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# A social and ecological imperative for ecosystem-based adaptation to climate change in the Pacific Islands

**T. Hills · T. J. B. Carruthers · S. Chape · P. Donohoe**

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**Abstract** Climate change is predicted to have a range of impacts on Pacific Island ecosystems and the services they provide for current and future development. There are a number of characteristics that can make adaptation approaches that utilise the benefits of ecosystems a compelling and viable alternative to other adaptation approaches. The objective of this paper is to determine what level of relative influence technical and planning considerations currently have in guiding the recognition and application of ecosystem-based adaptation (EbA) approaches in the Pacific Islands context. The technical feasibility of EbA in relation to the expected impacts of climate change and the compatibility of adaptation planning processes of the Pacific Islands with EbA requirements was considered. The main barrier to fully implementing EbA in the Pacific Islands is not likely to be financial capital, but a combination of stable technical capacity within government departments to advise communities on EbA opportunities and the compatibility of planning frameworks.

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## Introduction

Climate change is predicted to have a range of impacts on Pacific Island ecosystems and the services they provide for current and future development. It is increasingly recognised that a relevant response to these impacts is the application of ecosystem-based adaptation (EbA) approaches (Reid and Swiderska 2008; World Bank 2010). By taking into account the ecosystem services on which people depend for their livelihoods and social and economic security, EbA integrates sustainable use of biodiversity and ecosystem services in a comprehensive adaptation strategy (CBD 2009).

A number of international organisations have begun to provide general guidance on EbA to help buffer communities from the worst impacts of climate change (Colls et al. 2009; Andrade et al. 2012) and the critical test for such guidance is whether it facilitates practical consideration of EbA across the full spectrum of adaptation contexts, including in the Pacific Islands. Advocates for adaptation approaches that target the specific vulnerabilities of the Pacific Islands have made significant contributions to global discussion of this issue in both policy and technical fora (Mimura et al. 2007; UNEP-WCMC 2006). This interest has translated into adaptation action in many Pacific Islands countries and territories, which increasingly show inclusion of biodiversity and ecosystems in priority activities described under National Adaptation Programmes for Action (Pramova et al. 2012).

There are a number of characteristics that can make adaptation approaches that utilise the benefits of ecosystems a compelling and viable alternative to other adaptation approaches but application is not straightforward.

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Grantham et al. (2011) suggest that in tropical Oceania implementing EbA requires a number of pre-conditions: effective governance regimes, policy instruments and economic efficiency. The objective of this paper is to build on this work and determine what level of relative influence technical and planning considerations currently have in guiding the recognition and application of EbA approaches in the Pacific Islands context, and to suggest ways that will increase such consideration in the future so that improved adaptation outcomes can be achieved in a more cost-effective and ecologically sustainable manner.

## The social and economic context for ecosystem resources in the Pacific Islands

The Pacific region contains globally significant natural resources, which are also essential in supporting the economies, lives and livelihoods of Pacific Island peoples. Of the total estimated global tuna catch in 2009, 58 % was caught in the Western and Central Pacific Ocean (WCPO) and approximately half of this catch was from the Exclusive Economic Zone of Pacific Island Countries and Territories (PICTs), providing significant income (Lehodey et al. 2011). In some 17 PICTs, 47 % of coastal households list fishing as either a primary or secondary source of income, and in rural communities, the subsistence fishery accounts for 60–90 % of all fish caught. As a result, national fish consumption in Pacific Islands is three to four times the global average, representing 50–90 % of animal protein consumed by many Pacific Island peoples (SPC 2008; Bell et al. 2009). The Pacific Plan, the overarching policy in the Pacific region endorsed by Forum Leaders at the Pacific Islands Forum meeting in Port Moresby in 2005, explicitly recognises that sustainable development in the region relies on effective management of fisheries and also the habitats that support them (Bell et al. 2011).

The timing of human settlement of the island of New Guinea is generally considered to be around 40,000 years ago, whereas there is little evidence of settlement in the more remote islands of the Pacific before 3,200 years ago (Kayser 2010). Regardless of its duration, human occupation has inevitably resulted in large changes to ecosystems and landscapes, with the extinction (in the case of endemics) or extirpation of many faunal species in Pacific Islands (Steadman 1995; Steadman and Martin 2003). However, cultural linkages to natural resources have traditionally been very strong and formed the basis of the sustenance and resiliency of Pacific Island peoples (Barnett and Campbell 2010).

## A vulnerability framework for Pacific Islands

According to the Intergovernmental Panel on Climate Change (IPCC 2007), the potential impact of climate change is determined by exposure, sensitivity and adaptive capacity, as follows:

*Exposure* The nature and degree to which a socio-ecological system is exposed to climatic threats (ActionAid 2005; Yusuf and Francisco 2009). Variables related to exposure can include proximity to the source of the threat, incident frequency or probability, magnitude, duration, or geographic impact (Cutter 1996).

*Sensitivity* The degree to which the system is affected adversely or beneficially by climate change factors (USAID 2009; Yusuf and Francisco 2009). Sensitivity can be determined through understanding impacts from past threats, individual or system-wide characteristics, and connectivity between individuals within and outside the system (Cutter 1996).

