Understanding climate-human interactions in Small Island Developing States (SIDS)

Implications for future livelihood sustainability

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Received 23 January 2017
Revised 3 April 2017
9 June 2017
Accepted 2 August 2017

Abstract

Purpose – Climate change poses diverse, often fundamental, challenges to livelihoods of island peoples. The purpose of this study is to demonstrate that these challenges must be better understood before effective and sustainable adaptation is possible.

Design/methodology/approach – Understanding past livelihood impacts from climate change can help design and operationalize future interventions. In addition, globalization has had uneven effects on island countries/jurisdictions, producing situations especially in archipelagoes where there are significant differences between core and peripheral communities. This approach overcomes the problems that have characterized many recent interventions for climate-change adaptation in island contexts which have resulted in uneven and at best only marginal livelihood improvements in preparedness for future climate change.

Findings – Island contexts have a range of unique vulnerability and resilience characteristics that help explain recent and proposed responses to climate change. These include the sensitivity of coastal fringes to climate-environmental changes: and in island societies, the comparatively high degrees of social coherence, closeness to nature and spirituality that are uncommon in western contexts.

Research limitations/implications – Enhanced understanding of island environmental and social contexts, as well as insights from past climate impacts and peripherality, all contribute to more effective and sustainable future interventions for adaptation.

Originality/value – The need for more effective and sustainable adaptation in island contexts is becoming ever more exigent as the pace of twenty-first-century climate change increases.

Keywords Livelihoods, Adaptation, Climate change, Food security, Islands, Sea-level change

Paper type Research paper

1. Introduction

Underpinned by time-honored interactions with the natural environment, the livelihoods of most inhabitants of oceanic islands are today widely considered to be under serious threat from climate change. Populist depictions of islands as the "canaries in the coalmine" or being "at the front line of climate change" abound. Often considered implicit, such views appear more likely to have been shaped by the media and the (unwitting) prejudices of international observers, both informed by a largely superficial knowledge of island environments and societies (Dreher and Voyer, 2015; Farbotko and Lazrus, 2012; Orlove

International Journal of Climate Change Strategies and Management
Vol. 10 No. 2, 2018
pp. 245-271
Emerald Publishing Limited
1756-8692
DOI 10.1108/IJCCSM-01-2017-0012

et al., 2014). The narratives of vulnerability that inform associated interventions are echoed by representatives of many Small Island Developing States (SIDS) in international fora, in often stark contrast to the views of their citizenry (Barnett and Campbell, 2010; Kelman, 2010; Lata and Nunn, 2012; McNamara, 2009; Mortreux and Barnett, 2009). For, as several recent studies have shown, island societies and cultural practices have often high degrees of resilience to external shocks (Allen, 2015; Lazrus, 2015; McNamara and Prasad, 2014), something that would be expected of societies that have evolved for millennia in sometimes effective isolation on comparatively small remote landmasses in the middle of the world's oceans.

The idea that islands in the world's oceans, their ecosystems, their inhabitants and their livelihoods are highly vulnerable compared to most other situations in which people live explains the long history of external interventions for climate change on oceanic islands. That most such interventions, which have increased exponentially over the past 25-30 years, have failed to be either effective or sustainable has been documented and is attributed to issues of both planning/design and implementation (Lane, 2006; Lebel, 2013; McNamara, 2013; Nunn, 2009b).

This paper seeks to disentangle climate–human interactions on oceanic islands because these commenced and to identify those special characteristics of island environments and societies that remain valid in today's globalized world and could be used to help make future interventions for climate-change adaptation more effective and sustainable. The first part describes the histories of both climate change and livelihood change on islands in different parts of the world ocean (Section 2) before going on to describe the most common types of climate-livelihood interactions in island contexts (Section 3); three case studies are used to probe past responses of island societies to long-term (multi-generational) environmental changes. The special characteristics of island environments and societies are described next (Section 4) with emphasis on the diversity of community coping capacity that is frequently overlooked yet may make a difference between effective and ineffective responses to (future) environmental changes. How all this can inform future interventions in island societies to help them adapt to climate change is then discussed (Section 5).

