Pacific Island Biodiversity, Ecosystems and Climate Change Adaptation: Building on Nature's Resilience

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A Report prepared for the Secretariat for the Pacific Regional Environment Programme by Conservation International
July 2011

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Design: MBE Business Services

Cover photo: Stuart Chape
Illustrations: Sevuloni Tora

SPREP Library/IRC Cataloguing-in-Publication Data
Hills, Terry ... [et al.]
Pacific Island biodiversity, ecosystems and climate change adaptation : building on nature's resilience / Terry Hills … et al. – Apia. Samoa : SPREP, 2011.

48 p. : col. ill. ; 30 cm.
Includes bibliographical references.
Also available online.

ISBN 978-982-04-0425-0 (print)
ISBN 978-982-04-0426-7 (online)
1. Ecosystems management - Oceania 2. Biodiversity conservation – Oceania. 3. Climatic changes – Environmental aspects - Oceania. 4. Conservation of natural resources – Oceania. I. Hills, Terry. II. Brooks, Ashley. III. Atherton, James. IV. Rao, Nalini V. James, Roger. VI. Pacific Regional Environment Programme (SPREP). VIII. Title.

333.95

Foreword

The people of the Pacific Island Countries and Territories have a long history of living in highly varied climatic conditions. Cyclones, storms and even droughts have challenged lives and livelihoods, but the traditional systems of the Pacific Island people have historically offered a high degree of resilience to these events. Now, as changes to the intensity, frequency and distribution of these extreme events combine with other aspects of climate change such as more subtle shifts in temperature and precipitation patterns, ocean acidification and sea level rise, the people of the Pacific Islands are amongst the most vulnerable to the impacts of climate change.

The biodiversity of the Pacific continues to attract many visitors because of its beauty and its uniqueness. However, it is the conditions that have created this distinctive and diverse biodiversity that make the terrestrial, freshwater and marine life particularly vulnerable to climate change. For example, geographic isolation, and often limited scope for upward shifts in altitude by mountain species makes species migration to more suitable areas particularly challenging.

The relationship between the people of the Pacific and their environment has always been very strong - with a high dependency on the services that the local ecosystems provide, such as food and freshwater. Over time, climate change will undermine the capacities of many ecosystems to continue to provide these services. Furthermore, it is not just climate change that threatens the productive ecosystems of the Pacific; environmental degradation associated with poor natural resource management continues to limit the options for future generations of Pacific Islanders.

In responding to climate change, governments across the world will need to make the best use of the full range of their social, political, technological, economic and environmental resources to provide the greatest opportunities for current and future generations. In the Pacific, the dominant adaptation responses to climate change have focused heavily on infrastructure and community-based approaches. This report calls for a third approach, which requires us to better harness the significant contributions that ecosystems can make in improving the resilience of the people of the Pacific to climate change - in the form of 'environmental infrastructure'.

We hope this report and its associated products will support decision-makers in their efforts to better view biodiversity conservation and ecosystem service values through the lens of climate change, and to identify practical actions that can be a integral part of the solution to this very complex problem.

We are pleased to introduce this project which explores the relationship between three of the greatest challenges of the 21st century: climate change, poverty and environmental degradation. This report is the product of a collaboration between SPREP and Conservation International and we believe that it offers a solid foundation for Pacific Island governments to make decisions, attract support and take action in a way that will enable the diverse and critical relationships between the people of the Pacific and their environment to be maintained into the future.

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Acknowledgements

The financial support of the Australian Government for this work under the International Climate Change Adaptation Initiative (ICCAI) is gratefully acknowledged. Additionally, the authors would like to thank the following individuals for their invaluable assistance in the production of this report:

Stuart Chape (SPREP), Alana Cornforth, Sue Taei (CI -Pacific), Radhika Dave (CI - HQ), Hannah Campbell (CI - HQ), Dave Hole (CI - HQ), John Matthews (CI - HQ), Emilia Pramova (CIFOR), Easter Galuvao (SPREP), Loraini Sivo (CI - Pacific), Schannel van Dijken (CI - Pacific), Bruce Jefferies (SPREP), Tim Carruthers (SPREP), Ravik Nijbroek (CI - HQ) and Robyn James (The Nature Conservancy).

Acronyms

ADB	Asian Development Bank
CBD	Convention for Biological Diversity
CCA	Climate Change Adaptation
CROP	Council of Regional Organisations for the Pacific
DRR	Disaster Risk Reduction
EbA	Ecosystem-based Adaptation
ENSO	El Nino Southern Oscillation
EEZ	Economic Exclusion Zone
GEF	Global Environment Facility
ICCAI	The Australian Government's International Climate Change Adaptation Initiative
IPCC	Intergovernmental Panel for Climate Change
NAPA	National Adaptation Programmes of Action
NBSAP	National Biodiversity Strategy and Action Plans
PCCSP	The Australian Government's Pacific Climate Change Science Program
PICT	Pacific Island Countries and Territories
PCCR	Pacific Climate Change Roundtable
SLR	Sea Level Rise
UNFCCC	United Nations Framework Convention for Climate Change

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1 Overview

Background

The combined pressures of climate change and development will not only aggravate existing challenges to the conservation of biodiversity in the Pacific, but also introduce new difficulties. There are a wide range of historical, current and planned studies that examine specific aspects of the relationship between climate change, conservation and development in the Pacific. However, resource management decision-makers often aren't able to allocate sufficient resources to review and synthesize lessons from the fast-moving body of climate change research into information that is directly relevant to their needs. Additionally, there are large gaps in the availability of baseline and monitoring data of species, habitats and ecosystem services that are critical to the livelihoods of the Pacific Island people. This lack of data is reducing the effectiveness of assessments of the vulnerability of the regional economy to climate change; an economy that is heavily dependent on natural resources.

Finally, while there is a lot of current interest in the capacity of ecosystems to help buffer human development from climate change, there is also a lot of rhetoric on the specific benefits of ecosystem-based adaptation (EbA)[1] and the conditions under which those benefits are likely to be received. In cases where EbA-relevant information is available, relevant and reliable, it is not typically presented in a way that is useful to development and conservation decision-makers in Pacific Island Countries.

Approach

Conservation International (CI) set out to compile the relevant biodiversity and climate change information relevant to the Pacific, evaluate it against the physical, cultural and socio-economic context of regional countries, and present it in a way that meets the information needs of decision-makers. While a comprehensive assessment of Pacific biodiversity and its vulnerability is not possible within the short time frames of this project, the preliminary assessment of available information and the identification of critical data gaps will inform decisions on the establishment of critical biodiversity and habitat baseline studies and monitoring strategies. This work will directly support decision-makers within national and regional institutions in the Pacific to better consider the role of ecosystems in their adaptation planning – covering terrestrial, coastal and marine environments. Particular attention is given to the coastal context due to the intense, growing and complex ecosystem and human interactions and high potential for adaptation impact in coastal areas. It should also be noted that the potential contributions from indigenous/traditional knowledge have not been considered in detail within this study.

The scope of work was guided by the following objectives:

1. To establish an information basis that will guide future decisions within planning and environment ministries across the Pacific Island Countries and Territories (PICTs) on the current knowledge of climate change impacts on biodiversity, including on the identification of critical data gaps.

2. To develop a strategy to fill the data gaps in the knowledge of the impacts described in (1).

3. To improve the awareness of the opportunities presented by EbA amongst planning and environment ministries and adaptation project designers and managers active in PICTs.

[1] "Adaptation that integrates the use of biodiversity and ecosystem services into an overall strategy to help people adapt to the adverse impacts of climate change" (CBD, 2009)

Overview of the Report

This report is the product of extensive stakeholder consultations and literature review of the specified topic. While the report captures the key background information, findings and recommendations, it should be regarded as a broad introduction to the wider program of work by Conservation International and SPREP for this project. For in-depth analyses of the various topics covered, the reader is advised to refer to the following Background Reports (available on the companion CD):

- Climate Change Adaptation Options for Species and Ecosystems in the Pacific: Background Paper #1.
- The Potential for Ecosystem-based Adaptation(EbA) in the Pacific Islands: Background Paper #2.
- Need Analysis for Information on Ecosystem, Biodiversity and Climate Change Adaptation in the Pacific Island Countries and Territories: Background Paper #3.
- Report on the Results Workshop from Nadi, 12-13 May 2011: Background Paper #4.

Section 2 is an exploration of the predicted direct and indirect climate change impacts to marine, terrestrial and freshwater ecosystems across the Pacific. The analysis also considers and compares the projected climate impacts on ecosystems with the non-climate change factors that degrade ecosystems (e.g. land clearing, pollution, and invasive species). This analysis is then used to identify and categorise the species and ecosystems that are most vulnerable to climate change. The adaptation options for such species and ecosystems are then proposed and outlined in Section 3. The research proposes a broad set of adaptation responses that include measures to reduce/eliminate non-climate change threats, to improve adaptive capacity of ecosystems, and to address overarching policy-level constraints to effective climate change adaptation.

Pacific Islands Countries and Territories have a wide variety of ecosystem types: Gondwana vegetation, Plaines des Lacs, New Caledonia. Photo: Stuart Chape.

Section 4 explores the role of ecosystem services in building the resilience of human settlements, with the target audience being planning, agriculture and disaster management institutions of the Pacific. This analysis involved an exploration of the key ecosystem service relationships that are relevant to the specific climate change exposures of the Pacific Island countries. For example, the capacity of mangrove ecosystems to act as a 'bioshield' to protect human settlements from cyclones and associated storm surge.

Section 5 provides the findings of a short analysis of the demand for information that links conservation, development and climate change actions. This section was derived from desktop analysis of strategies and plans, and also from a survey conducted at the 3rd Pacific Climate Change Roundtable(PCCR) in Niue (11-14 March 2011), which was further validated at the project's Results Workshop in Nadi, Fiji (12-13 May 2011). The survey explored the perceptions of risk related to climate change, the information needs for tools, and the format in which such information would be preferred. In the desktop analysis, the coverage of these topics within existing strategy and practice was examined in two areas:

- Extent to which adaptation planning has been considered in national and regional conservation planning in the Pacific

- Extent to which ecosystems and biodiversity has been considered within mainstream adaptation planning in the Pacific

Section 6 describes the information requirements associated with the various adaptation objectives proposed by this work. It also captures and discusses the current status of relevant information on ecosystems and biodiversity and their sources and limitations. This section closes with an outline of initiatives currently underway that share data in order to highlight that such approaches can enhance adaptation planning in the Pacific.

Section 7 provides a brief overview of one of the major outputs of this work – the Toolbox for Biodiversity, Ecosystems and Climate Change Adaptation in the Pacific Islands (the Toolbox). As there is already an enormous range of climate change tools available, a decision was made that new tools would not be created as a part of this project. The Toolbox comprises a set of succinct overviews of existing tools that are relevant to climate change adaptation planning, which are then contextualized/assessed for use in the Pacific. On a practical level, all tools are relevant to a) building ecosystem and biodiversity considerations into national communications under the UNFCCC and b) undertaking vulnerability assessments and climate change adaptation actions in areas of high ecosystem service/conservation value. The Toolbox also will allow decision-makers from national to local governments, NGOs and community groups to take a diagnostic approach to adaptation in the Pacific context: matching the practical tools with the local needs.

2 Vulnerability of species and ecosystems in the Pacific

Climate change in the Pacific

Climate change will have severe and unique impacts on Pacific Island Countries and Territories (PICTs): severe due to characteristics such as the low lying topographical nature of many islands and the limited refuges from intensifying storms and rising sea levels; and unique due to limited 'room to move' because of isolation and small island size. Beyond the seasonal, inter-annual and decadal variability of Pacific climatic processes, the region is already experiencing changes to average background conditions. Observed changes (Kinch et al., 2010) include: a warming sea surface temperature of 1 to 1.5° C over the past 50 years, with predictions of an additional increase of 0.5°C to 0.8°C from current temperatures by 2035; sea levels have risen (non-uniformly) across the Pacific and have averaged 1.7 to ~3.1mm/yr over the past few decades. This trend is likely to continue with seas predicted to rise in the range of 0.18 – 0.59m by the end of the century (IPCC, 2007); weather patterns are changing with increases in precipitation across the region, and more frequent and more intense storms predicted over the coming decades. Additionally, ocean acidity globally is suggested to have risen by 30% since the industrial revolution which is having profound impacts on ecosystems and species. For example, the estimates for reaching associated 'tipping points' for corals in the Pacific based on existing emission scenarios range from 2030 to 2100. For a species-level example, recent studies suggest that the capacity of clownfish to sense predators may be compromised by higher ocean acidity levels. However, the accuracy of many of the climate projections for the Pacific are constrained by significant data gaps, and the presentation of model results typically acknowledge significant uncertainty, challenged by a context of high variability.

The concept of vulnerability is prevalent in many discussions on climate change risk. Box 1 illustrates this concept and the accepted approach to its assessment. It should be noted that such assessments are rarely a straightforward exercise as relationships between livelihoods and ecosystems that underpin vulnerability are typically very complex and site-specific. For example, in Milne Bay in Papua New Guinea the seasonal markers that traditionally guide commencement of specific livelihood activities are increasingly becoming 'out of sync' with the agricultural productivity cycles. More specifically, the seasonal marker provided by the new emerging leaf shoots of the rosewood tree *Intsia bijuga* that signals the time for planting of yams *Dioscorea* spp is becoming less reliable, creating confusion and despondency from gardeners.

Photo: Stuart Chape

This background analysis does not go into detail on current projections for climate change in the Pacific; the likely climate change 'exposures' of Box 1. This is detailed comprehensively in a number of other studies, the most authoritative being the Intergovernmental Panel for Climate Change (IPCC) results from their 2007 Fourth Assessment Report(AR4). One of the more significant efforts for the Pacific Islands since the publication of the AR4 is the work being undertaken by the Pacific Climate Change Science Program (PCCSP) under the Australian Government's International Climate Change Adaptation Initiative(ICCAI). In anticipation of the upcoming release of the results from PCCSP, this study focuses predominantly on the sensitivity and adaptive capacity elements of ecosystems and biodiversity vulnerability.

There is a high degree of confidence that projected changes in climate will result in the degradation, redistribution, and/or fragmentation of ecosystems and the loss of biodiversity, species, and ecosystem services in the Pacific over the coming decades. While global climate systems change incrementally, there is a continuum of increasing risk of loss of ecosystems and species as the magnitude of change increases (Schneider et al., 2007); even small changes can impact some ecosystems and species due to complex requirements and relationships. However, the scale of response by individual species and ecosystems will vary depending on their sensitivity, the level of exposure to climate threats, and their adaptive capacity in the face of disturbance. Together, these factors determine species' and ecosystem vulnerability to climate change.

While the traditional systems of the Pacific Islanders are generally considered to offer a high degree of resilience to climate change, Pacific countries are typically described as highly vulnerable to climate change due to their developing country (low adaptive capacity) and small oceanic island (high exposure) status (ADB, 2010). On closer examination of the role of ecosystem services in this vulnerability, additional multiple stressors at the local level ensure that ecosystems and species across PICTs are significantly predisposed to impacts of climate change. For example, the insularization of small islands; combined with rapid population growth and consumption pressures has the potential to result in significant environmental degradation, associated fragmentation of ecosystems and high risk of species loss.

Box 1: What is vulnerability and how is it assessed?

In keeping with the IPCC definition of vulnerability, this report uses the 'hazard of place' vulnerability framework to explore species and ecosystem service vulnerability to climate change. Here, vulnerability is a function of an external dimension represented by 'exposure' to climate variations, and the internal dimensions comprising 'sensitivity' and 'adaptive capacity' to stressors (Figure 1) (Fussel and Klein, 2006). Despite its origins in social and development theory, the consideration for both external and internal dimensions of vulnerability allows such a framework to be readily adapted to species and ecosystems.

