THE ROLE OF ECOSYSTEMS IN RESILIENT FOOD SYSTEMS IN THE PACIFIC

3.0 ECOSYSTEMS AND FOOD SECURITY

Ecosystems fulfil important functions that underpin food security in a number of ways. Based on the categories of ecosystem services specified within the Millennium Ecosystem Assessment (2005), it could be argued that the two most important are *provisioning services,* which means providing a supply of food that is sufficient to meet nutritional and dietary requirements, and *regulating* services, which means stabilizing this food production by regulating conditions, such as by acting as a "bioshield" to disperse energy from extreme events.

In the Pacific, the likely changes to the intensity and occurrence of extreme events expected under climate change has led to a disaster risk reduction approach within many national adaptation planning responses. The Millennium Ecosystem Assessment (2005) (See TOOL 39) produced clear evidence that in addition to supporting people's day-to-day livelihoods, ecosystems such as coral reefs, mangroves, wetlands and mountain forests are also important in mitigating the impact of natural hazards. Analysis of recent disasters, such as the December 2004 Indian Ocean tsunami and the hurricanes that struck North and Central America in September and October 2005, demonstrates the importance of habitat protection and natural resource management in decreasing our vulnerability to extreme events. Unfortunately, these factors are often not considered in development planning and disaster relief operations. This leads to increased vulnerability to future hazards and loss of biodiversity.

This chapter outlines the relationship among the food security issues, ecosystem services and climate change impacts in Pacific Island countries. One of the challenges in ecosystem-based adaptation is that the interaction among these ecosystem service and climate variables is very complex, and providing quantitative estimates of their significance is nearly impossible. According to UNEP (2009), the key ecosystem service variables are not currently accounted for in most models and scenarios of food production. (See TOOL 38.) Hence, rather than providing quantitative tools to support decision-making, this chapter describes contexts in which a selection of the ecosystem-based adaptation options may be part of the solution to food insecurity.

Across the Pacific Island countries, the main ecosystem types that underpin the sustained productivity of some of the key food resources relate to the functions of terrestrial, marine and coastal ecosystems. While some of the key ecosystem service and adaptation relationships are described in this chapter, the list is not comprehensive and other approaches may be applicable in some Pacific contexts, such as those which link forests and wetlands with water regulation, the role of marine and terrestrial protected areas and pollination/insect services.

3.1 TERRESTRIAL SYSTEMS

3.1.1 Vegetation complexity and landslides

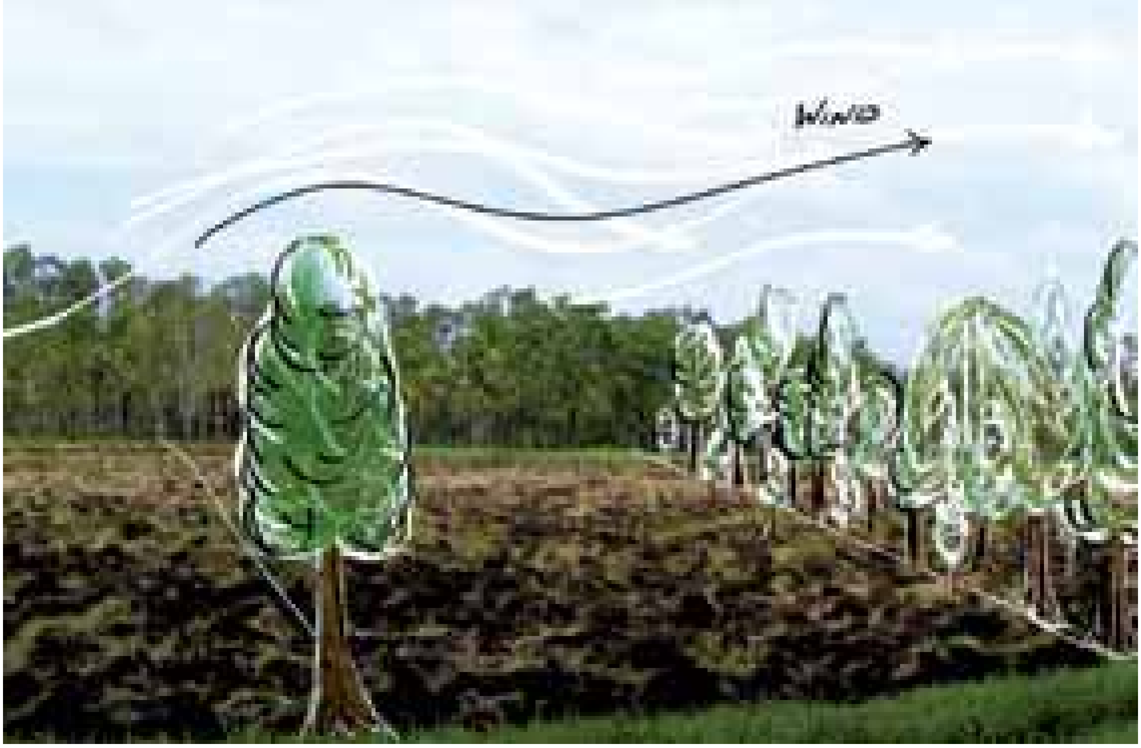
One of the most practical ecosystem-based adaptation applications that can be considered in the Pacific is based on the relationship between vegetation and landslides. Increase in populations and other development pressures in mountainous environments of PICTs such as Fiji and PNG see agriculture moving to more marginal areas including hill slopes. These areas are already vulnerable to landslides, and the combination of land clearing and the potential for more intense rainfall events in future climate regimes translates to an even higher level of landslide risk. There is an increasing body of evidence that supports this. For example, Philpott *et al.* (2008) found that at the farm scale, increasing management intensity (reducing vegetation complexity) correlated with an increased proportion of farm area and roadsides affected by landslides. (See TOOL 37.)

