E. Maginnity, V. & Brunnschweiler, J. M. 2010. Using local ecological knowledge to identify shark river habitats in Fiji. Environmental Conservation, 37(1), 90-97.

Reddy, M. 2018. Minister visits agriculture offices. Fiji Sun. Depinfo News. Accessed 28 February 2020. https://fijisun.com.fj/2018/12/19/minister-visits-agriculture-offices/

Reed, W. 2005. Ecosystems and human well-being, Synthesis. Accessed 31 October 2020. http://www.oas.org/dsd/Tool-kit/Documentos/ModuleIdoc/Summary%20for%20Decision-Makers.pdf/

Regenvanu, R. Wyatt, S. & Tacconi, L. 1997. Changing forestry regimes in Vanuatu: Is sustainable management possible? The Contemporary Pacific. 9(1) 73-96.

Rossing, T & Nyman, N. 2015. Generating multiple benefits from Ecosystem-based Adaptation in mountain ecosystems. Global Ecosystem-Based Adaptation In Mountains Programme. United Nations Development Programme.

Schlein, O. 2021, REDD+ Community Exchange in Fiji: At the end of 10 years of REDD+ support by GIZ in the Pacific Island Countries. SNRD ASIA AND THE PACIFIC. Accessed 30 September 2021. https://snrd-asia.org/redd-community-exchange-in-fiji-at-the-end-of-10-years-of-redd-support-by-giz-in-the-pacific-island-countries/

Singh, C., Ford, J., Ley, D. Ley.D., Baza. A., Revi. A., 2020. Assessing the feasibility of adaptation options: methodological advancements and directions for climate adaptation research and practice. Climatic Change 162, 255–277. https://doi.org/10.1007/s10584-020-02762-x.

SOE, 2016. Importance of biodiversity. Biodiversity. State of Environment, Australia. https://soe.environment.gov.au/theme/biodiversity/topic/2016/importance-biodiversity

SPREP. 2012. Traditional knowledge valuable resource for the Pacific. CBD COP 11, Hyderabad India https://www.sprep.org/news/traditional-knowledge-valuable-resource-pacific

SPREP, 2015. Ecosystem-based adaptation to build resilience in Fiji begins. reliefweb. https://reliefweb.int/report/fiji/ecosystem-based-adaptation-build-resilience-fiji-begins

SPREP 2018. Planning for ecosystem-based adaptation in Port Vila, Vanuatu. A synthesis report by the Secretariat of the Pacific Regional Environment Programme, Apia, Samoa. 16 pp.

SPREP, 2018a. Pacific ecosystem-based adaptation to climate change. NEWSLETTER. ISSUE 6. APR TO JULY 2018. (SEP) l ISSN: 2519-5506.

SPREP 2018b. Planning for ecosystem-based adaptation in Taveuni, Fiji. A synthesis report by the Secretariat of the Pacific Regional Environment Programme, Apia, Samoa. 16 pp.

SPREP 2018c. Planning for ecosystem-based adaptation in Honiara, Solomon Islands. A synthesis report by the Secretariat of the Pacific Regional Environment Programme, Apia, Samoa. 16 pp.

SPREP, 2020a. Ecosystem-based Adaptation options assessment and masterplan for Taveuni, Fiji. Apia, Samoa.

SPREP, 2020b. Ecosystem-based adaptation options assessment for Macuata Province, Fiji. Apia, Samoa.

Sulu, R. 2004. Traditional law and the environment in the Solomon Islands. Case Study 5. Traditional laws and conservation practices. SPC Traditional Marine Resource Management and Knowledge Information Bulletin #17

Thaman, R. 2000. Traditional environmental knowledge and community-based biodiversity conservation in Fiji: current status and priorities for its protection and utilisation. Working Paper No. 7 Geography Department University of The South Pacific Suva, Fiji.

Terton, A. Ledwell, C. Kumar, S. 2021. How Fiji Is Using the National Adaptation Plan (NAP) Process to Scale Up Ecosystem-Based Adaptation (EbA). Country Brief. NAP Global Network.

UNDP, 2009. Community-Based Adaptation: Samoa. Climate Change Adaptation. Accessed 9 September 2020. https://www.adaptation-undp.org/projects/spa-community-based-adaptation-samoa/

UNEP, 2020. Making Eba An Effective Part Of Balanced Adaptation Strategies: Introducing The UNEP EBA Briefing Notes - Briefing Note 1. United Nations Environment Programme World Conservation Monitoring Centre. Accessed 5 September 2020. https://wedocs.unep.org/bitstream/handle/20.500.11822/28174/EBA1.pdf?sequence=1&isAllowed=y>.

Zari, P. Kiddle, L. Blaschke, P. Gawler, S. Loubser, D. 2019. Utilising nature-based solutions to increase resilience in Pacific Ocean Cities. Ecosystem Services. 38. 10.1016/j.ecoser.2019.100968.

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