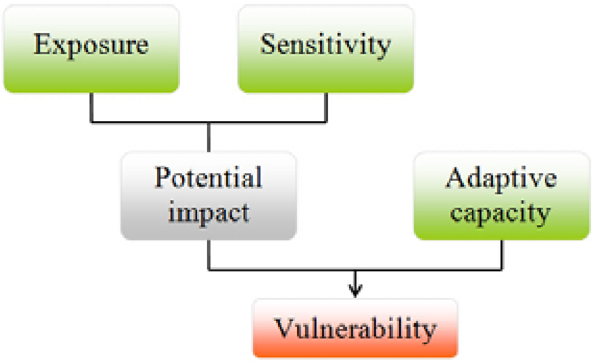


Figure 1: Components of vulnerability
Adapted from: (The Allen Consulting Group, 2005)

The potential impact of climate change is determined by a combination of exposure and sensitivity – or the degree of likely damage (USAID, 2009). Exposure is the likelihood of being affected, and the nature and degree to which species or ecosystems are exposed to climatic threats (Yusuf and Francisco, 2009). Variables related to exposure can include proximity to the source of the threat, incident frequency or probability, magnitude or duration (Cutter, 1996). Sensitivity is the degree to which species and ecosystems are affected either adversely or beneficially by climate changes (USAID, 2009). Sensitivity can be determined through understanding impacts from past threats, individual or system-wide characteristics, and connectivity between individuals and the system. Another important element of exposure and sensitivity is reversibility of changes (i.e. can the species or ecosystem be recovered following adverse impact?). At the species level, extinction is of course irreversible, and similarly for ecosystems, once the structural foundation is lost, recovery of ecosystem goods and services can be impossible.

Adaptive capacity is the ability of a species or ecosystem to respond to disturbance such that they 'manage' their exposure and/or sensitivity to climatic influences (USAID, 2009). Thus, adaptive capacity is the ability to moderate or reduce the degree of likely damage, to take advantage of any opportunities, or to cope with the consequences (IPCC, 2007).The net effect of exposure, sensitivity, and adaptive capacity is vulnerability. An exploration of these factors was conducted to assess potential impacts on species and ecosystems due to climate change, and to identify those most vulnerable in the Pacific region.

Climate change impacts on ecosystems

Climate change is predicted to have significant impacts on marine, terrestrial and freshwater ecosystems:

- **Mangrove ecosystems** are exposed to and threatened by sea level rise, although this is dependent on a range of factors, including the dynamics of the catchment. In response to sea level rise (SLR), mangroves may migrate landward or increase peat production in place. Where migration is not possible mangrove species and ecosystem area will decline or be lost in that area. There is increasing evidence that changes to precipitation (both direct and on the local catchment) may also influence phase shifts of mangrove systems into other tidal wetland systems, such as salt marshes.
- **Coral reef ecosystems** are exposed to and highly threatened by the cumulative threats of ocean acidification, rising sea temperature, SLR and increased storm activity. The synergistic effects of these threats will likely result in the accelerated degradation of coral reef ecosystems over the coming decades. Many coral reef ecosystems may undergo a phase shift to alternate ecosystems lacking the structural topology of reefs fundamental for ecosystem service provision.

Healthy coral reef ecosystems are more likely to be resilient to climate change.
Photo: Conservation International

- **Seagrass ecosystems** are exposed to and threatened largely by SLR and rising sea temperature. Rapid SLR will generally result in seagrass die-off if species are unable to migrate to new habitat, while rising sea temperatures beyond seagrass thermal thresholds will lead to species shifts and eventually seagrass loss. However, it should be noted that Pacific tropical seagrass species are more ephemeral than their temperate counterparts, and change position constantly.
- **Terrestrial ecosystems** are threatened by climate change in a number of ways, including by weakening their natural adaptive capacity through disturbance. As precipitation and temperature patterns change, forests will be more susceptible to invasive species or fire which may lead to broad ecosystem shifts, loss of services in that area, or a loss of habitat completely. Terrestrial ecosystems which are already degraded by non-climatic factors (e.g. human degradation or invasive species), or are fragmented, have high species specialisation or narrow climatic tolerances, will likely be the most vulnerable to climate changes.

- **Freshwater ecosystems** will be primarily impacted by changing precipitation regimes. Decreasing precipitation regimes will impact all freshwater ecosystems and result in: ecosystem transformation, biodiversity loss, contraction of watershed area, and loss of freshwater lens. Increasing precipitation into the future is predicted to have largely positive impacts in all freshwater ecosystems where they maintain intrinsic integrity - although increased variability of droughts and flooding may introduce new stresses.

Finally, due to strong co-evolutionary interactions between species and strong linkages between marine and terrestrial ecosystems on small islands, adverse impacts to one ecosystem will impact other linked ecosystems and species, and may result in a decoupling of species linkages that may lead to failure of reproduction and biodiversity loss.

Non-climate change threats to ecosystems

While Pacific islanders have a long history of resilience to climate variability, many Pacific island countries are already experiencing disruptive impacts consistent with the predicted consequences of climate change that are beyond their historical experience including more frequent and intense storms, coastal erosion, flooding, drought, and rising sea levels (ADB, 2010). However, most of the immediate threats to Pacific island biodiversity and ecosystems are non-climatic. These include: land use change and habitat destruction, modification of river flow, freshwater pollution, over-exploitation of resources, and invasive species. While projected climate change impacts will be felt in coming decades, these non-climate threats are immediate, acute, locally generated and are more significant source of ecosystem decline and species loss regionally. In addition, these threats serve to increase ecosystem vulnerability to future climate changes. The key non-climate change factors currently threatening biodiversity and ecosystems across the Pacific are summarised in Table 1.

Table 1:Summary of non-climate change threats and impacts on ecosystems

Overarching threats	Threats and impacts
Centralised governance	Weak policies and policy-making processes to address drivers of environmental problems.
Population growth	Rapid increase in pressure on natural resources for food, water and energy. An additional one million people predicted in the region over the next five years.
Natural disasters	Ecosystems uniquely susceptible to destruction by catastrophic events (such as tsunamis, floods, cyclones, droughts, and earthquakes) primarily due to their geographic isolation and that many islands have topographies that do not rise far beyond sea level. These make them highly exposed and vulnerable to the effects of extreme weather events. Impacts on species include, loss of habitat and food, increased predation, failure to breed, and an overall degradation of ecosystem resilience and health.
Invasive species	Invasive species are responsible for more species extinctions than any other threat. At the species level, direct effects will occur through predation, competition, transmission of pathogens and parasites, which can all lead to population declines and extinctions. Each of these impacts alters species richness and abundance, distribution, and ecosystem processes.
Marine ecosystems	
Pollution	Pollution from land-based liquid and solid waste is causing ecosystem degradation.
Coastal habitat destruction	Results in significant loss of species, and ecosystem processes, and often have compounding effects downstream. Threats include, logging of mangroves, foreshore reclamation, coral harvesting, dredging, sand mining, and coastal development.
Over-exploitation	Over-fishing and exploitation reduces species richness and abundance and often causes ecological shifts that further compromise ecosystem services and goods. There is evidence from rapidly declining populations of large tuna, sharks and sea turtles.
Terrestrial ecosystems	
Land-use change conversion	Land-use change, and habitat loss due to conversion of terrestrial ecosystems to agricultural, urban, or other human dominated systems, is a major driver of biodiversity loss. Direct threats include logging, burning and alteration of flow.
Hunting	Evidence of negative impacts from coconut crabs, pigeons, and fruit bats.
Freshwater ecosystems	
Pollution	Indirect threats include pollution, erosion, and saline intrusion.

Species and ecosystems most vulnerable to climate impacts

In the Pacific Islands the non-climate stressors (e.g. high human dependence on ecosystem goods and services, and rapid population growth) combine with specific species and ecosystem characteristics (e.g. high levels of species specialisation and endemism) to create a high sensitivity to climate change.

Building upon the vulnerability framework described above, an assessment of those species and ecosystems most vulnerable to climate change can be made by considering both the external context (i.e. exposure to climate change and or anthropogenic pressure), and internal characteristics (i.e. adaptive capacity, ecosystem health and sensitivity to that external context.) Bringing these elements together allows us to make broad inferences about the most vulnerable species and ecosystems. These are summarised in Table 2.

Table 2: Species and ecosystems most likely to be vulnerable to climate change

Species-level high vulnerability context and conditions	
General issues	• Threatened/endangered
	• Small populations
	• Narrow climatic tolerance
	• Highly specialised
	• Are exploited for use/under stress from human use
	• Specialised habitat requirements (i.e. spending part of life cycle as a larvae)
Capacity for movement	• Limited geographic range
	• Located on remote islands or mountain peaks
	• Low migratory capacity/poor dispersal
	• Poor colonization potential
Relationship with other species	• Dependent on other species vulnerable to climate change
	• Low competitive capability
Ecosystem-level high vulnerability context and conditions	
Coastal ecosystems	• Exposure to SLR, increased storm activity and storm surge; or are already under stress from human use disturbance.
Mangrove ecosystems	• Have no external source of sedimentation; are isolated; have no capacity to migrate; or are already under stress from human disturbance.
Montane/cloud ecosystems	• Have narrow climatic tolerances; limited/no potential to migrate upslope; or are already under stress from human disturbance.
Dryland ecosystems	• Have high levels of endemism; are susceptible to fire and insects as a result of increasing summer temperatures and precipitation declines; or are already under stress from human disturbance.
Coral reef ecosystems	• Have narrow climatic, thermal and physiological tolerances; are situated at the mouth of watersheds (exposure to silt and pollution); or are already under stress from human disturbance.
Seagrass ecosystems	• Located in isolated areas or on submerged banks; limited ability to migrate; or are already under stress from human disturbance.
Freshwater ecosystems	• Close to coastal area (salt water intrusion from SLR); are already under stress from external disturbances (human land alteration; high level of disruption or diversion of flow (e.g. dams/irrigation); barriers to species movement and migration exist; or pollution);

Conclusions and recommendations on impacts

Based on the available knowledge of climate change across the Pacific Island region, impacts are likely to be severe and widespread. Few ecosystems and human settlements could be said to be completely buffered from predicted impacts. Many of the ecosystems identified as most vulnerable to climate change are those that are already strongly linked with livelihoods and cultures, and proximate to population centres (i.e. mangroves, sea grass beds, coral reefs, and coastal and freshwater ecosystems). Significant changes to these ecosystems are therefore highly visible to resource users and residents, and adverse climatic impacts would have almost immediate and tangible impacts on households and incomes. In this regard, proactive responses to climate change to protect and restore these ecosystem services are considered urgent, the ownership of the challenges and solutions need to be local, and awareness of the issues is already high in many cases. These three issues represent potential enabling factors for effective proactive adaptation responses.

3 Adaptation options for biodiversity conservation planning

Adaptation is defined as “an adjustment in natural or human systems to a new or changing environment” (Julius and West, 2008:6). Adaptation to climate change is therefore a biological or societal response to actual, or expected climatic changes, so as to reduce harm or exploit opportunities (ADB, 2010). This can occur through either autonomous (reactive) or planned (proactive) responses. In human systems, autonomous adaptation could be a gradual retreat of housing to higher ground, or relocation of crops, as sea water intrusion occurs. In biological systems, adaptation could be genetic change due to natural selection where characteristics become better suited to certain environmental features (Mimura et al., 2007).

Planned adaptation involves societal intervention to manage systems based on the knowledge that conditions will change, and where actions are undertaken in order to reduce any risks that may arise from that change within vulnerable systems (Julius and West, 2008). Within this, ecosystem-based adaptation (EbA) has emerged as one of the strategies to integrate planned adaptation strategies with ecosystem services in the face of change. In this regard, the management, conservation and restoration of ecosystems are integrally linked to reducing the vulnerability and increasing resilience of human communities. Here, if ecosystem goods and services (e.g. freshwater, storm protection, habitat, income sources etc.) can be sufficiently maintained (either through periods of acute climate events, or in preparation for chronic long term change), then significant disruption and adverse impacts of climate change on human communities can be moderated (Pramova et al., 2010). Section 3 of this report focuses on the adaptation solutions that are relevant to biodiversity conservation planning in the Pacific Island region. The potential of EbA in the Pacific will be dealt with separately in Section 4.

Box 2: Uncertainty in Climate Change Adaptation

Given the uncertainty associated with climate change, Willby and Dessai (2010) introduce the concept of the ‘cascade of uncertainty’ - see Figure 2. The authors suggest that a ‘cascade’ of uncertainty begins at the top of the pyramid with a lack of understanding of future society (and their carbon emissions), moves down the pyramid through the limitations of climate and impact models and finally to the effectiveness of adaptation options. Each of the layers contributes to a full ‘envelope of uncertainty’ - represented by the broad base of the pyramid. Using this conceptual model can help to understand the full range of appropriate adaptation options; it is necessary to either a) reduce the uncertainty by investing in research to narrow the base of the pyramid) or b) select adaptation options that are sufficiently robust to accommodate a wide range of climate futures.

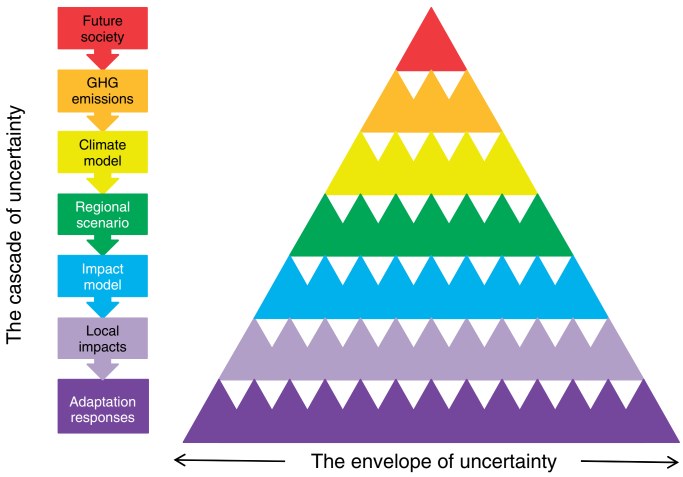


Figure 2 - The Cascade of Uncertainty (Willby and Dessai, 2010)

This section provides an overview of options for planned adaptation strategies, with a focus on the potential to integrate adaptation into biodiversity conservation activities. Given the inherent uncertainty in the process of identifying adaptation options (see Box 2), there is a strong possibility of introducing additional risk unless a cautious site-specific approach is taken that considers all sources of uncertainty in the local context. For example, making a decision for prioritizing funding for an adaptation action that is based entirely on the results of one impact model that uses a single climate scenario may not deliver the best ‘value for money’ adaptation outcome. Similarly, decisions on ecosystem and species vulnerability and associated adaptation options based on generic advice may not deliver the best adaptation outcomes. Thus, this section should be regarded only as a rapid assessment of current knowledge in the literature, and should be used to guide discussion and as a foundation for site-based research and actions only.

Integration of adaptation into biodiversity conservation activities can be divided into two broad approaches: creating conditions that reduce exposure (to non-climate threats); and creating conditions that increase the adaptive capacity of ecosystems. A discussion of these two approaches is followed by a summary of the overarching governance and policy requirements that cut across all adaptation strategies.

Reduce exposure to non-climate change threats

As discussed in Section 2, a range of non-climate stresses to ecosystems pose immediate and acute threats to ecosystem health across the Pacific region. Severe threats include fires, hunting, logging, invasive species, and conversion of coastal zone for development or aquaculture, over-fishing, pollution, and structural damage from anchoring, blast fishing and tourism. Reducing or eliminating these non-climate change stresses can help improve ecosystem resilience and reduce vulnerability to climate changes (Leadley et al., 2010).

Strategies to reduce these threats can include ecosystem management actions such as 'no-take' fishing zones, restriction on the collection of herbivorous fish and sea urchins (that control algal populations), a reduction in practices that damage coral structure (blast fishing and boat anchor damage), and maintenance of good water quality through mitigation of land based pollution. Another action to reduce threats is the development or support of alternative livelihoods and incomes; diversifying income and food sources can reduce pressure on specific ecosystem services and contribute to ecosystem resilience.

Increase adaptive capacity of species and ecosystems

Adaptive capacity of ecosystems depends on two factors: their intrinsic capacity to adapt; and the ability of species to migrate or modify physiology/behaviour. Thus, in order to maximise adaptive capacity for ecosystem resilience to climate change, any strategy must foster these two factors at the species and ecosystem level. Five principles can be employed to achieve this:

1. *Connectivity:* Ecosystem connectivity is a vital component of species' ability to migrate to accommodate incremental change or following disturbance. For both marine and terrestrial ecosystems, it is critical to maintain or maximise habitat connectivity to allow species populations to move to more suitable habitat or refuges, or to allow dispersal or replenishment from other sites (Leisz et al., 2009). Actions must be taken to identify existing or past patterns of connectivity among source and sink areas, and among associated habitats (such as between coral reefs, mangroves and seagrass beds), so that these can be promoted or protected (Hannah, 2011).