2. Climate change and human livelihoods on oceanic islands

Rather than considering all islands, this paper focuses on those islands in the world ocean that are sufficiently distant from continental margins for their societies to have evolved largely in isolation from continental people before the era of globalization (Leppard, 2014). Most such oceanic islands fall into four geographical groups: those spanning the tropical Pacific (most numerous), those in the Caribbean, those (elsewhere) in the Atlantic and those in the tropical Indian Ocean. Baselines for discussion are provided by times of earliest sustained colonization/occupation of particular island groups.

Owing to the vast area and number of islands involved, the situation is most complex in the Pacific where almost all island groups were colonized as part of a broadly west-east migration that was completed before Europeans were even sure the Pacific Ocean existed. The earliest settlement occurred in the Mariana Islands (northwest Pacific) from the Philippines around 3,500 years ago (Hung *et al.*, 2011). Yet the colonizing voyages that led to the discovery and settlement of most Pacific Island groups began in the Bismarck Archipelago (Papua New Guinea) about 3,300 years ago (Specht, 2007) and led people to Solomon Islands and Vanuatu about 3,100 years ago, Fiji about 3,000 years ago (Nunn and Petchey, 2013) and central Polynesia about 1,200-800 years ago, a prolonged migration that culminated in occupations of the western seaboard of the Americas in at least three places (Baudouin *et al.*, 2014; Jones and Klar, 2005; Storey *et al.*, 2007; Ward and Brookfield, 1992) and the colonization of New Zealand around AD 1300 (Hogg *et al.*, 2003).

In the Caribbean, colonization/settlement in Cuba and Hispaniola began 5,000-3,000 years ago, perhaps from Belize (Cooper, 2010). Elsewhere in the Atlantic, people first reached the island of Lanzarote in the Canary Islands, 125 km from the African coast, 2,900 years ago (Atoche, 2008), but island groups farther from shore – like the Cape Verde and Azores island groups – are not believed to have had any human presence pre-dating the past millennium. Aside from the Maldives, which may have been occupied first almost 3,000 years ago (Forbes, 1987), no isolated islands in the Indian Ocean are known to have been colonized before the end of the fourteenth century when trading vessels likely encountered Mauritius and Réunion for the first time (Tibbetts, 1971).

It can be concluded that for those oceanic island groups settled for more than a millennium, a baseline age of 3,000 years ago for initial colonization is acceptable as a starting point for describing subsequent human–environment interactions. Most colonizers of these island groups developed livelihoods built around marine foraging; the pristine reefs fringing many tropical islands presented abundant possibilities, at least for a few hundred years (Giovas, 2016; Nunn and Carson, 2015b). For along most oceanic-island coasts 3,000 years ago, sea level was falling from its mid-Holocene maximum and eventually exposed reef surfaces, causing a rapid loss of useful bioproductivity and forcing foraging humans to diversify their livelihoods. This marked the first in a series of societal responses to (climate-driven) environmental forces in island contexts that was complemented by a number of human impacts on island environments and ecosystems, ranging from extirpations of the most readily acquired food species (Seeto *et al.*, 2012; Steadman *et al.*, 2002) to the decline of natural forests (de Nascimento *et al.*, 2016; Hope *et al.*, 1999).

2.1 Climate change affecting tropical oceanic islands: the past 3,000 years

In the tropical Atlantic, Indian and Pacific Oceans, the past 3,000 years was marked by an overall cooling (Marcott *et al.*, 2013), and there is compelling evidence to suppose that this period also saw a falling sea level in all these regions (Dickinson, 2001; Gherardi and Bosence, 2005), something for which empirical data are absent in the Caribbean owing to minor isostatic subsidence (Milne and Peros, 2013). Critical for understanding human livelihoods on islands in these regions is the presence of coral reefs that in some places had grown above present low-tide level when sea level was higher 6,000-4,000 years ago ("keep-up" reefs) but elsewhere had their surfaces below this level at this time ("catch-up" reefs) (Neumann and MacIntyre, 1985). It is probably no coincidence that islands with the latter types of reef were those most commonly colonized around 3,000 years ago when many such reef surfaces "met" falling sea level and began growing laterally, amplifying their food-resource potential for pioneer settlers; examples of such situations come from the likely first settlements in the Pacific island groups of Fiji and Tonga (Burley and Dickinson, 2001; Nunn, 2009a).