*Adaptive capacity* In a human system this refers to the set of resources available for adaptation (information, technology, economic resources, institutions and so on), as well as the ability or capacity of that system to use the resources effectively in pursuit of adaptation (UNDP 2005). Ecosystems and biodiversity can enhance adaptive capacity as they help to define the options available for adaptation by being included within the list of "raw materials on which adaptation can act" (Chapin et al. 2009). It is this link to adaptive capacity that is most relevant in communities that are most strongly and directly dependent on natural resources for their well-being. However, at the broader scale, ecosystem health and integrity is also a prerequisite for ensuring the sustainability of Pacific Island nations as a whole, not only the communities within them. Therefore, it is vital that there is a coherent national response to climate change that integrates social, economic and ecological approaches at all levels of society.

The net effect of exposure, sensitivity, and adaptive capacity is vulnerability, and an exploration of these factors in the Pacific region with a particular focus on natural capital is given in the sections below.

## Physical exposure and sensitivity to climate change in the Pacific

Small island states are recognised as hotspots for climate change, particularly in relation to sea level rise (Lewis 1990; Leatherman and Beller-Simms 1997; Mimura 1999). However, an important context for potential exposure and sensitivity to climate change is the range of coastal impacts resulting from human activity; including sediment erosion, destruction of habitat, urban expansion including in-filling of lagoons, invasive species, unsustainable fisheries practice and eutrophication (Newton et al. 2012; Fig. 1).

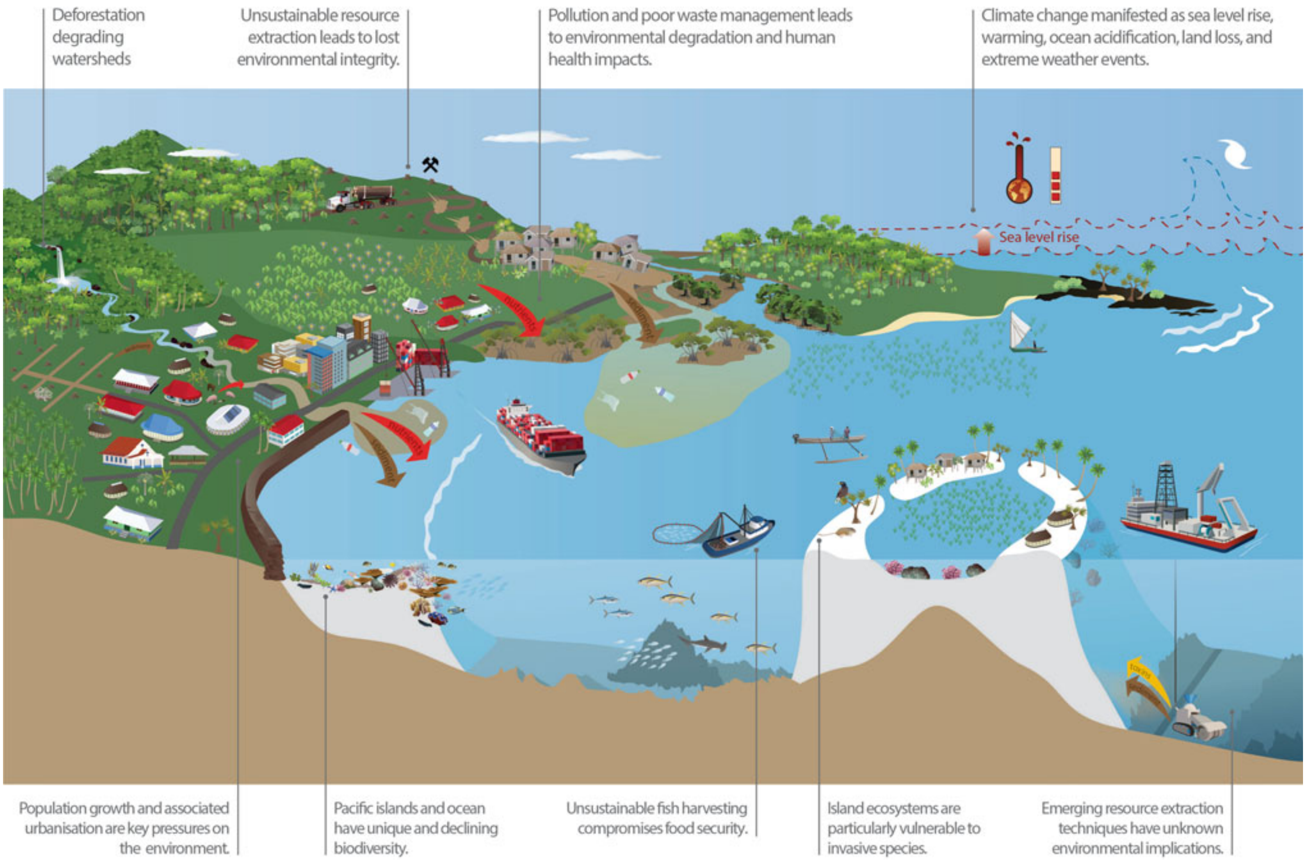


**Fig. 1** Key threats to ecosystems in Pacific Island countries and territories

Across Pacific Island countries, climate change is generally predicted to increase the frequency and intensity of extreme heat and extreme rainfall days, increase the intensity of cyclones in the South Pacific, while resulting in continued sea level rise and ocean acidification (Australian Bureau of Meteorology 2011).