2. *Representation:* In order to insure against catastrophic/chronic climate events resulting in species or ecosystem loss, adaptation strategies must ensure protection of a full range of habitat types in order to represent the area's total biodiversity, and therefore ecosystem services (Stolton and Dudley, 2010).

3. *Identification of resilience:* Identification and protection of species, habitats, or ecosystems that have been resilient to, or recovered rapidly from past degradation or climate events can be an effective strategy to combat climate change. These can serve as refuges and provide seed/larvae/recruits to repopulate and enhance the recovery of areas damaged by climate change (Salm and Mcleod, 2008).

4. *Maintenance of biodiversity:* Large areas of intact ecosystem with high biodiversity, particularly areas with a wide elevational ranges, will have the greatest capacity to buffer the impacts of climate change (Leisz et al., 2009). The presence of elevational gradients will be critical for allowing habitat or climate sensitive species to relocate to more suitable habitat over time (Leisz et al., 2009).

5. *Restoration and protection:* Restoration and protection approaches typically address each of the four principles outlined above, but also constitute a traditional approach to conservation. Restoration approaches restore or rehabilitate ecosystems that previously existed but where their goods and services have been lost (Leadley et al., 2010). The protection of ecosystems can occur through the strengthening of existing protected areas, the establishment of new areas, or developing connections between areas. Protected areas in their own right will not be effective in achieving these purposes if management is weak, if they are highly exposed spatially to degraded land/seascapes, or if they are isolated, fragmented or disjunct from similar ecosystems. Protection of representative ecosystems and services will also only be effective if managers look beyond their immediate sectoral and geographical boundaries and begin to work closely with local resource users and management bodies, and development and government planning agencies to ensure integrated approaches to protected area management (Salm and Mcleod, 2008).

Mangrove Nursery - Photo: Terry Hills

Governance and policy requirements

Many of the management options outlined above for improving adaptive capacity are proven workable solutions to ecosystem conservation, restoration and resilience. However, without the support of robust policy instruments and their effective delivery in practice, many adaptation efforts will be ineffective or unsustained. Good governance and 'ownership' of adaptation will be strengthened by facilitating the input of local communities into policy processes, incorporation of traditional knowledge, and the design of adaptation responses that recognise the diversity of local contexts and aspirations. Participatory processes also offer an opportunity to raise community awareness of the wider implications of local actions and global responses (Vignola et al., 2009).

It is also essential that adaptation measures are integrated into national development plans and programs, and this is already part of an ongoing regional effort. PICTs have variously enacted, stand-alone adaptation policies such as implementing National Adaptation Programmes for Action (NAPAs), or requirements for sectoral agencies to consider adaptation in budget submissions. Other approaches include no or low-regrets policies, which are policies undertaken that have clear benefits with or without climate change threats. e.g. water security and improved access to water and sanitation, or location of infrastructure in non-vulnerable areas (Wilby and Dessai, 2010), and integration policies, where adaptation is integrated into development proposals and planning (King, 2010).

A proposed adaptation framework for biodiversity conservation in the Pacific

An adaptation response framework (Figure 3) has been developed as part of this work to act as a simple tool to conceptualise adaptation decision-making in the conservation context in the Pacific.
The underpinning principle of the framework is to highlight that any adaptation response will not occur in isolation, and will necessarily involve a range of stakeholders, including local communities, resource users, decision-makers, scientists, practitioners, and funding bodies acting across a range of spatial and temporal scales. Furthermore, the adaptation approaches suggested in the framework have their roots in more traditional concepts of conservation, sustainable development, awareness raising and integrated planning and management. There is therefore a body of knowledge that can be immediately drawn from existing initiatives across the region that seek similar outcomes for livelihoods and ecosystems.

The effectiveness and sustainability of adaptation responses is therefore enhanced by this knowledge. The framework allows the following broad recommendations for adaptation responses to be made:

Where ecosystems are highly vulnerable to climate change as well as under stress from non-climatic impacts CONSERVE AND ADAPT:

- Adapt with protection of any healthy ecosystems, and restore degraded areas where possible;
- Reduce human pressures, including through developing alternative incomes/livelihoods;
- Reduce human exposure to climate shocks by protecting and strengthening natural defences, and implementing resource management practices that support ecosystem resilience and recovery (i.e. eliminate destructive practices and over exploitation, and protect keystone species);
- Reduce invasive species stresses by reducing or eliminating established populations, preventing new introductions, followed by restoration of native biodiversity; and
- Improve resource management and economic development planning through institutional strengthening and integrated planning across sectors.

Where ecosystems have low vulnerability to climate change, but are under high stress from non-climatic factors SUSTAINABLE NATURAL RESOURCE MANAGEMENT:

- Adapt with protection of any healthy ecosystems, and restore degraded areas where possible;
- Reduce human pressure by developing alternate incomes/livelihoods;
- Reduce invasive species stresses by reducing or eliminating established populations, preventing new introductions, followed by restoration of native biodiversity;
- Ensure sustainability of resources through improved management and zonation; and
- Enhance economic development planning through institutional strengthening and integrated planning across sectors.

Where ecosystems have both low vulnerability to climate change and low stress from non-climatic factors REFUGIA:

- Protect healthy ecosystems as refuges for habitat, and the provision of services to aid in the recovery of degraded ecosystems;
- Build connectivity with degraded / linked ecosystems to allow species migration or dispersal;
- Monitor and assess species, habitats, and ecosystems, for resilience to climate change impacts in the absence of non-climatic factors; and
- Prevent introduction or spread of invasive species through strengthening bio-security.

Where ecosystems have high vulnerability to climate change and low stresses from non-climatic factors LEARNING:

- Protect as monitoring sites for climate change impacts in the absence of non-climatic factors; and
- Prevent introduction or spread of invasive species through strengthening bio-security.

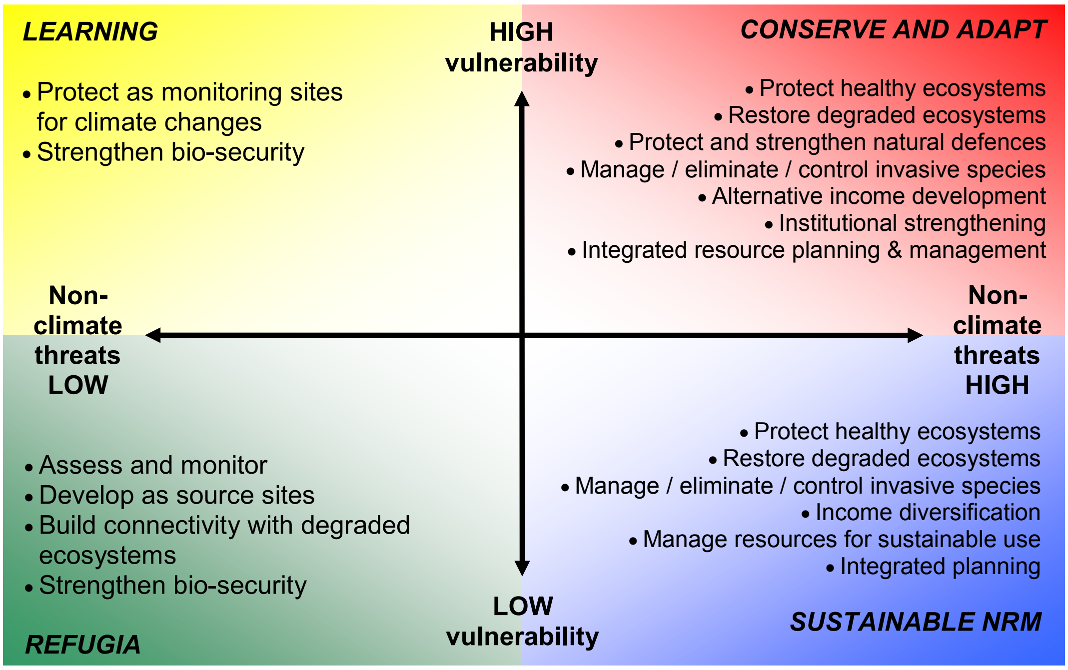


Figure 3: Proposed adaptation response framework for the Pacific

Notes: The framework represents any ecosystem type, or a group of linked / coupled ecosystems in a given area. For example this could be a series of linked coastal ecosystems including mangroves, sea grass beds and coral reef ecosystems. The framework allows for basic determination of adaptation response required for the range of ecosystem status and levels of threat from climate change; NRM – Natural resource management.

4 Ecosystem-based Adaptation in the Pacific

There is an increasing level of interest in the capacity of ecosystems to help buffer human development from climate change, particularly in developing countries where natural capital forms a larger proportion of wealth. For example, in its 2010 report 'Natural Hazards, Unnatural Disasters' the World Bank recommends three top spending areas for disaster prevention as early warning systems, critical infrastructure and environmental buffers (World Bank, 2010:18).

Restoration of vegetation in Samoa. Photo: Terry Hills

The concept of EbA is not embedded within the discussions under the United Nations Framework Convention for Climate Change (UNFCCC) but is within the Convention for Biological Diversity (CBD): "Adaptation that integrates the use of biodiversity and ecosystem services into an overall strategy to help people adapt to the adverse impacts of climate change" (CBD, 2009). Hence, the primary beneficiaries of EbA are people rather than the local ecosystems. While there is overlap between these two groups of beneficiaries, discussion on EbA within this report has been separated from discussion of biodiversity conservation-focussed issues because the relationship between biodiversity and ecosystem services is complex, the main actors are different and also the objectives of the conservation community and the development community are typically different.

There is growing consensus that using natural capital is an important part of 'climate proofing' human development. However, compared to the other forms of capital, investment in these areas of adaptation represents a low proportion of adaptation activity, in the Pacific and elsewhere (Pramova et al., 2010). Hence, there is a need to understand to what extent EbA is living up to its full potential in the Pacific context and if not, identify and clear the obstacles to delivering on this potential. Based on the consultations and analysis undertaken as a part of this study (see Section 5), a key barrier to the uptake of EbA in the Pacific is likely to be awareness of practical options which are suited to the local context.

There is a significant amount of information available on the role of particular ecosystem services in a specific development context scattered across the academic literature. However it is difficult to find central resources that pull information together into a single volume, and even more difficult to find such resources that would be suited to the specific development and climate context of PICTs. Importantly, decision-makers in planning and finance institutions in the Pacific need to be convinced that 'environmental infrastructure' is capable of meeting their adaptation objectives. This will require frank communication on the applicability and limitations of EbA options against the 'hard' infrastructure alternatives so that direct comparisons can be fairly made. Consequently, this document (and the associated Toolbox) have been framed to enable consideration of EbA against a suite of other alternatives.

Additionally, this information is presented with an acknowledgement that EbA is not the best adaptation solution in all contexts, but has more potential to be used as part of the solution to climate change vulnerability in the Pacific than is currently reflected within adaptation planning and practice.

The valuation of ecosystem services in the context of EbA

The ability to effectively communicate the relative advantages of EbA against alternatives will be critical to fully realizing the full potential of EbA in the Pacific Island context. An important part of this communication will be through the valuation of ecosystems services through economic instruments such as cost-benefit analysis. In selecting the most appropriate method for ecosystem valuation, there are a range of options which can generally be classified as 'direct market methods', 'revealed preference methods', and 'stated preference methods'. These are summarized in Table 3. It is worth noting that the different valuation methods can elicit different results when examining the same service, hence it is important to take the method into consideration when extrapolating to policy decisions. Additionally, studies such as meta-analyses seek to assimilate the results of several studies (each of which often use different methods) and generally account for these methodological differences to examine how they affect results.

Table 3: Economic methods used for ecosystem service valuation

Direct Market Methods	
Market price based approaches	• The market price can be taken as an accurate reflection on the value of commodities.
Cost based approaches	• Based on estimations of costs expected to be incurred if the ecosystem service benefits were recreated artificially.
Production function based approach	• Estimates how much a given ecosystem service contributes to the delivery of another service/commodity which is traded on an existing market.
Revealed Preference Methods	
Travel cost	• Estimates the demand for the resource based on the fact that recreational activities are associated with a cost.
Hedonic pricing	• Uses information about the implicit demand for an environmental attribute of marketed commodities.
Stated Preference Methods	
Contingent valuation	• Uses surveys to ask people to state their willingness to pay to increase the provision of an ecosystem good or service.
Choice modelling	• Models the decision process of an individual, given alternatives, with and without shared attributes of ecosystem services.
Group valuation	• Combines the above two methods with a deliberative process (from political science) which can account for pluralism, incommensurability, non-human values or social justice.

The value of both subsistence and commercial activities should be included in cost-benefit analysis. In 2007, PNG represented 12% of coastal commercial fishing in the Pacific but 27% of coastal subsistence fishing.
Photo: William Cross

Potential EbA options in the Pacific context

Based on the development, ecosystem and climate change contexts across PICTs, a set of EbA relationships have been outlined below. In each case generalized information is presented on the current state of knowledge, advantages and disadvantages when compared with 'conventional' adaptation alternatives such as hard structures. Conceptualising the complex relationships that underpin EbA can be difficult, so illustrations have been used in this section (and in the Toolbox) to support decision-makers in their efforts to consider the relevant issues that underpin each of the EbA relationships described. It should be noted that there are other EbA relationships that have not been explored as a part of this study as they have been dealt with comprehensively as a part of other efforts (such as within the Food and Agriculture Organisation's 'Pacific Food Security Toolkit on Building Resilience to Climate Change for Root Crop and Fishery Production - 2010' or the recent guide on Catchment Management and Coral Reef Conservation by Wilkinson and Brodie - 2011. Additionally, descriptions of EbA relationships have not been described where there are still significant unknowns associated with the relationship, such as the role of coral reefs as a bioshield; there is some evidence that under certain conditions the presence of a reef could worsen storm surge impacts (Mukherjee et al, 2010).

COASTAL VEGETATION AND STORM SURGE/CYCLONE PROTECTION

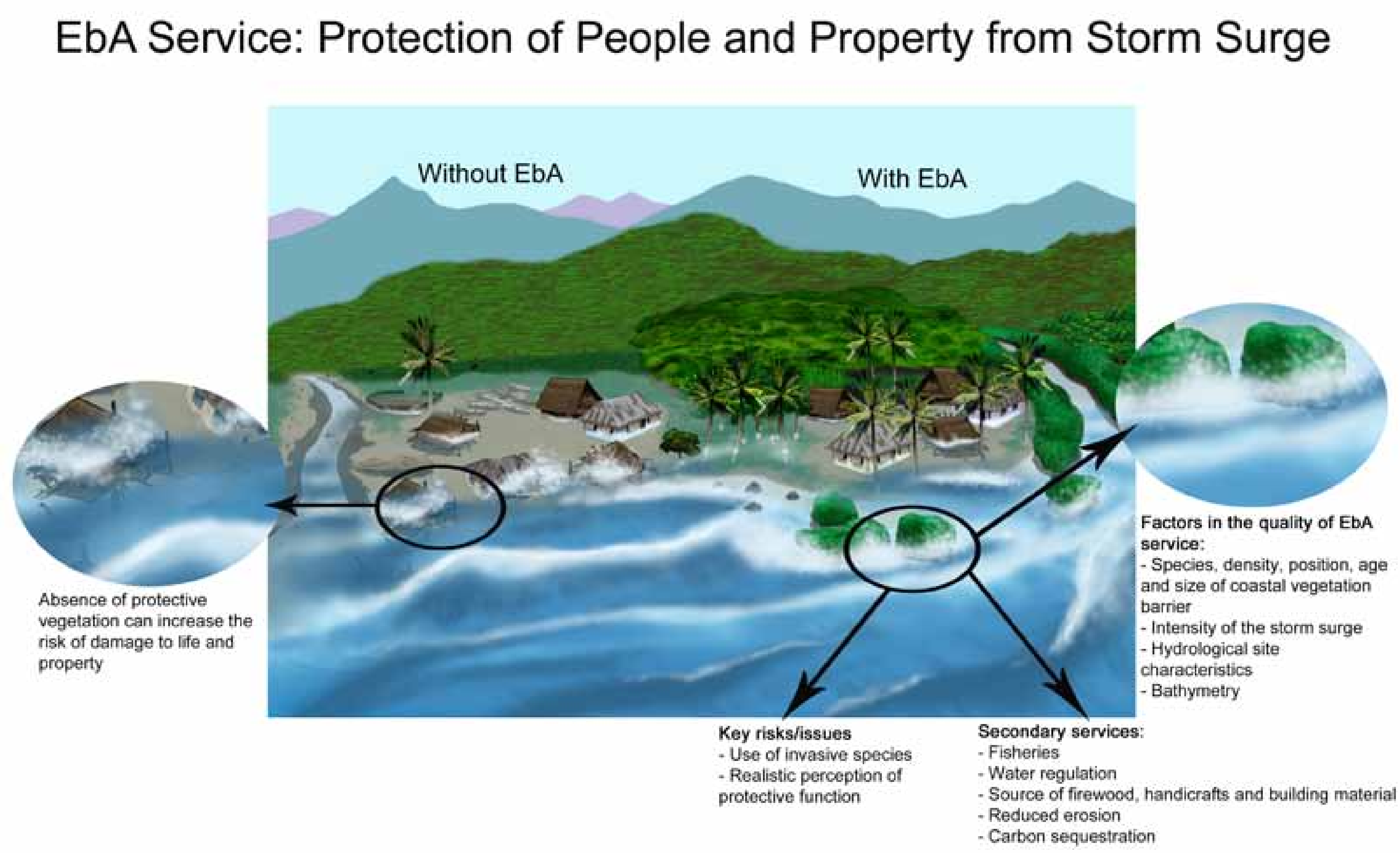
Protection and restoration of natural defences such as mangrove ecosystems can play a vital role in coastal protection and Disaster Risk Reduction (DRR). There are two main EbA functions that are relevant to coastal vegetation: reducing coastal erosion from storm surge/cyclones and protection of coastal inhabitants from loss of livelihoods and life - the 'bioshield' function. Illustrations 1 and 2 help to describe the differences between these functions and the issues that underpin their effectiveness, all of which are further elaborated within the toolbox.