Paleoenvironmental records from most parts of these regions show that there were low-magnitude fluctuations in temperature and sea level within the past 3,000 years (Duprey *et al.*, 2014; Jones *et al.*, 2009; Woodroffe and Horton, 2005). Despite their comparatively minor nature, they often had major effects on island societies as these increased in density and complexity. The past four climate periods in most parts of the oceanic-island world were the Medieval Warm Period (Medieval Climate Anomaly) (AD 750-1250), the AD 1300 Event (AD 1250-1350), the Little Ice Age (AD 1350-1800) and the period of Recent Warming (after AD 1800) (Mann *et al.*, 2009; Nunn, 2007b; Saez *et al.*, 2009).

The Medieval Warm Period was a time of warming in all island regions (Gischler *et al.*, 2008; Oppo *et al.*, 2009), and there is evidence suggesting sea level also rose slightly during this time (Kopp *et al.*, 2016; Nunn, 2007b). Marking the ~100-year transition to the Little Ice

Age, the AD 1300 Event involved uncommonly rapid cooling and sea-level fall, evidence for which is widespread on tropical Pacific islands (Nunn, 2007a; Nunn, 2007b). The Little Ice Age is considered a global phenomenon (Mann *et al.*, 2009) and island paleoenvironmental records show it involved cooling and probably lower-than-present sea level in most parts of the world ocean (Burn and Palmer, 2014; Canellas-Bolta *et al.*, 2013; Wirrmann *et al.*, 2011).

Because it overlaps with the widespread installation of devices for monitoring temperature and sea level, the nature of climate change within the period of recent warming is well known. The broad pattern of warming and sea-level rise is unequivocal (Church *et al.*, 2013; Hartmann *et al.*, 2013).

In addition to decadal-century scale climate change, oceanic islands are periodically subject to shorter-onset climate events, not only typically associated with the El Niño-Southern Oscillation (ENSO) phenomenon but also including tropical cyclones (hurricanes or typhoons). Since AD 750, the influence of ENSO on tropical ocean climates has varied. During the Medieval Warm Period, for example, La Niña events were common and generally brought weather exhibiting fewer extremes than at other times, ensuring a regular seasonality that facilitated agricultural intensification on many tropical islands. This in turn supported population growth and allowed societal complexification as well as long-distance voyaging that sustained contacts to be maintained between island peoples across considerable distances[1].

The AD 1300 Event witnessed a sharp frequency increase of El Niño events in the tropical Pacific that introduced considerable inter-annual climate variability to tropical islands and derailed many of the subsistence systems that had hitherto largely sustained their inhabitants for centuries (Nunn, 2007a; Nunn, 2007b). The ensuing Little Ice Age was marked by a similarly high level of climate variability, especially (successive) multi-year droughts, that challenged the viability of many island societies in ways that came to define them, at least in the words of their earliest chroniclers (Allen, 2010; Field and Lape, 2010; McNeill, 1994)[2].

Tropical cyclones are more likely to develop in the Pacific Ocean during El Niño events but less likely to do so at such times in the Atlantic. Significant for island societies in the central and eastern tropical Pacific is that tropical cyclones tend to develop much farther east than usual during El Niño events and can often affect peoples on these islands at such times who are less familiar with tropical cyclones and consequently often ill-prepared to cope with their impacts. There is evidence that the incidence and intensity of tropical cyclones varied as climate has changed, particularly within the past 1,200 years (Terry, 2007). In recent decades, tropical cyclones in the western Pacific have become fewer yet those that have developed have generally been stronger (Walsh *et al.*, 2016)[3].