The geological history of the Pacific Islands is both dynamic and complex. While New Caledonia and southern Papua New Guinea are Gondwanan fragments of raised continental crust, a small number of limestone islands were formed from uplifted coral atolls, such as Niue and Nauru (Neall and Trewick 2008; Ellison 2009). However, the majority of Pacific Islands occur within one of the 11 main linear volcanic chains, and vary in age from younger volcanic high islands through to older coral atolls (Neall and Trewick 2008; Barnett and Campbell 2010). This geomorphological structuring of islands provides a useful lens through which to consider potential vulnerability to climate change, and associated possible adaptation measures (Table 1).

Vulnerability within Pacific Islands is related closely to the broad island typology of high volcanic islands, coral atolls and emergent limestone islands (Gillie 1997; Chape 2006; Ellison 2009; Barnett and Campbell 2010; Forbes et al. 2013, this volume). While high islands of the Pacific vary in size and age, the largest occur in Melanesia (Table 1). These have high elevation with deep soils, high biodiversity and large rivers with flood plains and are therefore vulnerable to landslides, riverine and coastal flooding; and high elevation ecosystems that are vulnerable to air temperature increases (Gillie 1997; UNDP South Pacific Office 2002). Papua New Guinea is the largest country in the Pacific Islands and is therefore unique in terms of vulnerability as it contains such a range of landscapes and diversity of biota (Barnett and Campbell 2010). Smaller high islands have steep topography and smaller rivers with less developed flood plains. These small islands are highly susceptible to cyclones and associated storm surges resulting in coastal flooding (Nunn and Mimura 1997). River flooding is localised and fresh water supply is vulnerable to changing rainfall patterns. Atolls are characterised by low-lying topography and little or no developed soil, usually large coastal lagoons, and no fresh surface water but important, and often limited, groundwater lenses. These are highly vulnerable to flooding from storm surges and extreme high tides, and are affected by changing rainfall pattern or salt water intrusion to fresh water lenses. Raised limestone islands are the least common island type, having steep outer slopes to the ocean, a large concave inner basin, relatively low elevation and no surface water or substantive surface soil. The greatest

**Table 1** Geomorphologic framework for exposure and adaptive capacity of Pacific Island countries and territories

| | Geomorphology | | | | | | Exposure | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | High islands[b,c,d] | Atolls[b,c,d] | Raised lime stone[b,c,d] | Land area ($km^2$)[b] | Number of island[a,b] | Islands over 1,000 $km^2$[a] | Coastal flooding[e] | River flooding[e] | Drought[e] | Cyclones per decade[f] | sea level rise (mm $year^{-1}$)[f] | Adaptive capacity (1 high, 4 low)[g] |
| Melanesia | | | | | | | | | | | | |
| Vanuatu | ■ | | | 12,189 | 84 | 2 | H | H | H | 23 | 6 | 2.3 |
| Fiji | ■ | | | 18,333 | 607 | 2 | H | H | H | 14 | 6 | 3.25 |
| New Caledonia | ■ | | | 18,576 | 36 | 2 | | | | | | |
| Solomon Is. | ■ | | | 28,300 | 347 | 6 | H | H | H | 13 | 8 | 2.3 |
| PNG | ■ | | | 462,243 | 151 | 8 | H | H | H | 6 | 7 | 1.8 |
| Micronesia | | | | | | | | | | | | |
| Nauru | | | ■ | 21 | 1 | 0 | L | na | H | 0 | 5 | |
| Marshall Is. | | ■ | | 181 | 607 | 0 | H | na | H | weak | 7 | |
| NMI | ■ | | | 471 | 14 | 0 | | | | | | |
| Palau | ■ | | | 488 | 300+ | 0 | M | na | H | few | 9 | |
| Guam | ■ | | | 541 | 1 | 0 | | | | | | |
| FSM | ■ | ■ | | 701 | 607 | 0 | H | na | H | few | 10 | |
| Kiribati | | ■ | ■ | 811 | 33 | 0 | H | na | H | 0 | 1-4 | |
| Polynesia | | | | | | | | | | | | |
| Tokelau | | ■ | | 12 | 3 | 0 | H | na | M | | | |
| Tuvalu | | ■ | | 26 | 9 | 0 | H | na | H | 8 | 5 | |
| American | ■ | | | 199 | 7 | 0 | | | | | | |
| Cook Is. | ■ | ■ | ■ | 237 | 15 | 0 | M | L | H | 11 | 4 | |
| Wallis and Futuna | ■ | | | 255 | 23 | 0 | | | | | | |
| Niue | | | ■ | 259 | 1 | 0 | L | na | H | 15 | 5 | |
| Tonga | ■ | | | 649 | 171 | 0 | H | L | H | 17 | 6 | |
| Samoa | ■ | | | 2,935 | 10 | 2 | H | M | L | 10 | 4 | 2.5 |
| French Polynesia | ■ | ■ | | 3,521 | 125 | 1 | | | | | | |

*L* low, *M* medium, *H* high, *na* not applicable

[a] Dahl 1991 (UN System-wide Earthwatch, Island Directory)

[b] Ellison (2009)

[c] Barnett and Campbell (2010)

[d] Chape (2006)

[e] UNDP South Pacific Office (2002)

[f] ABM (2011)

[g] Pelling and Uitto (2001)

vulnerability in such islands is likely to be fresh water shortage, with flooding rare except in some lower islands or where there are multiple terraces with communities living on coastal terraces (Barnett and Campbell 2010; Table 1).

## Adaptive capacity in the Pacific Islands

Calculations of natural capital are based on quantification of the services that this capital provides to people. The

Millennium Ecosystem Assessment (2003) defined ecosystem services as "the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits."