In order to understand the potential role of ecosystems in protecting coastal areas from surge and cyclones when compared to ‘hard resilience’ alternatives, it is firstly necessary to examine the objectives of the many different forms of coastal defences. One of the most common typologies for coastal adaptation approaches was proposed by the IPCC’s Coastal Zone Management Subgroup(1990), as follows:

1. Protect: defend vulnerable areas, especially population centres, economic activities and natural resources

2. Accommodate: continue to occupy vulnerable areas, but accept the greater degree of flooding by changing land use, construction methods and/or improving preparedness

3. Retreat: abandon structures in currently developed areas, resettle inhabitants and require that new development is set back from the shore, as appropriate.



The selection of technologies that sit under these three categories (e.g. sea walls, sea dikes, closure dams, wetland restoration, flood proofing, managed realignment, coastal setbacks) needs to be guided by the local objectives(likely to be defined by adaptation planning in this case) and resources required across the full life cycle of the technology.

In relation to the bioshield function, there are many lessons from the study of tsunami impacts that are transferable to storm surge - both being long-period waves. Doubts in relation to the influence of vegetation compared to other factors such as topography, bathymetry and distance from the shore (Mukherjee et al, 2010) suggest that a diverse approach to disaster risk management is preferable to a single ‘bioshield’ solution and that the precautionary principle should be applied.

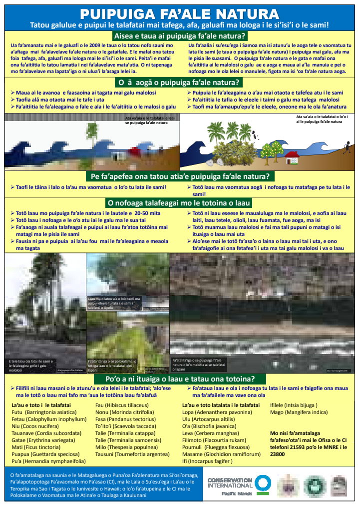
For effective and long term outcomes it is suggested that the emphasis of wetland restoration programs should be on the restoration of ecosystem function in the local hydrological context, rather than just planting the target number of seedlings. While programs focussed on ecosystem function are more complex to design and implement, this is preferable given the large failure rate in restoration programs and the additional livelihood benefits of a more rigorous approach. Experience from projects in the field provide guidance on avoiding the ‘pitfalls’ in mangrove restoration programs, including species selection, hydrological considerations and rehabilitation design. Additionally, it should be noted that the use of bioshields in coastal protection can illustrate the tradeoffs between ecosystem service function and biodiversity. For example, there are instances in which bioshield plantations have displaced native ecosystems in many areas; exotic *Casuarina* spp plantations have been promoted as a better alternative to native species.

SLOPE VEGETATION AND LANDSLIDE RISK REDUCTION

Likely increases to the intensity of precipitation and/or extension of the rainy season under new climate regimes creates increased potential for landslides in areas with steep slopes, particularly where vegetation has been removed. A number of studies have been undertaken to assess the nature of this relationship, and the results from these studies offer EbA opportunities for areas already affected by landslides and those that are likely to be affected in the future.

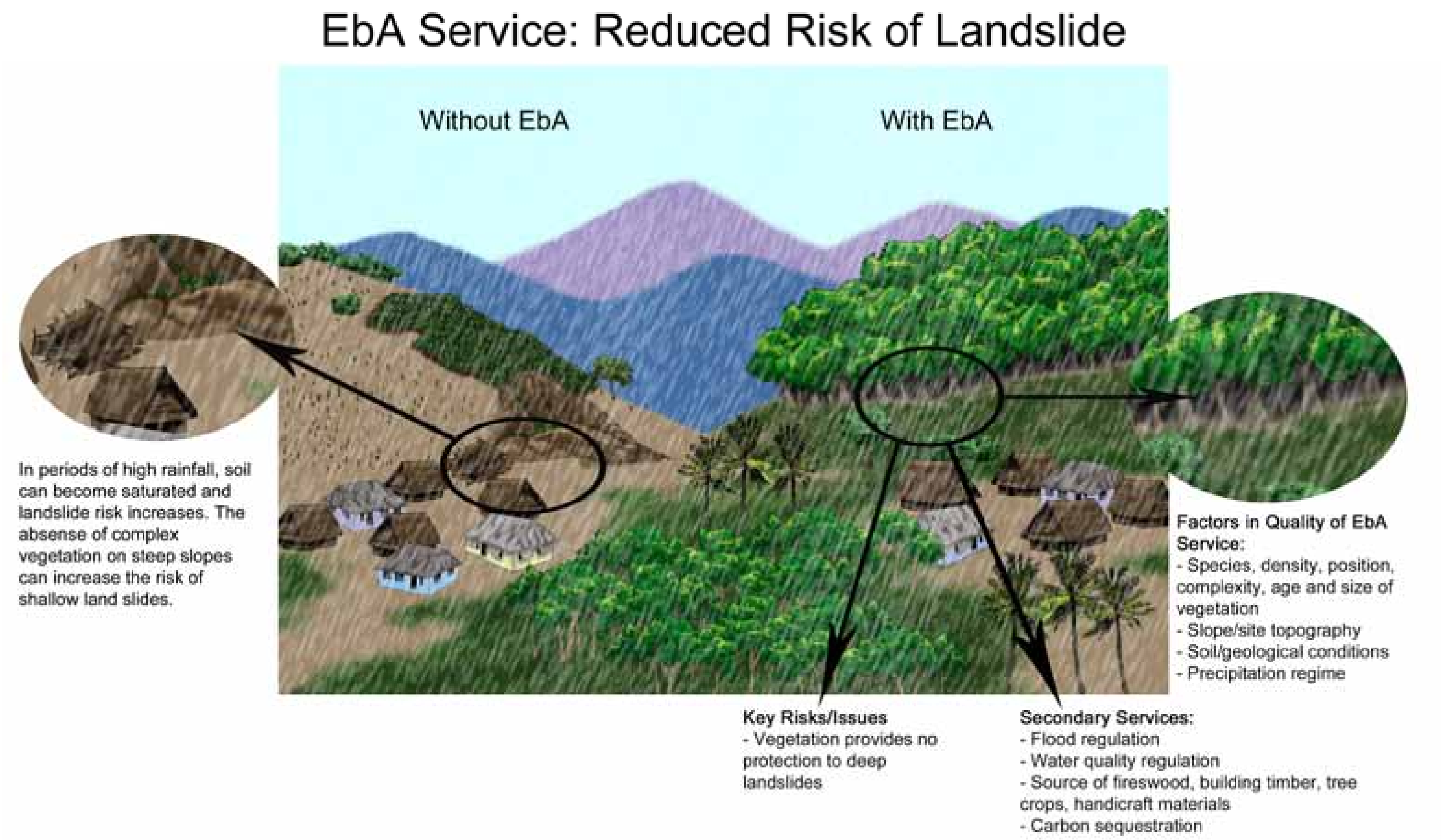
The two key characteristics of vegetation that define this stabilization function are 1) the ability of the vegetation to modify the soil moisture regime through evapotranspiration processes, and 2) providing root cohesion to the soil mantle (Siddle, 2008). For the first function, when large and high intensity storms occur during drier conditions, the deep roots of woody vegetation serve to dry the soil at greater depths compared to shallow-rooted vegetation (McNaughton and Jarvis, 1983). The second function makes a more significant contribution to slope stability in a number of different ways: in shallow soils, tree roots may penetrate the entire soil mantle and anchor the soil into more stable substrate, dense lateral root systems in the upper soil horizons form a membrane that stabilizes the soil and larger tree roots can provide reinforcement across planes of weakness (Siddle, 2008). Both functions have a particular implication in cases where woody vegetation on sleep slopes is removed for the purposes of agricultural production, where such risks are likely considered, but the short term benefits associated with land conversion commonly outweigh the risks of erosion.

Box 3: Ecosystems and Disaster Risk Reduction



Following the tsunami in Samoa in 2008, a campaign was established by Conservation International and the Kulunani Urban and Community Forest Program to encourage the establishment of 'bioshields'. This was an awareness raising program that encouraged communities to both avoid cutting down coastal trees and forests, and also plant native and useful trees and shrubs on the coast. Importantly, the guidance suggested the use of specific buffer species (i.e. planting for the first 10 metres) and secondary species to plant from 10-50 metres. Such resources are a strong example of low cost community education in circumstances where there is an extremely strong awareness of coastal vulnerability. While tsunamis are not linked to climate change, there are some clear lessons relating to perception of risk and associated 'windows of opportunity' for adaptation action. The challenge for EbA in the disaster context is to encourage such activity without the additional incentive of a recent disaster event.

The policy and management implications of this relationship are that more diverse vegetation regimes should be applied to reduce risk in areas of agricultural production that are vulnerable to increased 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 intensity of rainfall events is expected.



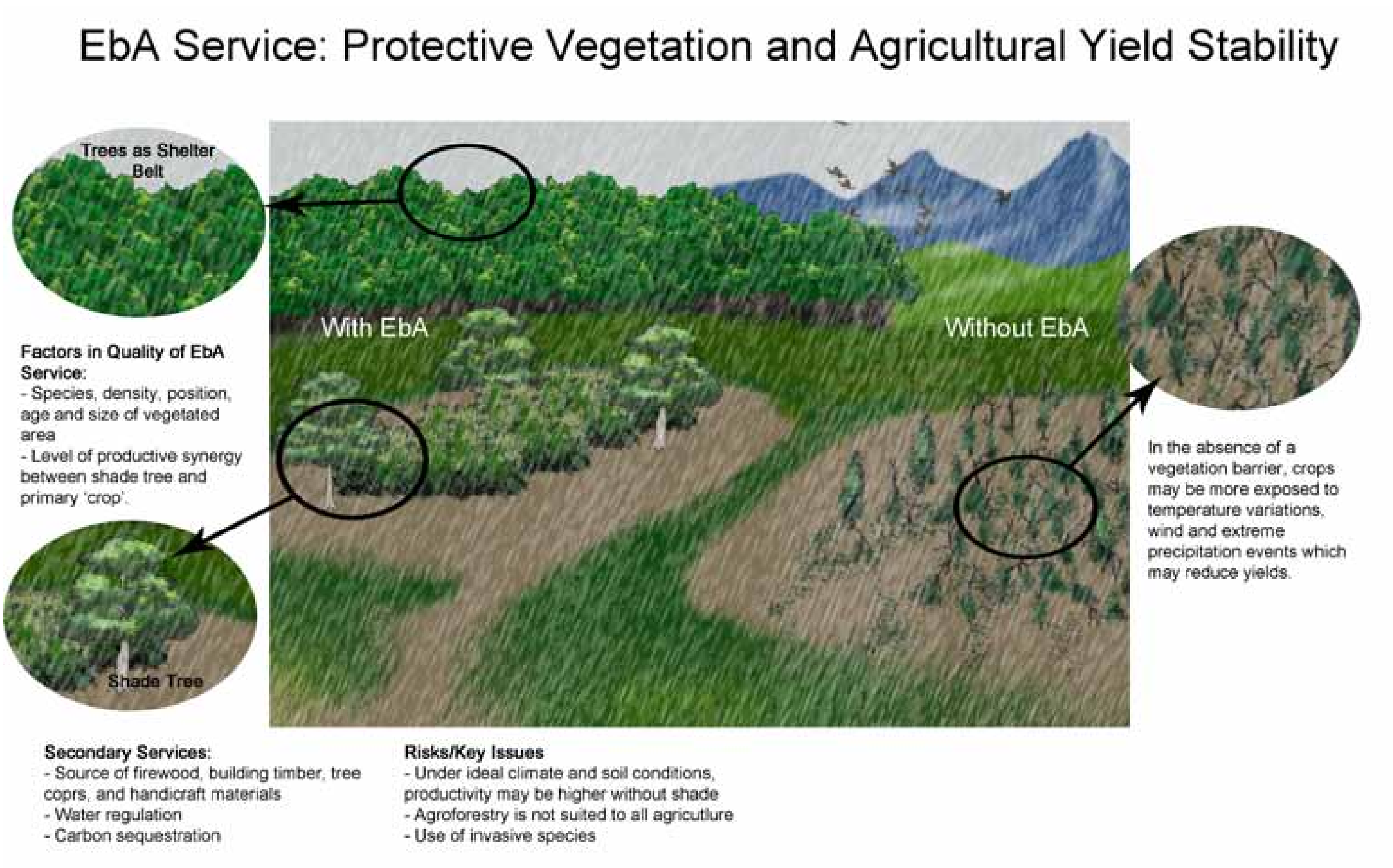
There is some generalized guidance on the relationship between vegetation and landslide risk that may be useful in the context of climate change adaptation. For example, Siddle (2008) suggests that removing woody vegetation on slopes exceeding 40 degrees should be avoided, and in concave slope depressions (hollows) that accumulate subsurface water. As with consideration of all of these EbA functions, local conditions need to be considered ahead of such 'rules of thumb'.

SEAGRASSES AND REDUCED SEDIMENTATION FROM FLOODS

While sedimentation is one of the key causes of seagrass decline, the removal of sediment and prevention of sediment re-suspension is the key ecosystem function of seagrasses relevant to EbA. The potential for seagrass communities to provide these services is strongly defined by the threshold at which the sediment removal function is inhibited, and mortality occurs i.e. where the rate of sediment deposition is faster than the ability of the seagrass to grow through it, plants will die. In the Pacific, increased turbidity associated with increased likelihood of storm events and the availability of sediment from shifting cultivation means that sediment management in coastal areas could be a significant focus of EbA efforts. Due to the ability of seagrasses living near the mouth of rivers to recover from sediment burial, there is low vulnerability to this threat. Structurally smaller species will be more vulnerable to the impacts of sediment deposition as a small change in sediment profile will cover or erode them - however some of the smaller species eg. *halophila* spp are generally much more dynamic and will re-establish more readily which may counter this vulnerability. Additionally, it should be noted that the ephemeral nature of tropical seagrasses makes such EbA applications extremely difficult.

AGROFORESTRY AND AGRICULTURAL YIELD STABILITY

Agricultural yields will likely be maintained in mono-cropping operations when the precipitation and temperature regimes are maintained within optimal growth parameters. However, in cases where increased variability is predicted, farmers will need to find techniques that are increasingly robust. Techniques are considered 'robust' when they maintain stable yields across a wider variety of climatic conditions.