This has direct application within agricultural practices in that monocropping operations with typically low complexity will translate to a higher risk of landslide. The policy and management implications of this are that more diverse agricultural regimes should be applied to reduce risk in areas of agricultural production that are vulnerable to increases in severe weather events. In Pacific landscapes, practical steps could include the integration of native and agroforestry operations to reduce the risk of landslides in agricultural areas where increased high intensity rainfall events are expected.

3.1.2 Shelter belts

Trees play an important role protecting crops from the ravages of storms, strong winds and salt spray. Live-tree shelter belts can provide farmers with a cost-effective means of protecting inland crops and soils from coastal winds that can rob soils of valuable moisture, elevate salinity levels and directly damage crops with wind throw and salt burn. Accordingly, trees play an integral role in traditional agricultural systems in the Pacific, providing shelter along with firewood, building timber, tree crops (nuts and fruits), and handicraft materials. (See TOOL 29.)

Figure 3.1: **Trees and carefully placed shelter belts add value to a farm. They can help reduce wind damage to crops; capture salt-spray; retain soil moisture; provide shelter to livestock; and produce fruits, nuts, firewood and building timber. So please think twice before clearing your land, as trees are an important resource that can both combat the impacts of climate change and help trap excess carbon dioxide in the atmosphere!**



3.2 COASTAL AND MARINE SYSTEMS

The coastal and marine systems offer both provisioning and regulating services – provisioning services largely through habitats, and regulation services by acting as ecological buffers from the destructive forces of extreme weather events. Both coral reefs and mangroves contribute significantly to the economies of small island developing states and, as such, their maintenance is important for livelihoods and food security throughout the Pacific (Wells *et al*., 2006: See TOOL 70). From a food security and livelihoods perspective, both coral reefs and mangroves support many types of fisheries – artisanal, commercial and recreational for numerous types of fish, lobsters, crabs, molluscs and many other species. Both of these ecosystems are prominent features of Pacific Island landscapes and offer significant opportunity to reduce the impact of climate change on food security across the Pacific.

While upland and floodplain forest-based adaptation solutions have limited application across the Pacific, adaptation options that take advantage of the ecosystem services associated with coastal and marine ecosystems have much broader scope for application. However, relative to the options available to terrestrial and coastal production systems, there is less that can be done to buffer the climate change impacts on marine systems. As a consequence, the ecosystem-based adaptation (EbA) options that are most likely to add resilience to the ecosystem services are those that remove other anthropogenic stressors, such as pollution, sedimentation, unsustainable fishing practices and poor coastal development planning.

While both coral reefs and mangroves can protect food security by reducing intensity of climate-related events such as storm surges before they reach areas of human settlement, the ecosystems themselves are usually damaged in such events. Thus their buffering capacity is a balance of both their resilience and vulnerability (Wells *et al*., 2006: See TOOL 70). In order to optimize the “bounce-back” of these ecosystems from such events, their resilience can be strengthened by minimizing anthropogenic stressors.

As the specific services and management responses for mangroves and coral reefs are quite different, their potential as EbA solutions is described separately below. Additionally, the role of seagrasses in adaptation is also explored.