In relation to applying national capital as an indicator of adaptive capacity, one of the most recent studies in this area was published in 2005 by the World Bank. This analysis divides the countries of the world into high, middle and low income categories and attempts to quantify three types of wealth [World Resources Institute (WRI) 2008]:

- intangible wealth—human capital and the quality of formal and informal institutions;
- produced wealth—derived from historical investment data;
- natural capital—based upon country-level data on physical stocks and estimates of natural resource rents based on world prices and local costs.

One of the main conclusions from this study was that natural capital represents a much more significant proportion of wealth in low-income countries than in high-income countries (Fig. 2), highlighting the importance of including natural capital assessments into adaptation planning frameworks in lower income countries, ideally through EbA.

## Current application of EbA in the Pacific Islands

There are a wide variety of interpretations of EbA, and evidence of success is scattered across various disciplines (Reid 2011). The most widely accepted definition from the Convention for Biological Diversity (CBD) is as follows:

> Ecosystem-based approaches to adaptation are the use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change [CBD 2nd Ad Hoc Technical Expert Group (AHTEG) on Biodiversity and Climate Change].

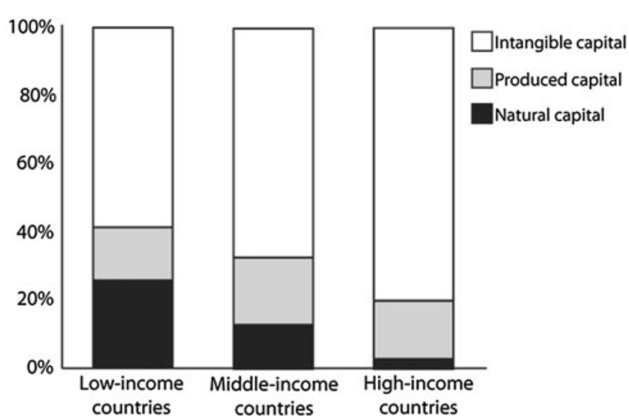


**Fig. 2** Distribution of total wealth by income group, 2000 (World Resources Institute 2008)

This definition places EbA at the intersection of climate change adaptation, development and conservation. The health of Pacific ecosystems and biodiversity is widely acknowledged to be already under significant threat as a result of habitat modification, over-exploitation of resources, invasive species and pollution, many of which are predicted to be further exacerbated by climate change (Kingsford et al. 2009; Bell et al. 2011; Polidoro et al. 2011). Also, there has been a general failure to implement effective environmental management policy in Pacific Island countries [Asian Development Bank (ADB) 2004; McIntyre 2005].

For the purposes of this study, two potential barriers to EbA are explored in the context of the Pacific Islands: (1) understanding the linkages of ecosystem values and services with climate change resilience and adaptation (i.e. technical feasibility/viability), and (2) the compatibility of adaptation planning processes with EbA requirements.

## Technical feasibility/viability

In order to compare various adaptation options for their relative suitability in reducing a given societal vulnerability, there are a number of key issues that need to be considered, including the following:

- 'Safeguards' to ensure that other forms of capital are not undermined by the adaptation activity (e.g. negative impact on social capital by reducing access to natural resources). Ideally, flow-on effects (which are particularly important in environmental systems) need to be understood as part of the 'early stage' appraisal process for adaptation options (UNDP 2011).
- A robust adaptation option that has the potential to reduce vulnerability across the broadest range of possible climate futures (Wilby and Dessai 2010). This is particularly important in cases of increased uncertainty of vulnerability for climate change and low-data contexts.
- Capacity of ecosystems to provide multiple services and establish a level playing field for assessment of alternative options. The quantification of these services can be difficult given the many variables associated with their delivery, which contrasts with engineering-based solutions that typically provide services according to relatively predictable functions (Hills et al. 2011).

Natural ecosystems have a fundamental role in reducing societal vulnerability to climate change and also provide a

**Table 2** Common ecosystem-based approaches to adaptation in the Pacific Islands from CBD (2009) and Hills et al. (2011)

| Adaptation | | Additional benefits (secondary services) | | | Threats to services |
|---|---|---|---|---|---|
| Adaptation measure | Adaptive function | Social and cultural | Economic | Biodiversity | Threats to ecosystems |
| Management of tidal wetland systems for coastal protection | Protection against storm surge and coastal inundation | Protection of coastal cultural sites | Production and maintenance of fisheries<br>Protection of coastal buildings | Conservation of species that live or breed in mangroves | Clearing for coastal development |
| | Adaptation to sea level rise (through migration of mangroves) | Protection of coastal community buildings | Provision of firewood | | Over use of mangrove for firewood |
| | Protection of beaches and islands from wave erosion | Maintenance of shellfish and other important foods | Carbon sequestration | Trapping of nutrients and sediments from drainage into nearby ecosystems (i.e. coral reefs) | Infrastructure that blocks the ability of mangroves to migrate with sea-level rise |
| Management of slope vegetation for landslide risk | Reduction of landslide risk | Provision of local timber/bush building materials | Ongoing source of income for sustainable selective harvesting of forest species | Conservation of habitat for forest plant and animal species<br>Maintaining freshwater ecosystem health | Unsustainable logging practices<br>Mining proposals involving forest clearing |
| | | Protection of cultural sites and traditional ecological knowledge | Carbon sequestration | Maintenance of coral reef health due to less sedimentation | Clearing for large scale agricultural production (e.g. oil palm plantations) |
| Use of agroforestry and use of shelter-belts for production stability | Yield stability in more variable climates | Resilience against non climate events from diversification of food and income sources | Maintain productivity through shocks (e.g. pest or disease outbreak) | Agroforestry trees can have habitat benefits for species | Large-scale mono-culture agricultural production (i.e. oil palm plantations) |
| | Maintenance of soil fertility | | Less reliance on external inputs (fertilisers/ pesticides) | | Excessive fertiliser/ pesticide use |
| | Protective barrier for crops | | Carbon sequestration | | Deforestation |
| Management of floodplain and riverine vegetation for flood management | Decrease the speed and size of the peak of floodwaters | Food security from improved fisheries | Protection of buildings from extreme flood events | Fish and wildlife habitat, breeding grounds for migratory species | Clearing of riparian vegetation for logging and agricultural production |
| | | | Delay of peak flood events may allow time for evacuation or flood preparedness | | Ineffective management of pollution and waste |
| | Allow floodwaters to disperse across a floodplain | | Carbon sequestration | Maintenance of important wetland high biodiversity sites | Unplanned urban development in flood prone areas |