One of the ecosystem-based techniques that help to maintain yields across a wider range of environmental conditions is through agroforestry. In the case of coffee production, for example, shade trees provide a number of yield stabilizing functions that are relevant to climate change, as follows:

- Decreasing air temperatures (3-4 °C)
- Decreasing wind speeds
- Increasing air humidity
- Protecting flowers from intense rainfall
- Avoids large reductions in night temps (reduced frost)

However, it should be noted that these advantages are crop and condition specific. For example, the utility of shade management in coffee production is also dependent on the quality of the soil; in 'good' soil and at ideal elevations for coffee production, too much shade may reduce productivity.

MANGROVES AND ACCOMMODATION OF SEA LEVEL RISE

One of the simplest methods to establish inundation estimates from sea level rise is by matching potential rise against existing topographic data, such as through the use of Digital Elevation Models. However, there are two possible situations under which topographic data may not be useful for inundation estimates. First, sea level rise redistributes sediment, causing the creation of more wetlands and tidal forest areas rather than the complete inundation of vast low-lying areas. Second, increased precipitation could a) increase sediment loads from the mountains causing sufficient land aggradation that offsets sea level rise downstream and b) increased river discharges create sufficient back pressure that mitigates stochastic tidal inundations. However, these possible effects depend on ensuring there is minimal human disturbance to the mangrove and upland watershed forests.

Based on the typologies of coastal adaptation described above, mangrove protection and restoration in the context of sea level rise is best characterized as an 'accommodation' option, although in cases where the conditions, including sediment budget and the absence of a barrier are suitable, upward migration could also be possible, which fits within the 'protection' category of climate adaptation.

Further, the potential of wetland ecosystems to help protect coastal communities from the impacts of sea level rise is influenced by the extent to which the local economy is dependent (indirectly or directly) on the local ecosystem services. To retain these services under sea level rise, the mangrove systems must have the capacity to migrate and the conditions for migration should be established.

While it is possible that wetland ecosystems can make a contribution to maintaining coastal livelihoods under sea level rise in Pacific Island Countries and that sea level rise can be accommodated within wetland restoration and protection programs, there is not specific guidance on the conditions under which these functions can be reliably integrated into coastal adaptation plans so such work is still considered experimental. However, given the range of other benefits of mangrove ecosystems, restoration and protection programs provide a broad set of functions which can be used to justify investment in most planning scenarios.

FLOODPLAIN AND RIVERINE VEGETATION AND REDUCED FLOOD DAMAGE

Floods rise following heavy rainfall, when the volume of runoff delivered to river networks exceeds the capacity of the system. Riverine vegetation has the potential to reduce downstream impact from flooding, and offers hydraulic resistance which delays and reduces flood impact. Creating such delays, when combined with early warning systems(EWS), can be an effective way of saving lives and property in areas of high risk of flash flooding. For example in Nadi, Fiji, flash flooding is common and the existing EWS is able to give 1.5 hours of warning. Each additional half hour in addition to this is estimated to save FJD40-50 Million.

The capacity of vegetation to delay and reduce the total volume of flood waters is dependent on a range of characteristics, including the level of soil saturation before the event. This function is commonly considered within urban planning and various models are available to predict responses. A number of studies have attempted to quantify this relationship based on observation of response under real flood conditions. Specifically, a study in the River Luznice Floodplain in the Czech Republic compared the performance of three floodplain segments (one preserved and two heavily transformed) and it was estimated that the peaks were delayed by two days due to the floodplain vegetation.

5 Needs analysis

Evidence of linkages between climate change adaptation and conservation planning in the Pacific

The presence of explicit linkages between climate change adaptation and biodiversity conservation planning suggests that there is clear awareness of the opportunities in this area. However where such linkages have not been articulated in key strategic documentation this suggests that either, a) such opportunities do not exist, b) such opportunities are of a relative low priority or c) that there is no awareness of these opportunities. This section explores the level of articulation of these linkages within planning and programming in the Pacific.

While various species and ecosystems are predisposed to greater levels of vulnerability and threat from externalities and climatic stressors, the quality of governance also influences vulnerability. National policies can either protect and buffer ecosystems so they continue to provide goods and services, or increase their exposure to external threats, and ultimately threaten ecosystem service provision. The loss of ecosystem services, whether through natural processes (e.g. natural disaster) or anthropogenic impacts, is a threat to national sustainable development and is therefore of fundamental importance at a policy level (Vignola et al., 2009).

Climate change poses unique challenges to PICTs for a range of reasons (Section 2), and the impact of ecosystem service losses will be compounded by the high numbers of poor communities who depend directly on them for subsistence and livelihoods. Across the region, climate change is not systematically embedded in environment and conservation policies at national level. Additionally, the mainstreaming of climate change across all sectors is itself only at an early stage, and largely driven by recent regional level instruments (Kinch et al., 2010).

National responses to the challenges of climate change adaptation are supported by the inputs of regional institutions, as well as multilateral and bilateral donors. Given the number of PICT governments with capacities and resources that are disproportionately low when compared to their vulnerabilities, the coordination of these inputs is a critical effort in sharing lessons and avoiding duplication. There are a number of fora dedicated to such efforts, including the PCCR.

Additionally, regional and national level policy frameworks focused on addressing the risks associated with natural disasters (e.g. disaster risk management and reduction policies) are increasingly common. The cornerstone of disaster risk reduction (DRR) is reducing the vulnerability of communities to hazards by improving the ability to anticipate, resist and recover from their impact (Hay, 2009, Mercer, 2010). The synergies with climate change adaptation (CCA) are clear, but until recently DRR policy-making has largely occurred in isolation of CCA. Many PICT governments now recognise the role DRR can play in reducing the adverse impacts of climate change (Hay, 2009). Thus, where approaches to DRR and climate change mainstreaming have converged across the Pacific, these approches have drawn heavily from DRR tools, or are embedded into existing DRR policies, or within new policies that seek to integrate both fields (Hay, 2009). This convergence of policy responses to immediate (DRR) and predicted future climate events (CCA), typifies the Pacific region's policy framework for climate change. A summary of the policy initiatives for climate change at the regional and national levels are outlined below.

Linkages between adaptation and conservation in regional policy

Regional policy initiatives are significant in their coverage and commitment by PICT governments. These initiatives form the framework on which national policies for climate change are built, are supported by global organisations, and can be used by national governments to leverage technical and financial support (Hay, 2009, Ellison, 2009). Regional policies and agreements are therefore comprehensive and well supported.

While the *Pacific Islands Framework for Action on Climate Change, Climate Variability and Sea Level Rise (2000-2004)* was the first major framework for the region on climate change, the policy framework that first created momentum for serious consideration of climate change as a priority for regional stability, integration and economic cooperation was the *Pacific Plan* of 2005. The third objective of this plan explicitly recognised the links between climate change, vulnerability and the environment.

Subsequently, the *Pacific Islands Framework for Action on Climate Change (2006-2015)* discussed ecological fragility and included an objective(4.1) that called for the consideration of environmental risk within capacity building efforts to assess risks and effects of climate change. More recently, the *Pacific Regional Environment Programme Strategic Plan (2011-2015)* includes two discrete targets that link ecosystems, climate change and biodiversity: one that calls for efforts to mainstream adaptation (including ecosystem-based approaches) in development plans (CC 1.1) and a second that calls for examples of EbA in PICTs (BEM1.1).

Linkages between adaptation and conservation in national policy

The formulation of robust climate policy frameworks at the national level has occurred at varying speeds due to resource constraints (e.g. lack of external support), data availability, funding mechanisms, concurrent/competing project priorities, and instances where climate change has not been considered explicitly important (SPREP, 2009, Hay, 2009). In addition, prior to the endorsement of The Pacific Plan there was little consideration for climate change in national level policies. Nevertheless, national climate change adaptation policies now either exist in their own right, through DRR, or are only recently being mainstreamed across all sectors.

In relation to conservation planning in the Pacific, there is commonly overlap and conflict between executing agencies and policies, out-dated or ambiguous policy, weak environmental protection and enforcement, and a lack of regulation, guidance and provision for environmental impact assessments. However, despite these general national-level policy shortcomings governing biodiversity and the environment, various countries have achieved some level of integration of climate change into national conservation policies, including the following examples:

- In Niue, where a ‘one budget’ approach to climate change adaptation has been established to ensure integration across all jurisdictions.
- In the Federated States of Micronesia (FSM), where the National Sustainable Development Strategy (NSDS) is the main mechanism for addressing adaptation and which includes biodiversity conservation issues. FSM also linked their NAPA and NBSAP processes.
- In Tonga, Vanuatu and the Cook Islands where integrated DRR and CCA policies have been developed and to some extent accommodate ecosystem issues.
- In Fiji, where an implementation plan for their NBSAP was developed which integrated a number of emerging issues, including climate change. Tuvalu’s NBSAP also includes climate change impacts.

Clearly, the approaches used to develop this integration are widely varied, and depend heavily on the local political context, including the size of the bureaucracy. However, while it is difficult to be prescriptive there is significant potential for the sharing of experiences across PICTs. Other mechanisms that could potentially be used to integrate climate adaptation and conservation include: National Environmental Management Strategies (NEMS), National Resource Inventories (NRIs), island biodiversity review processes and State of the Environment Reporting(SOE).

From these examples, it can be concluded that there is a growing awareness in the Pacific Islands in the opportunities presented by integration of climate change adaptation and conservation planning, and that barriers to integration of these two disciplines should be addressed to ensure that a) those without relevant strategies are able to develop them, and b) those with strategies are able to implement them.

Linkages between adaptation funding programs and conservation

One of the key global funding mechanisms for adaptation is the Least Developed Countries Fund (LDCF). The establishment of a National Adaptation Programme of Action (NAPA) is required to be approved by the managers of the LCDF before funding can be released to countries for implementation. As part of this programme, NAPAs have been prepared by the eligible PICT countries Kiribati, Samoa, the Solomon Islands, Tuvalu, and Vanuatu. Each NAPA includes concepts for a range of priority projects and in each country's programme of action there is explicit inclusion of ecosystem-specific initiatives, though they typically represent less than half of the total proposed projects (Kiribati 2 EbA projects out of a total of 10 projects; Samoa 1 out of 9; Solomon Islands 4 out of 7; Tuvalu 2 out of 7; and Vanuatu 2 out of 5).

As can be demonstrated through mechanisms such as the LDCF, there is potential for new adaptation funding programs to undermine regional and national strategy if priorities are not appropriately aligned. This can happen by imposing the objectives of the donor rather than aligning priority support with the objectives of an existing local strategy. However, this is an issue that is increasingly being recognised and managed by donor and Pacific Island governments.

In relation to specific funding resources for adaptation for conservation, while there is currently only limited consideration of ecosystems and biodiversity within adaptation funding windows for the Pacific, this is also now changing. One promising example of this is the inclusion of 'promote resilience to climate change through EbA, protection of biodiversity, Integrated Catchment Management and Integrated Water Resource Management (IWRM)' as an explicit consideration within the Action Plan (2011-2013) of the Pacific-EU Joint Initiative on Climate Change, discussed in Vanuatu in early 2011.

However, the absence of specific conservation criteria in adaptation funding windows should not be considered as a barrier to accessing funding resources for EbA; where the value of EbA can be demonstrated in terms of development outcomes, such approaches should be part of 'mainstream' adaptation funding applications.

Constraints to linking adaptation and biodiversity conservation policy

While there are instances of isolated activity, a range of constraints exist at national and regional levels that have limited the systematic uptake of climate change in biodiversity policies. However, it is likely that most of these constraints relate to the broader challenges of developing climate policies more generally rather than being specific to biodiversity. Additionally, processes for integrating climate change policy at a regional level seem only to have gathered momentum in the past few years (and since regional agreement of the Pacific Plan in 2005), and not enough time has passed for comprehensive absorption of recommendations and framework action plans at a national level.

Obstacles that have constrained national level uptake of climate policies were outlined in a recent regional institutional analysis (Hay, 2009). These include:

- The lack of a coordinated and harmonised donor funding approach for climate change regionally has resulted in high administrative burden, and complex procedures for accessing and utilising funding;
- Without substantive resources, finances, and technical capacity, PICTs rely significantly on donor funding for climate change policy development. The result is a high dependence on regional frameworks and programs that seek national level outcomes. The frameworks themselves are suggested to be insufficient in coordinating the efforts of many individual government agencies and development partners, and a more systematic whole-of-country approach to both planning and implementation is required;
- The lack of emphasis on bottom-up approaches to climate change adaptation means that communication of climate issues at the local level has been ineffective in shaping decision-making processes for resource-users;

- Local tenure regimes unique to the Pacific are an issue in terms of adherence to, and enforcement of proposed policy actions. Regional and national policies confer significant responsibility to local communities and councils in many instances, while doubts remain around capacities at the local level to fulfil such national requirements within regional frameworks;
- Significant climate data gaps exist for the Pacific. Modelling of projected climate changes, and subsequent policy responses, therefore relies on coarse scale modelling or existing climate variability and extremes;
- Conflicting and often competing environmental management responsibilities are dispersed across multiple agencies and legislative instruments nationally. Such gaps and overlap in responsibility have hampered effective policy development and enforcement; and
- Weak integration of DRR and CCA.

Survey of Information Needs on Ecosystems, Biodiversity and Climate Change Adaptation

Objectives, context and content of the survey
The key objective of the survey was to establish the information needs of the participants of the PCCR, held in 11-15 March 2011 in Niue. The survey was distributed following a short presentation in the plenary of the PCCR, which described the background to the project, the progress to date and the next steps. It is not suggested that the participants of the PCCR are representative of the full client base for this project. However, as participants of the PCCR are nominated leaders for their countries and organizations for climate change, it is suggested that their opinions are worthy of consideration.

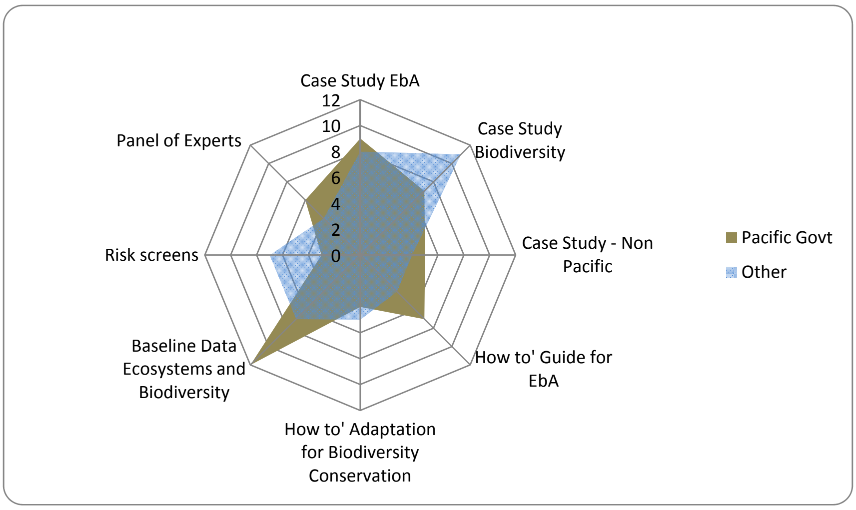
Profile of Respondents
Across the 27 survey respondents, PICT governments made up just over 50% of the total. This was useful in that the needs and demands of the PICT government could then be compared with the needs described by other groups: NGOs, regional organizations, donor, academic and community representatives. There was also a balance of representation according to the level of activity in which respondents were involved. Respondents were variously involved in national, regional and wider international programs, although the majority participated solely on national initiatives. Participants were also evenly spread in terms of their primary focus across adaptation, disaster risk reduction, conservation, and food security sectors.

Results
Storms and cyclones were the climate exposures with the highest level of interest, followed by sea level rise, and droughts were also considered to be a significant issue, but predominantly from the non-PICT government grouping. Fires were considered to be a low-priority by respondents, but given that representatives from PNG and New Caledonia (where ENSO related fires are a significant issue) were not in attendance, this exposure cannot be ignored. In response to the question regarding sectoral impacts from climate change there was a clear interest in livelihoods, but a greater interest in ecosystems from the PICT government representatives, and a significant interest was expressed from the non-PICT respondents in agriculture, health and fisheries.