2.2 Livelihoods on tropical oceanic islands: the past 3,000 years

Reef foods played a key role in sustaining early settlement on many tropical islands (Szabó and Amesbury, 2011). In addition, the existence of naïve faunas, particularly (flightless) birds became important to human diets at least until the supply became exhausted, something that happened when islands were first colonized in both the distant and more recent past (Allen and Craig, 2009; Milberg and Tyrberg, 1993).

While such modes of subsistence could sustain pioneering populations, it is likely that as these grew substantially and wild food resources declined – both because of unsustainable levels of human predation and climate-driven sea-level fall (see previous section) – island peoples added other forms of food production. Both horticulture and agriculture feature in the earliest centuries of occupation of many western Pacific islands (Kirch, 2001; Valentin *et al.*, 2010). At the early Bourewa site in Fiji, it is proposed that during the first 200 years or so after colonization, people were sustained solely by wild foods but that, after cultivars of taro and yam reached the area (plausibly through return voyaging), this increasingly supplemented diets (Nunn, 2009a). On the island of Rapa (French Polynesia), the construction of pond-fields for intensified agricultural production began some 300 years after colonization, probably as a result of increased pressure from a growing population on dwindling wild food resources (Kennett *et al.*, 2006). A contrasting situation is found in the Canary Islands where the earliest colonizers, arriving perhaps 2,500 years ago, are concluded to have brought both domestic animals and a range of cereal cultivars with them, obviating any need to depend on wild foods (Morales *et al.*, 2009).

The roots of modern globalization took hold on most oceanic islands 150-500 years ago and initiated livelihood changes that became more dominant subsequently (Connell, 2013; McNeill, 1994). Plantation agriculture dislodged subsistence systems on many islands and the introduction of a cash economy disincentivized subsistence farmers in many places. A reliance on cheap imported store-bought foods is now widespread on many more populous islands with agriculture and fisheries often sidelined, sometimes considered more recreational or income-supplementing than a core activity although it remains thus on most more rural/peripheral islands (Campbell, 2015; Potter *et al.*, 2004).

3. Climate-livelihood interactions on islands

For most of the past 3,000 years on most inhabited oceanic islands, livelihoods took advantage of (and sometimes extended) opportunities for food acquisition afforded by island environments but were also forced to respond to (climate-driven) environmental changes: sometimes slow, sometimes rapid, invariably disruptive (Hannon *et al.*, 2005; Nunn, 2007b).

In addition to the collection of wild (reef and terrestrial) foods, most island environments offered opportunities for lowland agriculture and horticulture, especially around river mouths, where various systems of drainage and irrigation were developed[4]. In steeper terrain, root-crop production on many islands was traditionally enhanced through terracing, a practice that maximized rainwater use and optimized production (Bayliss-Smith and Hviding, 2015; Earle, 1980)[5]. Agroforestry was also used as a strategy for optimizing food production on islands (Athens *et al.*, 1996), but it has (like agricultural terracing) in many places become a casualty of globalization: a system of sustainable low-input production displaced by readily acquired imported foods. The current revival of interest in agroforestry on many islands is seen both as a way to improve diets (and reduce the incidence of non-communicable diseases) and also to lessen island nations' dependence on food imports (Clarke and Thaman, 1993; Hviding and Bayliss-Smith, 2000; Palada *et al.*, 2005; Pandey, 2011).

The contribution of marine foods to islander diets varied in time and space; on better-endowed islands, fisheries have for millennia commonly dominated livelihoods for coastal dwellers. Island societies often evolved techniques for food preservation (McNamara and Prasad, 2014; Svanberg, 2015), a buffer against drought and other climatic extremes, and routinely generated surpluses to help sustain people following disasters (Janif *et al.*, 2016; Johnston, 2014). When surpluses were unneeded, it allowed periodic feasting, considered characteristic of consumption habits in some island cultures (Leach, 2003; Myles *et al.*, 2011).