variety of other functions. Table 2 summarises some of the EbA relationships relevant to the Pacific Island adaptation planning context.

In order to explore issues of technical comparison more specifically, the evidence of a climate change exposure and associated EbA option that is particularly significant for the

Pacific Islands will be examined—the capacity of coastal vegetation to buffer the impacts of storm surge.

A wide range of technologies provide coastal protection services but one of the most common approaches that has been applied in coastal rural settlements in Pacific Islands since the 1960s is sea walls, typically constructed using locally available materials such as reef rock or hard rock (Mimura and Nunn 1998). However, poorly designed seawalls are likely to cause significant erosion in adjacent areas and local issues caused by 'overtopping' of waves (Zhu 2010), prevent natural migration of mangroves to accommodate sea level rise (Gilman et al. 2006), and component rocks have been known to become dangerous projectiles in larger wave events in the Pacific (Etienne et al. 2011). Well designed coastal defences are able to avoid many of these potential problems but require not only design skills and appropriate materials, but good quality, long-term environmental data and a strong maintenance regime (Zhu 2010), the costs of which can be prohibitive in Pacific Islands states (Pratt and Govan 2010).

The relative effectiveness of vegetation systems in achieving coastal protection objectives is the subject of ongoing debate. As an example, there has been commentary across literature reviews on the protective function of wetlands—often referred to as a 'bioshield'. As noted by Feagin et al. (2010), 'coastal vegetation has been widely promoted for the purpose of reducing the impact of large storm surges and tsunami'. In reviewing this commentary, it is useful to separate two major sources of damage in extreme events: inundation/flooding and wave impact.

Feagin et al. (2010) also observed that a UNEP study found that 'vegetation had no effect on tsunami inundation at 52 sites throughout the Indian Ocean'. Given the structural similarities between tsunami and storm surge (both being long period waves), it has been suggested that the inundation impacts of these extreme events are significantly more dependent on other physical factors like topography, near-shore bathymetry and distance from the shore (Mukherjee et al. 2010), and so such damage would be likely to occur in some higher-end extreme events, regardless of the ecosystem or engineered protection that was in place. There are also many case studies that provide compelling arguments for a viable protective function from vegetation for the impact from storm waves. McIvor et al. (2012) examined many of the factors described by Mukherjee et al. (2010) and suggested that the central factor affecting wave attenuation in mangroves is the density of obstacles that waves encounter as they pass through the mangrove, and the height of these obstacles relative to the water depth. Das and Vincent (2009) also argued that through restoration of mangroves the average opportunity cost per life saved based on data from the super-cyclone that struck in Orissa, India in 1999 was 11.7 million rupees. In a developed country context, Naidoo et al. (2008) use meta-analytic regression techniques to argue that annual value of coastal wetlands for hurricane protection in the USA amounts to US$ 8,240 $ha^{-1}$ $year^{-1}$.

Adaptation planners now have a number of tools that can support their decisions, including models such as SWAN (Simulating Waves Nearshore) and Wave PROpogation in MANgrove Forest (WAPROMAN) and classification systems (such as Bao's 5 point classification system for mangrove forest protection) but it should be noted that the majority of these resources are derived from studies of relatively small waves (<70 cm), so additional guidance is needed for larger scale waves to ensure that the models and guidance hold (McIvor et al. 2012).

It should also be noted that hybrid ecosystem and built engineering solutions to increased coastal vulnerability are possible, although rare in practice in the Pacific Islands. Such hybrid systems went to preliminary design under the Kiribati Adaptation Programme (Hardwick 2010) but were not implemented.

The broad lessons from coastal protection services of vegetation are likely to be applicable across other forms of EbA; not all habitats and vulnerability contexts are amenable to EbA approaches but there are contexts where it offers the most cost effective reductions in societal vulnerability. Interested decision-makers in the Pacific may benefit from guidance that allows them to confidently identify the contexts in which potential EbA options are technically superior, socially acceptable and more affordable than alternatives.

## Consistency of planning approach with EbA requirements

While EbA is a relatively new approach, some studies have already been conducted to determine the extent to which EbA has been successfully embedded into various policy and planning activities across adaptation, development and conservation, such as those by Pramova et al. (2012) and Ikalla (2011). These two studies focus on the level of representation of EbA as a proportion of total number of planned adaptation activities, with Pramova noting that 16 % of the 468 NAPA projects within this study focus on ecosystems for societal vulnerability and Ikkala observed that 43 % of visions, objectives, policies and strategies for adaptation in the three study countries included references to EbA.