The next set of questions explored the awareness of respondents to both the potential of ecosystem services to reduce the impact of climate change on people (i.e. EbA), and the threat posed to biodiversity from climate change. There was general acceptance of the threats but over one third of respondents indicated they “don’t know” for the question on the potential of ecosystems to reduce risk for human health and property. In examining the main sources of information that were relied upon by the respondents, there were a number of strong themes. Most respondents accessed information from Council of Regional Organisations for the Pacific (CROP) agencies, communities, national meteorological data, national socioeconomic data, with a reasonable dependency on guidance documents and databases. Next the demand for the different types of information was examined (Figure 4). There was highest demand for baseline data for ecosystems and biodiversity from PICT government representatives and a general interest in case studies.

In response to questions on the preferred format for receiving this information, there was a strong demand for online information across both respondent groups, with some interest in both group training and in hard copy resources.

Figure 4: Count of responses to the survey question, "what kind of information or tools would be most useful on the role of biodiversity and ecosystems in climate change adaptation?"



Discussion and conclusions from the survey

While the survey was based on a very small sample, it did provide some direction on the content and format of the Toolbox. The relatively high 'don't know' response on awareness of EbA potential, suggested that introductory-level resources on the potential for EbA should be included within the Toolbox. Such introductory-level resources were subsequently designed to outline the basic options and context in which they can be applied, the current state of knowledge on the strength of the relationship and direct interested parties toward more detailed technical resources to support detailed planning.

Tools which are relevant to all climate exposures and sectoral impacts known to be problematic in the Pacific are covered in the CD Toolbox. However, based on the current climate risk perceptions from the survey and other sources, the dominant exposures examined in the toolbox will be storms/cyclones, sea level rise and droughts and the impacts focus heavily on livelihoods and ecosystems. One surprising aspect of the survey results was that the issue of ocean acidification was not strongly expressed as a core interest but according to the literature is considered to be a significant threat over the long term.

While only 59% of respondents claimed to have responsibility for conservation issues, 70% of respondents indicated baseline data on ecosystems and biodiversity as critical information needs, and 86% of PICT government respondents. This suggests a strong awareness of the challenges that a lack of baseline data presents, even those which are not directly responsible for conservation work. The relatively high demand for online resources suggests that the material associated with the Toolbox should be linked to one (or all) of the online climate platforms for the Pacific, such as the Pacific Climate Information System(PaCIS), or the proposed Pacific Climate Change Portal. This preference may be related to frustration with CD resources becoming out-dated very quickly. As there was reasonable demand for small-group training, the nature of this demand should be better characterized, existing resources on these areas of training should be converted for the Pacific context and suitable delivery mechanisms identified, including through those Pacific educational institutions that are already progressing similar programs, such as the University for the South Pacific (USP).

Overview of the results workshop

The Results Workshop for SPREP's Pacific Biodiversity and Climate Change: Analysis and Needs Assessment Project was held on 12-13 of May 2011 in Nadi, Fiji. Participants of this workshop were a mix of government representatives from Pacific Island countries, CROP agencies, Pacific academia, UN agencies, donors and NGOs.

Development Break-out Group at Results Workshop. Photo: Schannel van Dijken

The key objective of the workshop was to share the findings of the analysis undertaken over recent months and also to seek feedback on the format and contents of the final products that this analysis informed. Workshop participants were guided through the results of the three background studies undertaken by the project team under this work: “Adaptation Options for Biodiversity and Ecosystems in the Pacific”, “The Potential for Ecosystem-based Adaptation in the Pacific Islands” and a “Needs Analysis for Information on Ecosystems, Biodiversity and Climate Change Adaptation”. Over the course of the two day workshop, participants:

- Noted the vulnerabilities of species and ecosystems in the Pacific to climate change including through the potential for climate change to exacerbate existing non-climate change threats.
- Noted the value in addressing non-climate impacts to ecosystems to build resilience of the system to climate change.
- Noted the contributions of healthy ecosystems to an integrated adaptation strategy.
- Noted the need to take holistic approaches to climate change adaptation, that better considers climate risk in conservation and also integrates Ecosystem-based Adaptation(EbA) across adaptation strategies and in broader national sustainable development strategies and activities.
- Noted the need to have better quantitative information on the potential of EbA in the Pacific(such as cost-benefit analysis), acknowledging that without this information it is difficult to link EbA into the broader adaptation planning process.
- Recognised the value in considering the integration of climate change impacts in the review of National Biodiversity Strategies and Action Plans (NBSAPs).

6 Managing information gaps

Information needs for linking climate, conservation and development

Understanding the information requirements for work that links climate change adaptation, biodiversity conservation and development objectives is a critical foundation for progressing practical action. Based on the findings in Section 2, there are a number of approaches that can be taken to reduce the vulnerability of species and ecosystems to climate change. Specifically, adaptation should focus on reducing or eliminating exposure to non-climate change stresses on ecosystems and/or enhance adaptive capacity of ecosystems through:

- improving ecosystem connectivity
- ensuring representation of all ecosystem types
- maintaining intact ecosystems with high biodiversity
- identifying species and ecosystems resilient to previous climatic shocks
- undertaking restoration and protection measures

The information requirements for these activities vary greatly, but generalizations can be made for each species or ecosystem group to help guide regional and national data collection and management efforts in relation to both biodiversity conservation and EbA (Table 4 and 5).

Table 4: Information requirements for tools that integrate adaptation into biodiversity conservation planning

Target of Activity	Information Requirements
Individual species	• Targeted vulnerable species could be monitored both for early warning signs of climate change and as empirical tests of predictions; monitor indicator/ keystone species or groups of species, functional groups.
	• Proximity to ecosystem boundaries; use transects to monitor status and movement along elevational gradients.
	• Human use trends, intensity and indirect threats.
Coastal and terrestrial ecosystems	• Where ecosystems have been shown to be resilient to natural disasters, and have minimal human stressors, protect these as refugia and monitoring sites.
	• Monitor human threats (coastal development, pollution); incidence and severity of storm surge; rate of sea-level change and response of indicator taxa; mapping of shoreline heights and locations of overtopping.
Mangrove ecosystems	• Where location conditions are suitable and minimal human stressors, sites should be protected for monitoring and climate change impact studies/assessments.
	• Monitor human threats; SST, ocean colour, temperature, tides, pH level, wave, currents, river flush, salinity, water tempt at different depths, plankton abundance and distribution.
	• Extent, condition and species composition of mangroves.
Montane/cloud ecosystems	• Monitor human threats (hunting, clearing).
	• Use transects to monitor differential response of species to local adaptations and establish monitoring protocols in fragmented montane areas.
Dryland ecosystems	• Monitor human threats, fire and insects.

Table 5: Information requirements for EbA tools

Objective	Relevant EbA Relationships	Information Requirements (see illustrations)
Reduce coastal erosion from wave action and sea level rise	Coastal vegetation and storm surge/cyclone protection	Species, density, position, age and size of coastal vegetation; rate of sea level rise, hydrological site characteristics, tidal regime, size of waves.
Protect coastal inhabitants/ settlements from storm surge and cyclones	Coastal vegetation and storm surge/cyclone protection	Species, density, position, age and size of coastal vegetation barrier; intensity of the storm surge, hydrological site characteristics, bathymetry.
Reduce losses associated with landslides	Slope vegetation and landslide risk reduction	Species, density, position, complexity, age and size of vegetation; slope/topography, soil/geological characteristics, precipitation regime.
Delay flood waters and reduce the total volume of flood waters	Floodplain vegetation and reduced flood damage	Species, density, position, age and size of vegetated area, precipitation regime, hydrological characteristics on site and upstream.
Maintain agricultural yields across a wider range of environmental conditions	Agroforestry and agricultural yield stability	Species, density, position, age and size of vegetated area. Productive (allelopathic) synergy between the shade tree and crop.
Maintain primary and secondary productivity of mangrove systems	Mangroves and accommodation of sea level rise	Hydrological site characteristics; precipitation (direct and on the catchment); vegetation species; rate of sea level rise; presence of natural or artificial barriers; and local sediment budget.

Current status of conservation and biodiversity data

While a wide range of data exists for the Pacific region, there are some significant constraints for region-wide analyses. Biodiversity data is generally dated and often the observation or collection localities are poorly defined and lack geo-referencing. In particular, museum collections are dominated by specimens greater than 50 years old so while these datasets provide an indication of historical distribution, they must be reviewed against current habitat coverage and the species' habitat requirements to assess the likelihood that the data points are still valid.

Habitat coverage maps are typically undertaken at a national level. There are no standardized categories for habitat or ecosystem classification, therefore to combine and compare the vegetation coverage of different countries will involve cross-matching at a more simplified level. For example, lowland forest may be defined by crown texture from aerial photographs, or dominant species from field surveys, but to match them would involve 'lumping' them all into a single category of lowland forest. Terrestrial ecosystems can be grouped into 12 broad ecosystem types, though anthropogenic grassland or agriculture systems are not included. Similarly, marine ecosystems are broadly classified into six types: mangrove, seagrass beds, coral reefs, continental shelf, pelagic, and deep sea. While separate data layers exist and can be obtained for coral reef and seagrass, and mangrove extent can be derived from country terrestrial vegetation layers, a fully integrated Pacific-wide marine ecosystem layer would have to be created by manually combining these different data into a single data set.

Data resources overview

While there are many adaptation-relevant data gaps in the information Pacific, there is also a vast range of existing information that can contribute to decision-making. Table 6 describes some of the key data sets and their function and ownership.

Table 6: Key ecosystems and biodiversity data sets and custodians

Title	Data Category	Content Category	Geographic Scope	Custodian	Access?
Regional Outcomes Database(ROD)	Biodiversity Data	Multi-taxa	Australasia-Oceania	CI	Yes
Cook Is Natural Heritage database	Biodiversity Data	Multi-taxa	Cook Islands	Cook Is govt	Web-source
Important Bird Area (IBA) database	Biodiversity Data	Birds	Fiji, New Caledonia, French Polynesia	BirdLife	No
Global Mammal Assessment	Biodiversity Data	Mammals	Global	IUCN/CI	Yes
Endemic Birds Areas	Biodiversity Data	Spatial Conservation Priorities	Global	BirdLife	Yes
Global Amphibian Assessment	Biodiversity Data	Amphibia	Global	IUCN/CI	Yes
Global Biodiversity Information Facility (GBIF)	Biodiversity Data	Multi-taxa	Global	GBIF	Web-source
Global Reptile Assessment	Biodiversity Data	Reptiles	New Caledonia	IUCN/CI	Yes
Coral diversity	Biodiversity Data	Coral	Pacific	CI	Yes
Pacific Biodiversity Information Forum (PBIF)	Biodiversity Data	Multi-taxa	Pacific	PBIF	Web-source
Invasive Species Database	Biodiversity Data	Invasives	Pacific	IUCN ISSG	Web-source
South Pacific Herbarium database	Biodiversity Data	Plants	Pacific (excluding PNG)	Institute of Applied Sciences USP	No
PNG Plants database	Biodiversity Data	Plants	Papua New Guinea	RBG NSW, PNG NFA	Web-source
Fiji vegetation	Ecosystem data	Vegetation types	Fiji	Fiji Forestry, USP	No
Fiji forest-cover	Ecosystem data	Forest cover	Fiji	Fiji Forest Department	Yes
French Polynesia vegetation	Ecosystem data	Vegetation types	French Polynesia	IRD	No
WWF Ecoregions	Ecosystem data	Biogeography	Global	WWF	Yes
Hotspots & Wilderness	Ecosystem data	Spatial Conservation Priorities	Global	CI	Yes
UNEP Islands Database	Ecosystem data	Biogeography	Global	SPREP	Yes
Fosberg& Mueller Dombois atoll typology	Ecosystem data	Ecosystem type	Kiribati, Micronesia	Unknown	No
New Caledonia vegetation layer	Ecosystem data	Vegetation types	New Caledonia	New Cal govt	No
PNG Land Systems	Ecosystem data	Vegetation x landform	Papua New Guinea	TNC	Yes
PNG Conservation Needs Assessment	Ecosystem data	Spatial Conservation Priorities	Papua New Guinea	CI/DEC	Yes
BioRAP (Rapid Assessment of Biodiversity)	Ecosystem data	Spatial Conservation Priorities	Papua New Guinea	CSIRO/DEC	Yes
FIMS-PNGRIS (Resource Information System)	Ecosystem data	Vegetation types	Papua New Guinea	CSIRO	Yes
UPNG Forest Change	Ecosystem data	Forest cover	Papua New Guinea	UPNG	No
Samoa vegetation	Ecosystem data	Vegetation types	Samoa	MNRE	Yes
Solomon Islands forest classification	Ecosystem data	Vegetation types	Solomon Is	SI Ministry of Forests	Yes
Vanuatu Resource Information System (VANRIS)	Ecosystem data	Vegetation types	Vanuatu	CSIRO	Yes
ReefBase Pacific	Ecosystem data	Marine species and habitats	Pacific-wide	WorldFish	Web-source

Assessment of key data management issues

Data collation across jurisdictions is rarely a straightforward process in the Pacific. In the event that the custodians are willing to share data, data sharing agreements normally need to be established. Some data custodians simply do not wish to share data, or request a significant fee for the usage. In some cases the data simply does not exist in digital form and needs to be digitized from hard copy which can be labour-intensive. However, perhaps the biggest issue with biodiversity and ecosystem data is creation and maintenance of metadata. Without metadata inconsistencies cannot be resolved, changes are not tracked, and the limitations of the data cannot be understood. Even in the simple compilation of mangrove and seagrass data extent for this report, inconsistencies (up to two orders of magnitude) were found in extent of mangrove area and even in EEZ areas by country between ReefBase Pacific website and Ellison 2009. Based on the range of issues, the key points regarding data-driven analyses in the Pacific are:

- Data collation is necessary (by country or by ecosystem), and this requires partnerships and good relations with custodians. Developing these relationships and agreements can take time, and is not always successful. For example vegetation datasets may be under custodianship of forestry departments which simply may not be willing to share with conservation agencies.
- Manual digitizing requires time and money and is often necessary but is rarely adequately budgeted. Similarly, data-cleaning and reformatting can also take time.
- Revision or even creation of metadata is necessary, as error levels can mean some datasets are not useful despite their content appearing to be valuable. Researching the origin and history of the dataset in order to create metadata can also be very time intensive.

Photo: Stuart Chape

Existing monitoring and data sharing efforts

There are a number of existing monitoring efforts that are complementary or directly relevant to this work. Key examples include:

Monitoring the Vulnerability and Adaptation of Pacific Coastal Fisheries to Climate Change
SPC is examining the status of monitoring and research projects on climate change impact on coastal fisheries in the Pacific. The study objectives were the following:

- Review of literature and consultation with experts in the field to identify the information needed to monitor climate change impacts on coastal fisheries.
- Identification of organisations and individuals already working in this field in the Pacific Islands.
- Recommend priorities for data collection and analysis to be initiated by the project.
- Identification of locations and partners for field testing, with a view to developing sustainable arrangements after the end of the project.

Monitoring Database under the Pacific Roundtable for Nature Conservation
There is an increasing amount of effort being placed on information sharing between conservation institutions in the Pacific, and these efforts include sharing performance information. One such effort is under the Pacific Roundtable for Nature Conservation, which seeks to monitor conservation projects in the region and their alignment against the principles that guide the work of the Roundtable - as articulated through the *Action Strategy for Nature Conservation and Protected Areas in the Pacific Islands Region: 2008-2012*. Such efforts seek to avoid duplication of effort and ensure alignment of work with national and regional priorities by sharing project information. Objective 4 of the Action Strategy is to 'manage threats to biodiversity, especially climate change impacts and invasive species', and as such this monitoring framework is a critical foundation for improving the uptake of adaptation within conservation planning in the Pacific - allowing lessons to be shared between relevant parties. However, this monitoring work is project-oriented, and does not cover information sharing on biodiversity/condition data.

7 Introduction to the toolbox for ecosystems, biodiversity and climate change adaptation in the Pacific Islands

The Toolbox on the companion CD comprises a searchable set of single-page overviews of existing tools that are relevant for climate change adaptation planning and which are contextualized/assessed for use in the Pacific. The objective of the Toolbox is to support decision-makers from national to local governments, NGOs and community groups to take a diagnostic approach to adaptation in the Pacific context: matching practical tools with local needs.