While most island societies evolved effective strategies for coping with short-term climate variability, responses to longer-term climate change were sometimes less successful. Three case studies are given below to illustrate the nature of such responses. The first two examples illustrate the profound cultural-societal impact that slight changes in sea level have had on island livelihoods in the past, the third example from recent times illustrating pathways toward maladaptation.

3.1 Case Study 1: sea-level fall about 2,570 years ago in western Pacific Island groups

Occurring at a time when sea level in the region was falling, the earliest period of human settlement in island groups of the western Pacific is archaeologically conspicuous. Dominated by marine foraging, it also involved the fabrication of often intricately decorated earthenware and shell valuables, suggesting food acquisition was comparatively easy, as might be expected for people who colonized islands with pristine ecosystems, onshore and offshore (Carson, 2014; Kirch, 1997). What is remarkable is that while this period of earliest settlement commenced (with colonization) at quite different times in different island groups, it ended abruptly at the same time – around 2570 cal yr BP (620 BC) (Nunn and Carson, 2015b).

This observation demands a regional (not multiple local) explanation, the most likely involving sea level falling below a critical (bioproductivity) threshold along reef-fringed coasts causing the rapid depletion of reef-surface foods. In turn, this forced communities that had previously settled adjacent to fringing reefs to relocate to places (like river mouths) where crops might be more readily cultivated. Dependence on agriculture required island societies to devote more energy toward food production than was the case when livelihoods were centered on marine foraging, so this time appears to mark the (archaeologically sudden) end of decorated-pot manufacture and probably other (non-production-related) cultural traits in these island societies (Nunn and Carson, 2015b).

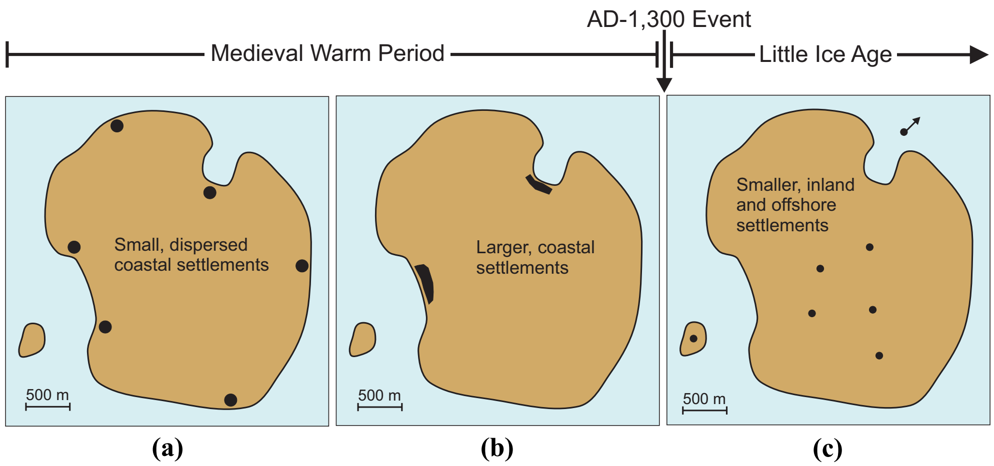
3.2 Case Study 2: the AD 1300 event throughout the tropical Pacific

In almost every group of tropical Pacific islands, settlement changed from being dominantly coastal to being significantly inland about AD 1200-1400. This is plausibly interpreted as a response to the onset of widespread conflict, forced by a massive drop in coastal-food availability, a likely effect of a ~70-cm drop of sea level during the AD 1300 Event (Nunn, 2007a; Nunn, 2007b).

Settlement on a typical high island in the tropical Pacific was coastal throughout the Medieval Warm Period. Increasing warming and sea-level rise throughout this period is inferred to have encouraged population growth and necessitated production intensification through cooperative activities, such as the construction and maintenance of agricultural terraces and the need to travel farther offshore to catch fish (after inshore stocks became depleted). This accounts for a shift from smaller nucleated coastal settlements early in the Medieval Warm Period to larger coastal settlements in its later part (Figure 1).