The classification system proposed by Pramova et al. (2012) makes a distinction between projects: (1) without ecosystem activities; (2) with ecosystem activities for the environment; (3) with ecosystem activities for social wellbeing; (4) with ecosystem activities for social adaptation. However, the application of this classification is unable to differentiate between societal vulnerabilities that are relevant to EbA and those that are not. The introduction of a fifth classification: 'EbA-relevant vulnerability' may help to better understand the decision-making processes that underpin the uptake of EbA. The examination of this group could describe whether there was a 'missed opportunity' for EbA; whether the early stage (i.e. pre-design) planning process excluded the consideration of ecosystem services in decision-making for adaptation interventions.

Guidance such as provided by Andrade et al. (2012) can be used to determine the compatibility of a particular planning process with EbA and hence determine whether opportunities to investigate EbA-relevant vulnerability were examined adequately. Many aspects of Andrade's guidance are consistent with broader 'best practice guidance' for development, conservation and adaptation, but there are two aspects that are sufficiently important in an EbA-specific process to warrant verification. These are:

- Understanding what makes ecosystems—and the services they supply—resilient; and
- Collaboration between sectors managing ecosystem services and those benefitting from ecosystem services

On the first point, the extent to which a process accommodates the role of ecosystem services in reducing vulnerability can be verified; this is the core of an 'integrated approach' to EbA. In our study this point is divided into two sub-criteria that can be used to examine whether the planning process: (1) recognises the links between ecosystems and development; and (2) considers the potential of ecosystem services in reducing societal vulnerability to climate change. The next criterion in our study is (3), which is based on the second point above, and relates to the quality of collaboration and can also be tracked through the planning process by examining evidence for cross-jurisdictional collaboration.

The starting point for this analysis is a review of the National Adaptation Programmes of Action (NAPAs) from the Pacific. NAPAs have been prepared in the PICT Least Developed Countries (LDCs) by the Government of Kiribati (2007), the Ministry of Environment, Conservation and Meteorology (2008) in the Solomon Islands, the Samoan Ministry of Natural Resources, Environment and Meteorology (2005), the National Advisory Committee on Climate Change (2005) in Vanuatu and the Ministry of Natural Resources, Environment, Agriculture and Lands (2007) in Tuvalu in order to advance project proposals and secure funding through LDC grant mechanisms. 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. Table 3 describes the compatibility of each planning process with EbA based on the criteria 1, 2 and 3.

The following themes and issues emerge from this assessment:

– There are no significant missed opportunities for EbA within the Pacific Island's NAPA process; the wide range of actions in the Pacific NAPAs typically connect EbA activities to areas of broad potential. However, there is not much evidence of 'whole of system' comparison of ecosystems services with other approaches to meet adaptation objectives—an analysis that is critical for detailed design. For example, in most cases both vegetation and seawalls are presented as solutions to coastal vulnerability, and little information is provided on the process to compare the merits of alternatives. This 'whole of system' comparison may become more prevalent as the five countries move towards a National Adaptation Plan (NAP) process, which builds on the NAPA through a more considered process, complementary to more medium- and long-term adaptation (LDC Expert Group 2012).
– The prioritisation process typically merges vulnerability issues with adaptation solutions for purposes of consultation and it could be argued that separation of these issues is critical to comparing EbA with alternatives. However, priorities that are commonly driven by local preferences better separate vulnerabilities and adaptation solutions than priorities developed within a sector-based approach.
– While consultative approaches to priority setting are preferable, the explicit preference for hard infrastructure expressed by communities in Samoa's NAPA (Table 3) suggests that awareness on the relative benefits of EbA may be limited at the community level. While an extensive study of the evolving preferences for coastal protection across the Pacific Islands has not been completed, Mimura and Nunn (1998) suggested that the removal of mangroves in Fiji associated with coastal development created the demand for hard infrastructure since the 1960s, displacing the common traditional practice of planting and protecting vegetation on shorelines. It was also suggested that design has generally been a secondary consideration compared to availability of raw materials and stability has suffered as a result (Mimura and Nunn 1998).
– NAPA sections are heavily aligned with government jurisdictions traditionally responsible for each sector, and opportunities for collaboration (a key requirement of EbA) may be more challenging as a result.

It should be noted that NAPAs represent a snapshot in time and are also only one element of a more complex planning process for each country. Notably, the Solomon Islands government has gone beyond the formulation of the

**Table 3** Ecosystem-based adaptation (EbA) approaches in National Adaptation Programmes of Action in the Pacific Islands