3.2.1 The role of mangroves

As discussed above, mangroves can play a critical role in protecting communities from increasing severe weather events, such as cyclones, that may become more intense with climate change. Not only can mangroves help save lives, they can also protect food production systems that lie further inland, along with the food production services that mangroves promote directly, as related to fisheries. Further study has shown that the buffering capacity of mangroves is impacted by both the quality of the mangrove forest, and its size or the extent of its re-growth if it has been cleared (Wells *et al*., 2006: See TOOL 70). Mangroves are critically important as breeding and nursery areas for many important species of fish and prawn and represent an important source of timber. For example, in Matang, West Malaysia, 40 000 ha of managed mangrove forest yields US$10 million in timber and charcoal and over US$100 million in fish and prawns every year (Talbot and Wilkinson 2001: See TOOL 19). In Southern Thailand, mangrove forests provide an estimated US$3 679 of coastline protection and stabilization service per hectare (Suthawan and Barbier 2001: See TOOL 79).

However, due to a lack of long-term sustainable management, mangrove ecosystems are threatened largely by conversion to aquaculture; industrial, residential and tourism development; timber extraction; and use of wood for fuel and charcoal production (Wells *et al*., 2006: See TOOL 70). Gilman *et al*. (2007: See TOOL 75) considers Pacific Island mangroves to be at high risk of substantial reduction.

An important characteristic of mangrove systems and their relationship with climate change relates to their capacities to accommodate sea level rise. In the absence of barriers such as those posed by coastal development and aquaculture ponds, mangrove systems have the capacity to migrate landward. Gilman (2007: See TOOL 75) notes that coastal planning can adapt to facilitate mangrove migration with sea-level rise "*through the management of activities within the catchment that affect long-term trends in the mangrove sediment elevation, better management of other stressors on mangroves, [and] rehabilitation of degraded mangrove areas…*".

Natural recovery from disturbances and removal of stressors is often sufficient to increase the resilience and health of ecosystems (Wells *et al*., 2006: See TOOL 70). However, active rehabilitation or restoration should be considered in areas of high risk of extreme climate events. In such cases, the emphasis of such programmes should be on the restoration of ecosystem function in the local hydrological context, rather than "getting seedlings in the ground". While such programmes are more complex to design and implement, this is preferable given the large failure rate in restoration programmes and the additional livelihood benefits of a more rigorous approach. The 5-step programme for the ecological restoration of mangroves outlined by the Mangrove Action Project provides guidance on avoiding the pitfalls in mangrove restoration programmes, including species selection, hydrological considerations and rehabilitation design. (See TOOLS 75-79 for more information on mangroves.)

3.2.2 The role of coral reefs

In addition to being one of the most biologically diverse ecosystems on earth, coral reefs play an important role in food security in the Pacific from both a livelihoods perspective and a food production or availability perspective. The reef fisheries of Southeast Asia, for example, generate approximately US$2.4 billion/year (Wells *et al*., 2006: See TOOL 70). Economic benefits derived from tourism and fisheries globally result in US$30 billion/year, and 25 percent of all marine species rely on coral reefs for critical habitat (Buddemeier *et al*., 2004: See TOOL 67)[4]. Coral reefs support both commercial fisheries and aquarium fish. In other words, coral reefs play a critical

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[4] The total annual economic value of reefs has been estimated at between US$100 000 and US$600 000 per km^2 and the value of mangroves at more than US$900 000 per km^2 (see TOOL 67).

role in ensuring food security. They provide livelihoods that enable people to afford to purchase food plus they directly support the fish that represent a critical source of protein, without which many could potentially face malnutrition.

Coral reefs also play an important role in protecting the coastline and serving in a buffering capacity as breakwaters. The role of this service varies, depending upon the activity it is protecting along the coast. For example, reefs in Indonesia have been valued at US$829/km, based on the value of agricultural production that would be lost if there were no protection, at US$50 000/km in areas of high population density, and at US$1 million/km in areas of tourism which incorporates the associated cost of maintaining the sandy beaches (Wells *et al*., 2006: See TOOL 70).

In the case of coral reefs, these ecosystems are especially sensitive to changes caused by climate change. They already are being impacted by increases in ocean temperature, which cause coral bleaching episodes, and by changes in ocean chemistry resulting from increased amounts of CO_2 dissolved in the ocean due to fossil fuel combustion (Buddemeier *et al*., 2004: See TOOL 67). As a result of these global stressors, coral reef systems are less resilient and more susceptible to local stressors, including disease, overfishing, use of destructive fishing methods, and pollution and sedimentation from humans (Wells *et al*., 2006: See TOOL 70).