Sea-level fall during the AD 1300 Event is thought to have caused a food crisis, both through exposing offshore reef surfaces, increasing nearshore/lagoonal water turbidity and lowering coastal water tables (Figure 2).

Within the course of perhaps 100 years, a plausible scenario is that as this food crisis worsened, conflict erupted and led to the abandonment of exposed coastal settlements in favor of ones inland/upslope/offshore in more defensible locations. Evidence for such a settlement-pattern change is found on numerous Pacific islands (Nunn, 2007b). Hillforts dating from this period have been described from many (Anderson *et al.*, 2012; Pearl, 2004; Robb and Nunn, 2012). The legacy of societal instability from the sea-level fall during the AD 1300 Event endured throughout the ensuing Little Ice Age, perhaps periodically reinforced by El Niño associated droughts that were more of a feature of this period than the Medieval Warm Period (see above).



Notes: (a) Early in the Medieval Warm Period, most settlements on high islands in the tropical Pacific were coastal, comparatively small, and dispersed; (b) later in the Medieval Warm Period, as populations grew and more food was required, cooperative enterprises (like agricultural terracing) were introduced, requiring that people live closer together. Larger settlements developed; (c) following comparatively rapid cooling and sea-level fall during the AD 1300 Event, coastal-food availability dropped dramatically (Figure 2), leading to conflict that drove coastal dwellers to establish new settlements in defensible locations (caves, mountain-tops, smaller offshore islands), a pattern that characterized the Little Ice Age
Source: After Nunn (2007b)

Figure 1. Typical settlement-pattern change driven by climate change on an imagined Pacific Island since AD 750

3.3 Case Study 3: responses to recent sea-level rise

Within the past 200 years or so, sea level has been rising around most oceanic islands (Church *et al.*, 2006; Velez *et al.*, 2014)[6]. The best-available projections for the future show that sea-level rise is likely to accelerate for the rest of this century (Church *et al.*, 2013)[7] and will continue rising thereafter for at least a few hundred years (Jevrejeva *et al.*, 2012). The ways in which island peoples have responded and are likely to respond to sea-level rise are relevant to understanding how best to sustain coastal livelihoods in the future.

It seems likely that before about AD 1850 along most oceanic-island coasts, settlements that became unviable for some reason were simply relocated, the architecture of most dwellings allowing for them to be comparatively easily rebuilt elsewhere. This is an obvious human adaptation to the long-term occupation of environments that are uncommonly exposed to environmental extremes including – for most such islands – tropical cyclones and storm surges, earthquakes and tsunamis, volcanic eruptions and even the abrupt collapse of steep island flanks (Nunn, 2009c; UNISDR, 2009).

Yet because foreign colonization and more recently globalization of many island societies, traditional attitudes toward coastal settlement have changed, becoming more aligned with those of the (continental) colonizers that treat long-term *in-situ* coastal settlement as normal and sustainable (Cunliffe, 2001; Gillis, 2013). So over the past 50-100 years on many oceanic islands, there has been increased and intensified occupation of the coastal zone: probably at levels earlier generations of islanders would likely have eschewed. Recent challenges to coastal living on islands have, as in richer/continental countries, been met with attempts to sustain *in-situ* settlement, generally through the construction of artificial shoreline-protection structures. The problems with this approach in an island