Some of the core applications of the tools described within the Toolbox are:

a) building ecosystem and biodiversity considerations into national communications under the UNFCCC.
b) undertaking vulnerability assessments and climate change adaptation planning in areas of high ecosystem service/conservation value.

However, there are a number of other contexts in which the Toolbox will be useful; any situation in which it is desirable to consider the relationship between ecosystems and climate change risk in the Pacific Islands. The common 'starting point' across all of these contexts is to consider the needs of the decision-makers, and to then build the adaptation activity around those needs as well as the available resources will permit. While some of the tools relevant to climate change adaptation do not require specialised scientific knowledge, the majority of the tools will require the engagement of scientists and/or building of local science capacity and identification and engagement of the appropriate skills is a significant challenge.

One of the approaches which helps to embed science into decision-making is the Science to Action framework - See Box 3. In relation to this framework, the Toolbox can help decision-makers to communicate information needs (Tip #1) with scientists as it can help to identify the challenges, understand the options for practical solutions and also learn from the experience of others; forming a solid foundation for productive collaborations that focus on a shared goal.

Box 3: Decision-making Process in the Science to Action Framework

Recognising the importance of informed decisions and the differences between the scientific and decision-making processes, this framework (and the associated guidebook), provide practical tips on how to best bring these worlds together: see tips one to seven in Figure 5. In doing so, this guidebook emphasises the roles of facilitating, synthesising, translating and communicating science to inform conservation action.

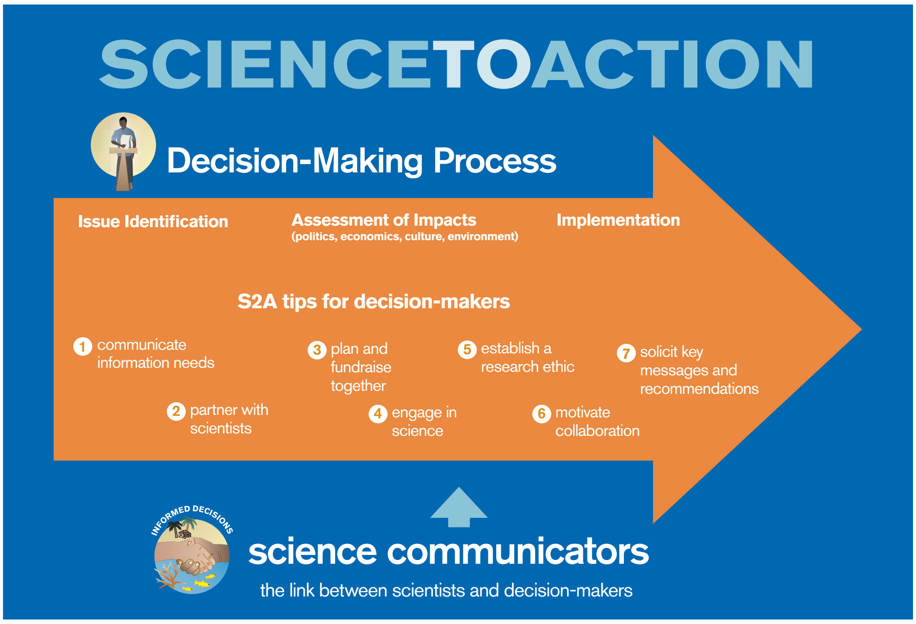
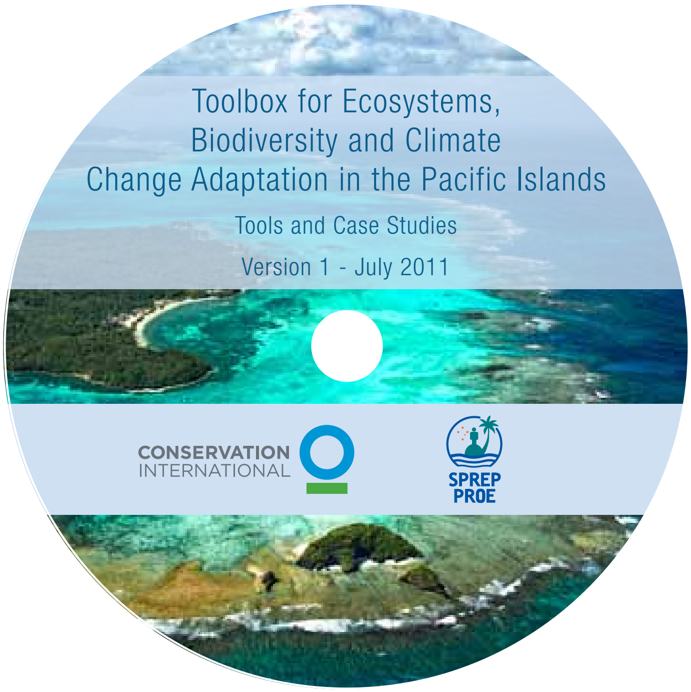


Figure 5 - Decision-making Process in Science to Action Framework
http://www.science2action.org/what-we-produce/typography-mainmenu-27/s2a-booklets/159

In order to best facilitate the communication of information needs between decision-makers and scientists, three categories of tools have been described within the Toolbox:

1. **Tools to build climate resilience of biodiversity conservation in the Pacific:** "What tools are available to help Pacific Island decision-makers build climate change adaptation into their biodiversity conservation planning, and vice versa?"
2. **Tools for adaptation in development:** "To what extent do the existing adaptation tools in the Pacific accommodate climate change impacts to ecosystems/biodiversity and/or EbA?"
3. **Resources on EbA relationships:** "What do we know about the capacity of ecosystems to make people more resilient to climate change?"



Additionally, the toolbox also includes a set of case studies where tools have been applied in a context that is relevant to the Pacific Islands.

During a breakout exercise in the Results Workshops participants were provided with a short design overview for one of the 3 tool categories, sample tool and a set of questions to structure discussion:

a. *Are there other questions that should be added under each type of tool to better describe what the tool is used for and how it is used?*
b. *Are there other tools that should be added to the list?*
c. *Are there ways in which the format / presentation of the tools could be improved?*
d. *Should SPREP offer training and support services on a small set of these tools and, if so, how should these tools be selected?*

Based on rich feedback from this exercise the toolbox was refined in order to better facilitate the quick and easy finding of appropriate tools - for example, respondents were interested in being able to screen tools by comparing inputs against outputs. To further aid easy identification of appropriate tools, a number of searchable data fields have been linked to each tool, for example whether the tool helps to answer any of the following questions:

- *Does the tool help to communicate the key risks to those with capacity to take action?*
- *Does the tool help create an understanding of what the future climate might look like?*
- *Does the tool help create an understanding of what this future climate means for the local 'system'*
- *Does the tool help identify practical adaptation options for those affected by climate change?*
- *Does the tool help to identify effective ways of communicating these adaptation options?*

For convenience, Annex 1 to this report briefly describes each of the tools considered within the CD Toolbox.

Annex 2 is a decision tree which can guide the assessment of EbA potential in a given project or planning exercise. This should be used in combination with the Toolbox descriptions of EbA relationships (Category 3, above).

8 Overall conclusions and recommendations

Conclusions

1. That the risks to ecosystems and biodiversity associated with climate change are not systematically considered within key national and regional adaptation planning exercises (such as National Adaptation Programmes of Action, or National Communications) or conservation planning exercises (such as National Biodiversity Strategy and Action Plans).

2. That the role of ecosystems in improving community resilience is not currently considered to its full potential in adaptation planning and projects, so ‘simple system’ adaptation options are generally preferred: i.e. those solutions which a) treat human vulnerabilities as discrete from the local and regional ecosystems and b) perform single functions according to known, quantitative (e.g. engineering) relationships. This contrasts with EbA which typically offers a range of functions that are delivered with a greater degree of uncertainty.

3. That there is significant potential to:
   a. better make use of ecological infrastructure to build resilience of the people of the Pacific Islands
   b. better consider climate risk and adaptation options within biodiversity conservation in the Pacific
   c. better link conservation and adaptation by taking advantage of efforts to integrate climate change adaptation and disaster risk reduction.

4. That the main barriers to unlocking this potential are:
   a. **Lack of Baseline Data:** Lack of baseline data at national and regional level (and the coordination and sharing of that data) means that it is difficult to compare risks and prioritise adaptation of conservation efforts.
   b. **Lack of Knowledge of EbA functions:** While this report has outlined the current state of knowledge on EbA relationships, the uncertainties in some of the key relationships are too significant to be reliably compared with alternatives as a routine part of adaptation planning so the precautionary principle applies.
   c. **Integration:** Jurisdictional issues associated with departmental responsibilities and global policy for biodiversity conservation, development, disaster risk reduction, and climate change adaptation are a significant barrier to integration.
   d. **Effective Mobilisation of Community Capacity:** While there are many examples of discrete efforts that capitalise upon community interest, knowledge and innovation, scaling up such approaches is less common. These efforts are not linked in a way that enables easy sharing of information on adaptation approaches between analogous contexts across the region.

Recommendations

1. **Building the knowledge base:**
   a. **Pacific Ecosystem, Biodiversity and Climate Change Monitoring and Analysis Program:** A regional effort to improve the information base for linking conservation, development and climate change adaptation should be established. This would be a broad scale ecosystem analysis that targets the information needs of countries and will initially involve the combination of three key sets of information:

    i. Country-level exposure projections established through the Pacific Climate Change Science Program (PCCSP) (and other similar sources)
    ii. Existing species and ecosystem-level data (Table 6).
    iii. The 'vulnerability context' results of this work (including Tables 2 and 4)

   This effort will inform priority efforts for a monitoring program that will establish baseline information and inform the application of the Climate vulnerability - adaptation response framework (Figure 2).

b. **EbA Data Collection and Analysis:** For each of the EbA relationships that are relevant to the Pacific, a series of sites should be identified where either a) a historical climate shock has occurred or b) where existing climate variability is high. Quantitative and qualitative data will be gathered that can then inform improved tools for EbA in the Pacific.
c. **Refine the Toolbox:** Based on feedback from users and tool managers, the toolbox should be refined and integrated into one of the existing or emerging web platforms for climate change in the Pacific.

2. **Taking action based on existing knowledge**:
   a. **Capacity Building Pool for Biodiversity and Climate Change Planning** This would involve the establishment of a 'pool' of capacity building support. Such capacity building sessions could focus on 'live' planning, design or evaluation exercises that would benefit from approaches described in the Toolbox. Examples of potential areas of capacity building support include: integrating climate into NBSAPs, integrating biodiversity into National Communications under the UNFCCC and designing GEF projects.
   b. **Design and Pilot of Community-Based Coastal Zone Monitoring for Climate Change** While the toolbox gives a general introduction to the concepts and limitations of EbA, the complex and site-specific nature of development, ecosystem and climate interactions mean that it is important that specific local conditions are considered before EbA options can be considered. This element would involve the design and piloting a regional mechanism that provides consistent technical advice to coastal communities on EbA options that suit their local context. This could involve information being collected by communities according to a basic guideline, then sent to a regional facility for classification against standards, and targeted, culturally appropriate advice on practical coastal management options could be provided.
   c. **Establish an EbA Rapid Assessment Program for the Pacific** While approaches under concept 2 (b) would be useful for most small community contexts, in larger systems with more complex drivers a greater level of analysis and expertise is required - including site-specific economic assessments of EbA. This element would develop and test a flexible assessment approach based on a modified version of the Rapid Assessment Programme (RAP) methodology currently used for biodiversity assessments: the Pacific EbA RAP. This element would most usefully combine the country-level information available through the Pacific Climate Science Support Program (PCCSP) with the results of an EbA-RAP to deliver an integrated assessment of a range of adaptation options. This element should be founded on a screening of the full climate and conservation project portfolio across the Pacific Islands, to identify key 'decision points' in the project planning process where EbA could be considered.

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Annex 1

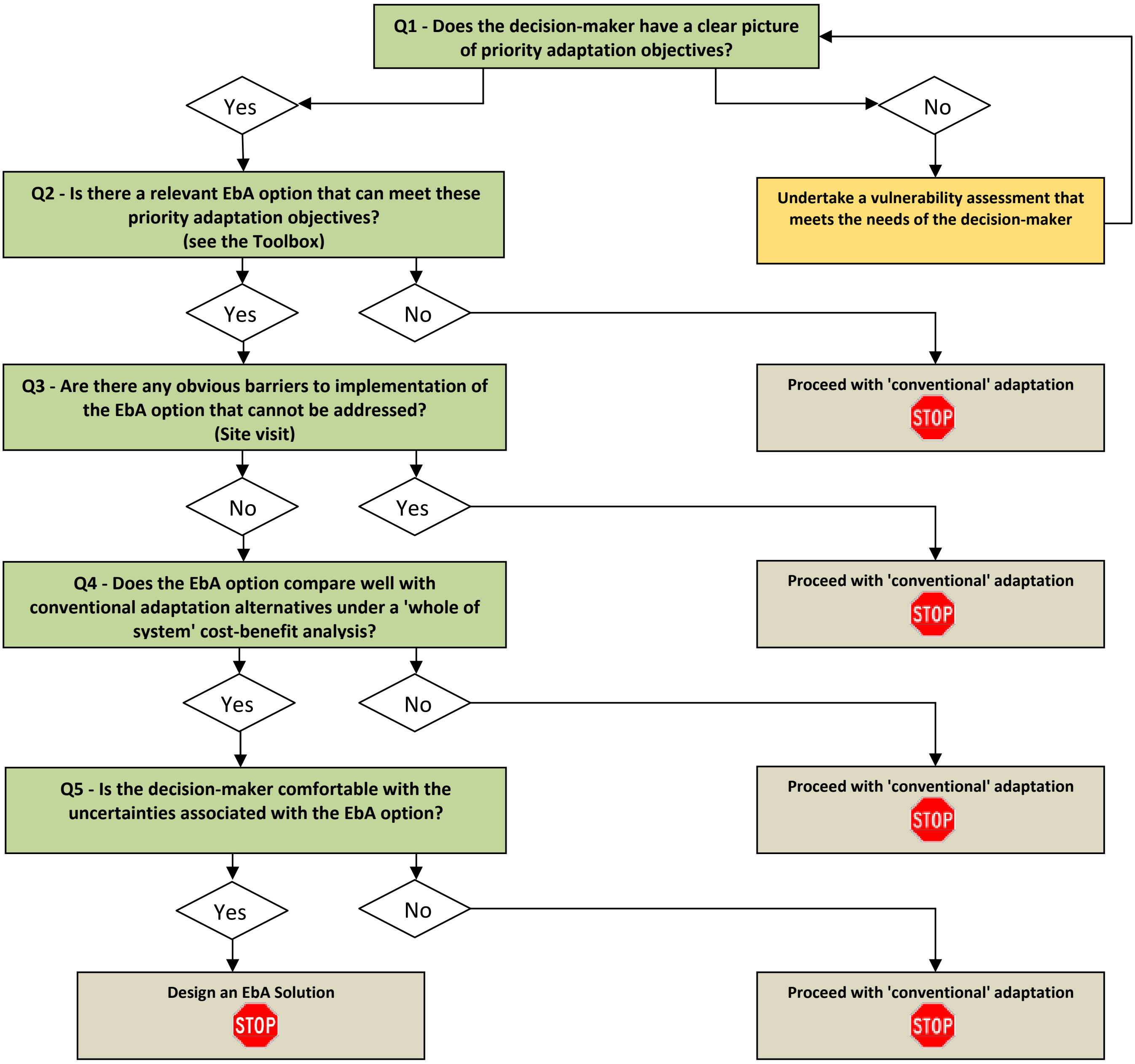
Summary of Tools in the Toolbox for Ecosystems, Biodiversity and Climate Change Adaptation in the Pacific Islands