In order to increase the resilience of the coral reefs and ultimately minimize and buffer against the negative effects of global climate change, efforts should be made to protect coral reefs from non-climate stressors (Buddemeier *et al*., 2004: See TOOL 67). This is relevant for food security, because it will ultimately reduce the risk to communities from loss of functioning coral reef systems. One method used for the identification of hot spots in reef vulnerability is the concept of degree heat weeks (DHW), which is the number of weeks in which the sea surface temperature of an area exceeds its average thermal maximum by 1-2° C. DHW has become a key operational metric for reef monitoring and management, and assessing the risk of coral bleaching. National Oceanic and Atmospheric Administration (NOAA) has combined this temperature threshold concept with a duration factor to develop the DHW alert system that uses satellite imagery of sea surface temperature to detect potential areas of coral bleaching (See TOOL 67).

Along with reducing pollutant loads, another ecosystem-based approach to reducing the local stressors on coral reefs, and thereby improving the bounce-back from bleaching and storm-event damage, is to design and implement locally managed marine areas (LMMAs). Such protected areas would help ensure the minimization of local stressors, promote local governance and locally derived benefits from eco-tourism and healthy fish populations, and require the establishment of a monitoring and evaluation programme in order to monitor the status of the coral reefs. (See TOOLS 66-74 for more information on coral reefs.)

3.2.3 The role of seagrasses

While there is less awareness of the ecological functions associated with seagrasses than with coral reefs and mangroves, their functions are no less important and have been estimated to be worth US$1.9 trillion in the form of nutrient cycling (Waycott, 2009: See TOOL 80). The other relevant ecosystem services provided by seagrasses and seagrass meadows that are relevant to food production include the provision of food for coastal food webs, provision of oxygen to waters and sediments, prevention of sediment resuspension, wave attenuation and shoreline protection (Duarte, 2002: See TOOL 81).

While there is reasonable understanding of the rate of decline of seagrasses in some areas, there is a large data gap that exists in the Indo-Pacific Region (Waycott, 2009: See TOOL 80). Globally, excess nutrients and sediments are the main current causes of seagrass decline (Orth, 2006: See TOOL 82). Subsequent loss of seagrasses causes sediment resuspension, which negatively affects fish populations. Similar to mangroves, seagrasses migrate landward with sea level rise, have extremely high light requirements, and barriers to such migration will cause dieback (Orth, 2006: See TOOL 82).

In the Pacific, the use of pesticides is generally a less significant problem relative to other regions due to the prevalence of shifting cultivation as a soil conditioner rather than a dependency on fertilizer, but increased turbidity associated with increased likelihood of storm events and the availability of sediment from shifting cultivation means that sediment management in coastal areas may become a significant focus of EbA efforts.

In some areas of the Pacific, there are high degrees of dependency on seagrasses for direct and indirect production of coastal resources (Unsworth and Cullen 2010: See TOOL 83). The loss of this habitat can therefore result in negative consequences for food security. Due to the importance of seagrasses for livelihood and food security in the Pacific, especially as certain organisms depend on this habitat throughout certain phases of their lives, an ecosystem-based approach would entail that seagrass beds be managed at scale, and interconnected to other important ecosystems to restore and maintain ecosystem health for the provision of the needed ecosystem services across the land and seascape. (See TOOLS 80-84 for more information on seagrasses.)

3.3 COMBATING LOSS OF BIODIVERSITY AND FARMING SYSTEMS DECLINE

Traditional farming systems in the Pacific have endured and sustained Pacific populations through centuries of droughts, cyclones and other natural disasters. Indigenous farming knowledge has been dutifully passed down through countless generations and is based upon low-input, sustainable practices that focus on crop integration and natural methods of controlling weeds, pests and maintaining soil fertility.

Many traditional farming practices provide a basis to address modern climate change by improving food security in times of climatic variability. They can be drawn upon to enhance food security and to prevent the proliferation of energy-intensive cropping practices, many of which are unsustainable in PICTs and contribute significantly to global warming and environmental degradation. Here are some adaptation steps that are designed to promote crop diversification and maintain ecosystem services, while minimizing adverse environmental impacts.

- **Step 17 –** PICT governments and communities should develop and promote the use of farming systems more suited to changing environmental conditions. Traditional agroforestry and "modern" organic farming systems focus on crop diversification, crop integration and low-input production practices. These farming systems take a balanced approach to crop production and have been shown to provide greater food security during variable and/or adverse climatic conditions. They also tend to conserve soil and water resources and the many ecosystem services that are critical to sustaining agricultural production.