| Country | Recognition of ecosystem services (1) | Relevance/exploration of EbA (2) | Jurisdictional/consultative issues (3) |
|---|---|---|---|
| Kiribati | Strong focus on environmental stress and explicitly recognises the importance of ecosystem function | The NAPA targets areas "not covered or inadequately covered" by the Kiribati Adaptation Programme (KAP) so is less focussed on water and coastal protection | Of the five EbA-relevant actions, the environment department is on the list of responsible ministries for three, the others being "Water Resources Adaptation Project" and "Upgrading of Coastal Defences and Waterways", which looks at maintaining existing structures as opposed to "Coastal Zone Management for Adaptation", which includes a focus on vegetation |
| | Prioritisation criteria used in the NAPA includes a 'safeguards-style' criteria of "prohibiting types of development that destroy the environment" | Five of the ten adaptation actions are EbA-relevant, and the others are focussed on institutional strengthening, which in some cases may help to inform EbA-relevant decisions in the future | |
| Samoa | The NAPA acknowledges a close relationship between natural resources and the community in terms of cultural and heritage value of the faa Samoa (the Samoan way of life). | The priority list includes six categories of action that are EbA-relevant, including one that is strongly conservation-focussed | The prioritisation process is reduced from 63 actions across 13 categories to 20 actions over 8 categories, which describe a range of government institutions as implementing or coordinating agency |
| | | The coastal management actions focus on the implementation of existing coastal infrastructure management plans in areas considered particularly vulnerable to climate change | There is a clear 'bottom-up' focus on the selection and prioritisation focus that involved national consultation, however noting that "rock seawalls tend to be preferred by the communities for their perceived protection" and this preference for seawalls is reflected in the priority list |
| Solomon Islands | The assessment framework under the NAPA acknowledges the risks to the environment associated with climate change, and also from the 'existing stresses from exploitative and extractive industries and activities' | The approach used includes a focus on 'no regrets' and 'precautionary adaptation' but doesn't have a strong focus on ecosystem services beyond fisheries resources, but does reference Integrated Water Resource Management (IWRM) and Integrated Coastal Zone Management (ICZM) | There is a strong focus on the vulnerability of ecosystems in the narrative, but there is some inconsistency in how the environment is managed across key sectors; studies of which are led by the relevant government jurisdictions<br>At the community consultation level the potential for EbA within key priorities is more apparent |
| | | The emphasis between hard and EbA solutions is not clear within the 131 actions described in the NAPA and demand for technical support is clear | The priority list (which was derived from community consultations) includes both sea walls and foreshore vegetation as a solution to coastal vulnerability |
| Tuvalu | Recognises the "vital role" of a green belt of vegetation in stabilising shorelines and protecting communities, and this is reflected in one of the project profiles as a complement to the establishment of a hard breaker structures | Ecosystems their services have relevance in four of the seven vulnerability problems identified in the NAPA process<br>There is evidence that the potential of ecosystems to contribute to solutions has been explored in three of the four project profiles<br>The hard breaker structure encompasses >90 % of the budget for the project profile for coastal protection | The project profiles described a wide range of executing agencies within each project, including non-government organisations (NGOs) and community-based organisations (CBOs), which potentially offers better opportunities for multi-sectoral collaboration critical to EbA, but may introduce coordination issues |
| Vanuatu | Adopts a 'no regrets' approach to adaptation planning and recognises a strong link between people and the environment, noting a "special association between the Ni-Vanuatu culture and the environment that goes well beyond simple synergies with other multi-lateral environment agreements" | In some areas where erosion was seen as a critical vulnerability the restoration of vegetation was seen as a key priority (such as Malampa and Shefa provinces) whereas other provinces focused on other options such as relocation and additional planning (Sanma province) | The criteria for selection considered impact on environment and impact on community as separate issues, and also the key vulnerabilities and adaptation actions were considered together, rather than separately which may have reduced the extent to which alternative adaptation actions can be compared |
| | | ICZM and IWRM featured strongly and are consistent with EbA | The full list of adaptation priorities from a province level consultation was translated into 11 priorities, then reduced by workshop participants to 7 |

NAPA to adopt a national climate change policy in 2012, which states: "healthy and functioning ecosystems are crucial for the achievement of adaptation and mitigation objectives" (MECCDM 2012). A subsequent vulnerability and adaptation assessment in Choiseul Province in the Solomon Islands, which included EbA within the assessment framework, clearly identified that social, cultural, environmental and economic vulnerability is already high as a result of non-climate change development factors (Mataki et al. 2013).

## Discussion

There is clear evidence that some consideration of ecosystems is embedded within Pacific Island adaptation planning, but this has not occurred through explicit consideration of EbA as an applied concept but rather has resulted from diverse approaches to the management of natural capital. This diversity can be explained both through a non-prescriptive approach to NAPA establishment, but also the wide range of jurisdictional imperatives that relate to the management of pressures on natural resources. A conceptual model is proposed that may help to disentangle some of the complex issues associated with EbA implementation in the Pacific.

Figure 3 illustrates the existing challenges of unsustainable development and poor natural resource management in the absence of climate change and their relationship to the consideration of EbA. More specifically, the policy and management precursors associated with development policy that are described in this figure 'set the scene' for the consideration of ecosystem service value in climate change planning.

Based on this study, it is suggested that there is divergence between the conceptual rationale for EbA and its application in practice. Specifically, there is little evidence that the relative benefits provided by alternative coastal protection options (i.e. EbA and hard infrastructure) were compared directly in a given context, for example by applying the available impact models for both applications. As a result, either both hard and soft options are articulated as part of a long list of priorities, or the 'default' approach of hard infrastructure is given preference.

It is suggested therefore that there are two approaches used to take ecosystems services into account in adaptation planning in the Pacific Islands, based on the extent to which the alternative adaptation solutions to a specific form of societal vulnerability are explored:

1. Targeted EbA: an adaptation choice based on the appraisal of different adaptation options and their relative capacity to reduce a specific societal vulnerability to climate change
2. General EbA: an adaptation choice based on the expected delivery of a wide range of services from ecosystems.