Tool	Brief Description
CATEGORY 1 - TOOLS TO IMPROVE THE CLIMATE RESILIENCE OF CONSERVATION IN THE PACIFIC	
1A - Dynamic Global Vegetation Models	Dynamic global vegetation models (DGVMs) are computer models that are used to predict how terrestrial vegetation may change due to future climates. DGVMs simulate vegetation growth mathematically using plant processes and externally derived corrections (or 'forcing') from observed changes in land use, atmospheric CO_2, and climate.
1B - Species Distribution Models	Species Distribution Models (SDMs), are used to predict species distributions across landscapes. SDMs are used in decision-making to determine where and when to implement conservation options and to identify threatened species.
1C - Marine Systems Models	Marine Systems Models map patterns and trends, and predict changes in marine systems that interact on large time (from days to millennia) and spatial (from metres to global dimensions) scales. Increasingly marine models are used as tools to support decision-making in assessments of climate change impacts on marine ecosystems, the role of oceans in the climate system, and in fisheries management and conservation.
1D - Degree Heating Weeks	The Degree Heating Weeks (DHW) system was developed by the United States National Oceanic and Atmospheric Administration (NOAA) in 2000 to predict and warn of coral bleaching events. Generally, a DHW value of >4–5 for an area is considered sufficient to result in extensive coral bleaching, and a DHW of 10 corresponds to massive coral mortality.
1E - Invasive Species Management	Across Pacific island countries, invasive species represent the second greatest threat to biodiversity and ecosystem services after land-use change. The actions for invasive species management specified within the Pacific regional guidelines provides a good opportunity for consideration of climate change.
1F - Elevational and Latitudinal Transects	Elevational transects (between lower altitudes and high altitudes) allow studies of population dynamics, and adaptation of life cycles in a species' range within the same locality with similar conditions. Latitudinal transects (between lower latitudes and higher latitudes) allow studies of species range shifts and migrations in response to temperature changes (for example, mapping of the predicted poleward retreat of boreal forests). A comprehensive network of transect studies globally can serve as a vital early warning system for incremental climate changes.
1G - Locally Managed Marine Areas	Locally managed marine areas (LMMAs) across Southeast Asia and the Pacific have arisen as a move away from top-down approaches to protection and management of coastal resources. LMMAs have 5 key objectives: Learning and monitoring, protection of biodiversity, promotion of the LMMA approach, building capacity for learning and implementation, and development of policies to support widespread adoption of LMMAs.
1H - Management Effectiveness Evaluation Framework	In response to the concern that many protected areas around the world are not achieving the objectives for which they were established the IUCN World Commission on Protected Areas (WCPA), developed the Management Effectiveness Evaluation Framework. The WCPA Framework is a system for designing protected area management effectiveness evaluations based around six elements of a site: context, planning, inputs, processes, outputs, and outcomes.
1I - Miradi	Miradi, a Swahili word meaning project or goal, is an adaptive management software program for conservation projects. Using Miradi, the team is guided through a series of step-by-step 'interview' wizards, based on the CMP standards. As the practitioners go through these steps, Miradi helps to define the scope of the actions, and design conceptual models and spatial maps of the project site.
1J - Tools for participatory natural resource management	This is an overview of a selection of participatory tools used in analysis, and decision making in natural resource management. Each tool is relevant in the context of climate change as they can be used as general-purpose tools in the early stages of an analysis that can feed into the range of other conservation tools described in this Toolbox.
1K - Key Biodiversity Areas	Key Biodiversity Areas (KBAs) help to identify important sites at regional, national and site level. Governments, intergovernmental organizations, NGOs, the private sector, and other stakeholders now use KBAs as a tool for identifying sites and networks of priority sites for conservation.
1L - Gap Analysis	Gap analysis is a method to identify biodiversity that is not adequately conserved within a protected area network. A gap analysis involves comparing the distribution of biodiversity, with the distribution of protected areas and finding where species and ecosystems are left unprotected or under-protected.
CATEGORY 2 - TOOLS THAT ARE COMMONLY USED IN ADAPTATION PLANNING IN THE PACIFIC	
2A - Vulnerability Assessment	Vulnerability Assessment (VA) is accepted as one of the core elements of climate change adaptation planning, and undertaking is a requirement for many adaptation funding mechanisms. The assessment will typically enable decision-makers to prioritize adaptation actions by identifying which area of the system is most vulnerable to climate change. VA can be applicable at multiple scales: Global, Regional, National, Sub-national, local to community level.

2B - Community-based Adaptation	Along with vulnerability assessment, community-based adaptation (CBA) approaches to adaptation planning cover a range of different methodologies, all of which are founded on a 'bottom up' process to the identification of both the risks from climate change and their solutions. ACBA is a community-led process, based on communities priorities, needs, knowledge and capacities, which should empower people to plan for and cope with the impacts of climate change.
2C - SimCLIM	SimCLIM is a computer model system for examining the effects of climate variability and change over time and space. Its 'open framework' feature allows user to customise the model for their own geographical area and spatial resolution and to attach impact models.
2D - Dynamic Downscaling for Climate Scenarios	Dynamic downscaling uses numerical models such as global models with varying spatial resolution, high resolution global models or more commonly regional climate models (RCMs) derived from coarse GCMs. RCMs are driven by lateral (ie edges of the RCM) boundary conditions obtained by a combination of model output and observation.
2E - Empirical Downscaling for Climate Scenarios	Empirical (or statistical) downscaling uses observed relationships between large scale climate phenomenon and local conditions to generate fine-grain projections from GCM output. The simplest empirical approach is the use of analogs; different weather types are identified manually or objectively using a variety of statistical techniques, and then changes in the frequency of weather types of interest are the used to project changes in the local climate variables.
CATEGORY 3 - PACIFIC-RELEVANT ECOSYSTEM-BASED ADAPTATION RELATIONSHIPS	
3A - Coastal Vegetation and Reduced Coastal Erosion	Designed and placed with careful attention to species, hydrology and storm levels expected/projected, coastal vegetation has a high potential to be a desirable mechanism to combat coastal erosion. In considering restoration as a measure to reduce erosion, the planner should examine whether vegetation restoration can occur in the area, the costs of restoration, the time scale over which the restoration will become effective. Planning, design, construction and maintenance costs can all be compared across the life cycle of alternative options.
3B - Coastal Vegetation and Protecting People and Property from Storm Surge	Coastal vegetation is able to protect coastal inhabitants/settlements from storm surge and cyclones (referred to as a 'bioshield' function). Designed and placed with careful attention to species, hydrology and storm levels expected/projected, coastal vegetation has some potential to be a desirable mechanism to combat storm surge. There are a number of factors that contribute to the effectiveness of vegetation for use as a bioshields, and there are still a number of uncertainties and such bioshields should be part of a diverse DRR program.
3C - Floodplain and Riverine Vegetation and Reduced Flood Damage	With likely changes in seasonality and extreme climate events, the risk of flooding will increase in some areas of the Pacific. Floodplain vegetation has the potential to both delay flood waters and reduce the total volume of flood waters/flood wave in some contexts. Similarly, riverine vegetation has the potential to reduce downstream impact from flooding, also offering hydraulic resistance which can delay and reduce the impact of floods.
3D - Slope Vegetation and Landslide Risk Reduction	The risk associated with landslides can be reduced by increasing the complexity of the vegetation on slopes. There is no evidence that slope vegetation provides protection from deep landslides - just shallow landslides. Management of slope vegetation should be considered part of a diverse disaster risk reduction strategy, along with early warning systems and other options.
3E - Protective Vegetation and Agricultural Yield Stability	In cases where increased climate variability is likely, farmers will need to find techniques that are increasingly robust; able to maintain stable yields across a wider variety of climatic conditions and spread the risk associated with a single event. One of the ecosystem-based techniques that helps to maintain yields across a wider range of environmental conditions and spread risk is through agroforestry. Trees can also play an important role in stabilising yields as 'shelter belts': helping to reduce wind damage and provide other services.
3F - Mangroves and Accommodation of Sea Level Rise	Mangrove communities typically adapt to rising water levels by reducing in stature, and by colonizing new, more favourable areas - this is known as 'landward migration'. The key outcomes of such migration is the maintenance of primary and secondary productivity of the mangrove system. With the disappearance of mangroves, there is typically no practical alternative to livelihoods and food sources provided locally.
CATEGORY 4 - CASE STUDIES OF ACTIVITIES THAT ARE RELEVANT TO THE PACIFIC	
4A - Mangrove Watch	Mangrove Watch that has been established in Australia to address the urgent need to preserve and protect threatened tidal wetland ecosystems as well as addressing both scientific and environmental management needs. This monitoring program targets estuarine and coastal systems where there are mangroves, saltmarsh and saltpans and uses a partnership between community volunteers and scientists.
4B - PABITRA	The Pacific Asia Biodiversity Transect (PABRITA) is a network of landscape transects across the Pacific, used to map and monitor species, biodiversity, and ecosystems services in the face of global climate change. Run by the Pacific Science Association, the PABITRA network allows for a horizontal comparison of biodiversity structure and function of individual ecosystems belonging to the same tropical Pacific-wide island biome.
4C Dugongs in the South Pacific	Populations of critically endangered dugong across the Pacific will continue to decline in the absence of coordinated regional actions. Dugongs may experience effects of climate change principally through impacts on seagrass. Seagrass ecosystems are considered sensitive to a range of predicted climate change stressors across the Pacific (rising sea surface temperature, increased storm activity and flooding, sea level rise, and altered currents). Seagrass dieback is linked to lower reproduction in dugongs, increased mortality and emigration.
4D - PASAP Country Activity for the Solomon Islands	The Pacific Adaptation Strategy Assistance Program (PASAP) aims to enhance the capacity of partner countries to assess key vulnerabilities and risks, formulate adaptation strategies and plans and mainstream adaptation into decision-making, and inform robust long-term national planning and decision-making in partner countries. The project is linked to priorities identified under the Solomon Islands National Adaptation Programme of Action (NAPA), which highlighted adverse impacts on agriculture and food security as a major concern for many communities and/or villages.
4E - Micronesia Toolbox	In 2010 the Micronesia Conservation Trust (MCT) and partners supported the development of Community-Based Adaptation (CBA) tools for use across Micronesia. The tools are the culmination of a collaborative process with community members, resources managers, conservation practitioners and climate change experts across Micronesia. As a result of this consultative process, the tools accurately reflect local needs to overcome the challenges of adapting to climate change.
4F - Reef-watch	The programme was developed to contribute to the health of the marine environment by training community volunteers to monitor the ecosystems using non-destructive, internationally recognised techniques. Volunteers collect the scientific data that informs management and conservation decisions.

Annex 2

Decision Tree for Building Ecosystem-based Adaptation(EbA) into Adaptation Planning/Projects



Annex 3

Pacific Ecosystems and Adaptation Information Needs Survey

1. Which of the following best describes the organization you work for? (please tick)

O Pacific Government
O Non-government Organisation
O Regional Organisation
O Business
O Foundation/Donor Organisation
O Academic/Research Institution
O Community Organisation
O Other____

2. At what level do you mainly conduct activities? (can select more than one)

O Community
O Local
O District
O Provincial
O National
O Pacific-wide
O Other____

3. Which of the following areas are you involved in: (can select more than one)

O Adaptation Planning or Projects
O Conservation Planning or Projects
O Disaster Risk Reduction Planning or Projects
O Food Security Planning or Projects

4. Which aspects of climate change are most relevant to your responsibilities? (can select more than one)

O Sea level rise
O Rising ocean temperatures
O Ocean acidification
O Droughts
O Floods
O Fires
O Storms and cyclones
O Other____

5. Which impacts of climate change are most relevant to your responsibilities? (can select more than one)

O Impacts on human health
O Impacts on agriculture
O Impacts on fisheries
O Impacts on infrastructure and settlements
O Impacts on livelihoods
O Impacts on ecosystems and biodiversity
O Other____

6. Do you think ecosystem services can reduce the impacts of climate change on people in the context of your work?
O No
O I don't know
O Yes (please specify how) ______________________________

7 - Do you think climate change is a threat to ecosystems or biodiversity in the context of your work?
O No
O I don't know
O Yes (please specify how) ______________________________

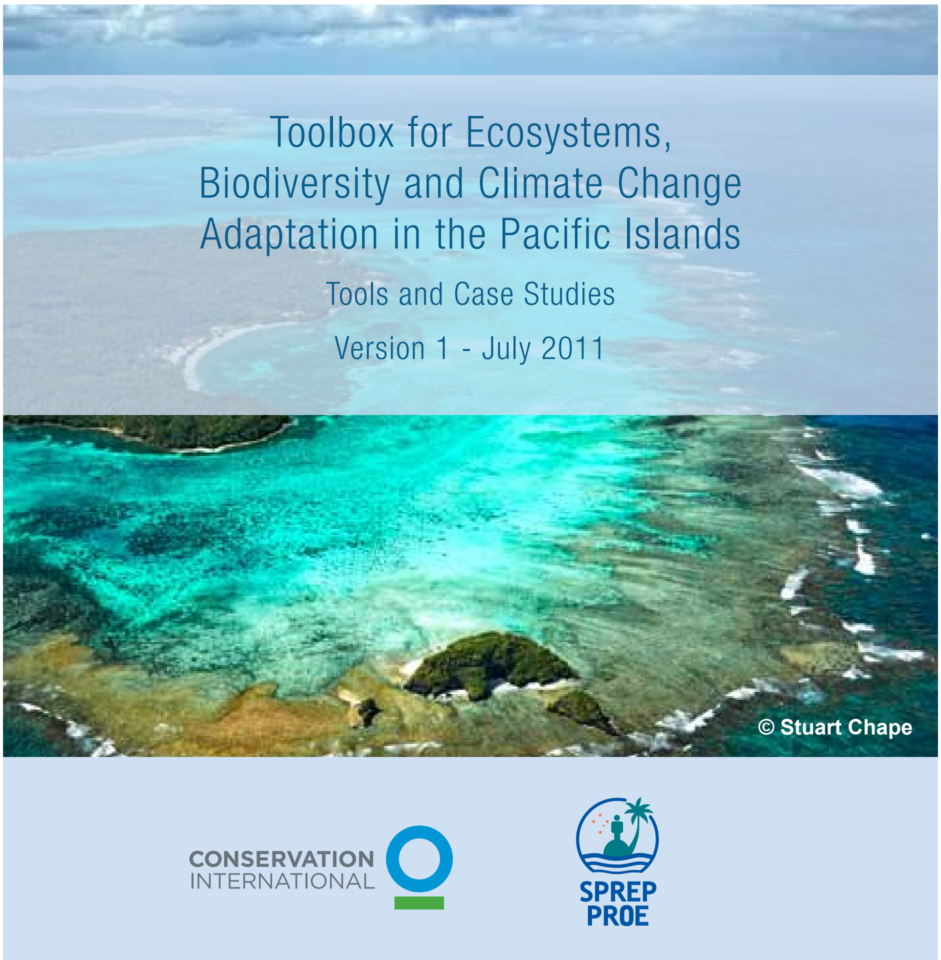
8. What are the main sources of information that you currently use in your adaptation work? (Please select up to 4)
O Adaptation knowledge platforms (eg weADAPT)
O Databases (e.g. from IPCC, World Bank)
O Guidance documents (e.g. UNDP Adaptation Policy Frameworks for Climate Change)
O National socio-economic and/or ecological data
O National meteorological data
O Climate models and scenarios
O Community consultations
O Directly from CROP Agencies
O I am not sure about the exact source
O Other______________________________

9. What kind of information or tools would be most useful on the role of biodiversity and ecosystems in climate change adaptation? (please select up to 4)
O Case-studies showing the role of ecosystems in vulnerability assessments and adaptation planning in specific sectors in the Pacific (eg agriculture, fisheries)
O Case-studies assessing climate change impacts on ecosystems & biodiversity in the Pacific
O Relevant case studies on biodiversity, ecosystems and climate change from outside the Pacific (eg other small island states)
O 'How to' guidance for analyzing ecosystem services and their role for the adaptation of specific sectors, including economic valuation
O 'How to' guidance for studying the impacts of climate change on ecosystems & biodiversity
O Baseline data on ecosystems & biodiversity
O Risk-screening tools for building adaptation into existing work
O Lists of available experts
O I don't need any information or tools on biodiversity and ecosystems
O Other______________________________

10. In which format would you prefer to receive this information? (please select up to 3)
O Online information
O Online training modules
O A compact disc (CD) with information
O Videos
O Hard copy manuals/books
O Group training
O Call centre for technical support
O I don't need any information or tools on biodiversity and ecosystems
O Other______________________________

Instructions: To use the toolbox please insert the CD and access information via a web browser or file manager.

Disclaimer: 'The authors have prepared this Toolbox as an introduction to a range of tools and experiences that are relevant to the Pacific Island context. This information is not exhaustive and should be considered as a guide only. The authors take no responsibility for decisions made based on the content of this Toolbox.

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