- **Step 18 –** The past push for monocultural, export-driven cropping enterprises that essentially "*put all of a farmers eggs in one basket*" must be reassessed within the context of pending climate change and increased climate variability. By design, monocropping initiatives tend to be high-input, involving large applications of fertilizers, pesticides and herbicides. They also lack crop diversity and, accordingly, run a higher risk of economic failure during market downturns and extreme weather events. Furthermore, they may offer precious little in the way of direct food security to farmers and their families.

- **Step 19 –** Farmers should be encouraged to draw upon those traditional and modern farming practices that focus on the sustainable management of soil fertility, pests and diseases. The use of tried and proven low-input practices such as integrated pest management, increasing fallow periods, companion planting and intercropping can all help sustain soil fertility levels and other ecosystem services. The adoption of sustainable farming practices is ultimately likely to reduce the vulnerability of root crop systems and the wider environment to the impacts of climate change.

- **Step 20 –** Sustainable farming practices that focus on building and maintaining soil humus (organic matter content) such as green mulching and manuring provide an important means of combating drought, nutrient leaching and soil erosion. These practices also contribute to capturing atmosphere carbon dioxide and help reduce climate change.

- ~ **Step 21** – The integrated use of trees in agroforestry production systems provides opportunities to expand livelihoods by utilizing planted trees for construction and handicraft materials, firewood and alternative sources of food. When used for live fencing, shelter belts and the stabilization of steep terrain, trees are an effective trap for carbon dioxide and also provide a cost-effective means of buffering against heavy rainfall, sun, wind and salt spray.

3.3.1 Combating pests and diseases

Predicting and controlling the proliferation of new and/or existing pests and diseases in a future Pacific is without doubt one of the largest and most poorly understood challenges facing PICTs. The following are some steps that can be implemented to help reduce the risk and impacts of pests and diseases.

- ~ **Step 22** – Awareness programmes to ensure that farmers and relevant stakeholders are aware of what "invasive species" are and how they can adversely impact agriculture and root crop production in Pacific Islands are critically important. Stakeholders also should be made aware of how individuals and communities can play a role in preventing the introduction of new pest species and the proliferation of existing pests and diseases.

- ~ **Step 23** – When it comes to invasive species, prevention is the best solution. Pacific communities must support authorities to implement quarantine measures that help ensure that new pests and diseases are not introduced from the illegal importation of plants and plant products, root cuttings, seeds, soil materials or fruits.

- ~ **Step 24** – Where invasive pests and diseases are already present in a country, communities and farmers can play an important role in helping eradicate and/or contain pests. This may involve helping physically eradicate pests and weeds; adhering to national quarantine restrictions; and reporting new outbreaks of invasive species and diseases to agricultural authorities.

~ **Step 25 –** It is vital that communities do not take biological eradication efforts into their own hands. Poorly planned biocontrol, such as introducing organisms, insects or animals (bio-agents) that attack a wide range of prey or hosts, has caused enormous problems on some islands. The ill-advised introduction of the cane toad (*Bufo marinus*) into Fiji and elsewhere to combat the cane beetle is an example of biocontrol gone wrong.

~ **Step 26 –** While it will be impossible to stop some pests and diseases from establishing and flourishing in a warmer Pacific climate, farmers can help build resilience to Pacific farming systems by utilizing sustainable farming practices that focus on diversity and nurturing ecosystem services. Such an approach will help ensure that farmers are less exposed to the risk posed by invasive species.

~ **Step 27 –** Mangroves and coastal forests play multiple roles in combating climate change and fostering food security. They provide habitats for birds, fish, crabs and other marine species and also provide a vitally important buffer between marine and terrestrial environments. As well as helping to protect land resources against the ravages of cyclones, storm surges and rising sea levels, they also simultaneously protect reefs and inshore fisheries from drainage waters that carry damaging silts and pollutants such as pesticides and fertilizers. Governments and communities must work closely together to secure and protect these vulnerable coastal ecosystems.

(See TOOLS section for further sources of information on a climate change mitigation and adaptation measures.)

Mangroves and coastal forests help protect inland crops from storm surges and damaging salt spray. They also help protect fisheries and coral reefs from the damaging effects of silts and pollutants. To help build resilience to climate change, we need to protect existing coastal forests and help to reestablish mangroves and coastal vegetation where they have been removed. Photo above shows mangrove deforestation; photo below shows mangrove planting. (Tongatapu, 2009)