Under this classification, targeted approaches will generally have more sophisticated data and analytical requirements, while more general approaches are more appropriate in contexts where there is interest in increasing resilience to predicted changes, but where there is high uncertainty of the local climate future and its impacts, very limited analytical capacity and/or limited resources for design, implementation and/or maintenance. Based on the examination of the NAPAs, there is little evidence of targeted EbA in adaptation planning in the least developed countries of the Pacific. However, it should be noted that

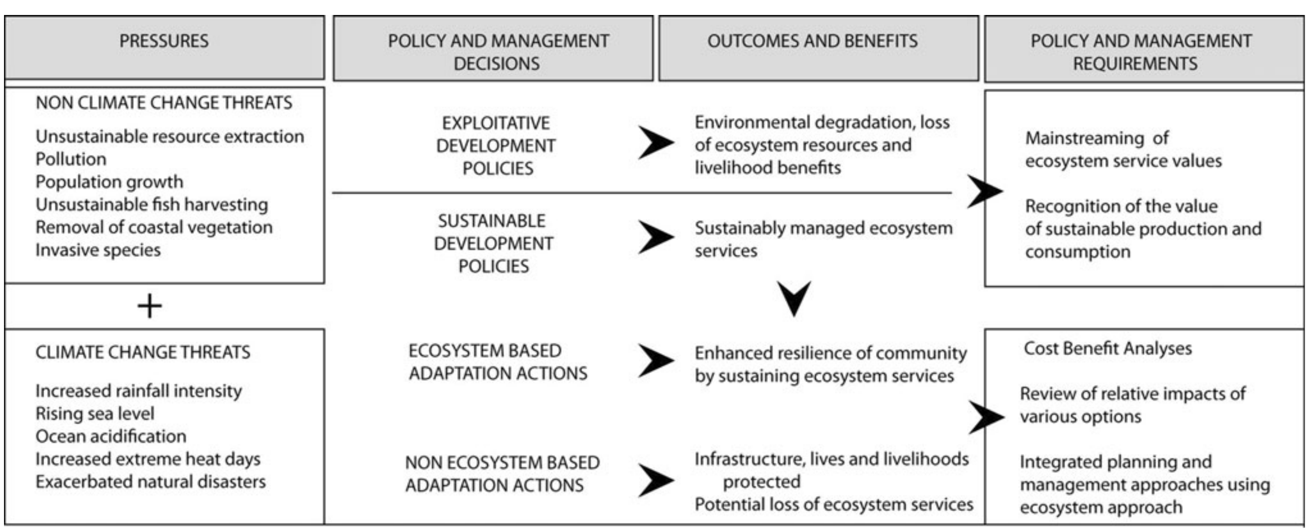


**Fig. 3** Policy and planning requirements and relationships for ecosystem-based adaptation

there are some recent examples of targeted EbA in these countries that are outside of the NAPA process, including a cost-benefit analysis of engineering and EbA examples in Lami Town in Fiji by Rao et al. (2013) that was part of the UNEP Ecosystem-based Adaptation Flagship Program and UN-HABITAT Cities and Climate Change Initiative.

In a Pacific Island context, it is suggested that the successful uptake of EbA is related to (1) demand from decision-makers for information on the full range of EbA and non-EbA solutions (often influenced by awareness of options and jurisdictional interests), and (2) the level of access to reliable data on the relative merits of alternative options in consideration of the local climate context, typically limited by relevant expertise, early-stage planning tools and associated financial resources for analysis, design, implementation and maintenance. In the Pacific, where natural capital is a greater proportion of wealth, these issues present a serious barrier to fully realising EbA as other forms of capital are required to effectively unlock this potential. Further, given the scale of donor investment in adaptation in the Pacific Islands, the main barrier to releasing this potential is not likely to be financial capital, but stable technical capacity within government departments to advise on EbA opportunities. Such capacity would likely create a broader uptake of targeted EbA efforts (including at the community level) and improve both the cost effectiveness and distribution of the adaptation investment portfolio across the region. An additional factor is the need for donor organisations to ensure that funds for climate change adaptation are applied following appropriate assessments of all relevant adaptation options including EbA but acknowledge that the high data, skill and resource requirements of targeted analysis will largely limit application to more general approaches of EbA.

## Conclusion

Sustainable livelihoods for Pacific Island peoples are highly dependent upon the significant natural marine and terrestrial resources within the region. Many of these resources have international and national economic value (e.g. tuna stocks) and global recognition (e.g. biodiversity). In addition, continued development, population pressure and wide spread non-sustainable land use practices are exacerbating vulnerability to extreme events and climate change impacts. Assessment of Pacific Island NAPAs in five countries suggests that conservation activities and relevant ecosystem services are given consideration in the planning process, but that there is limited evidence of full integration of EbA or direct comparisons of EbA options with alternatives in the process for identifying and prioritising adaptation activities. There is also a broad lack of awareness of the relative benefits of EbA, particularly challenging in the Pacific Islands where prioritisation is guided primarily by local preferences in a 'bottom up' decision-making process.

The need to maintain delivery of climate-relevant ecosystem services provides a strong social and ecological imperative to develop and widely implement EbA solutions throughout the Pacific Islands. To better act on this imperative it is recommended that Pacific Island country governments:

- Include consideration of EbA options explicitly in adaptation planning, including through the upcoming NAP process.
- Ensure that cross-cutting policy and planning instruments have integrated objectives compatible with EbA (e.g. in biodiversity and disaster management planning).
- Increase the national-level capacity to advise on EbA opportunities.

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