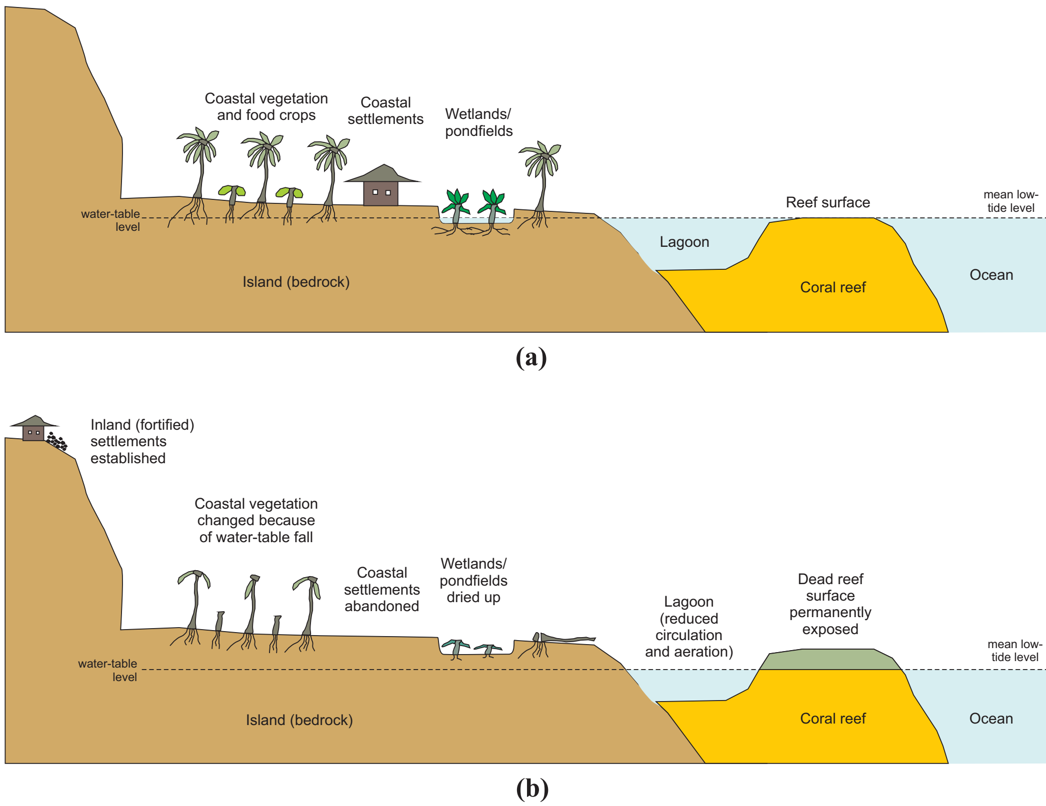


Figure 2.
Changes in coastal-food productivity on a typical high Pacific island between AD 1200 and AD 1400 were forced by a sea-level fall driven by cooling during the AD 1300 event

Notes: (a) Typical high-island coast during the late Medieval Warm Period. Coral reefs aregrowing at and below low-tide level; reef-bounded lagoons are regularly flushed; coastal plains host various food-production systems yielding regular foods to sustain (dense) coastal populations; (b) typical high-island coast during the early Little Ice Age following the fall of sea level and water tables during the AD 1300 Event. The surface of the coral reef is permanently exposed, its former bioproductive capacity lost; reef-bounded lagoons have become turbid and inadequately flushed to sustain their former levels of food production; water tables have fallen on coastal plains meaning that many food crops die
Source: After Nunn and Carson (2015a)

context are twofold. First, islands have far longer coastlines (per unit area of land) than non-island countries so that shoreline protection is generally far more expensive and far more prone to failure. Second, most oceanic islands are part of poorer/developing nations where funding for the construction and upkeep of such structures is often prohibitive. Yet they continue to be built.

This “seawall mindset” (Nunn, 2012) can be seen an outcome of globalization where island peoples have embraced an apparent global orthodoxy without fully evaluating its applicability to their particular context. In most island countries, beyond the main urban centers (where aid often provides for the construction and maintenance of shoreline protection), failed seawalls, which have collapsed and for which insufficient funding is available for rebuilding, litter many shorelines.

Seawalls are a common form of maladaptation in island countries yet remain, like other short-term adaptive solutions, a popular response to the increasingly widespread problems of shoreline erosion and lowland coastal flooding driven by sea-level rise. Longer-term adaptation is much discussed but, as yet, rarely fully embraced in island contexts for, in the absence of sufficient funds to adequately engineer hard-structure solutions, the only viable option in most situations is relocation: on higher islands, generally upslope and inland; on lower islands, often over-sea resettlement to somewhere less vulnerable[8]. Like coastal dwellers in most countries who have become accustomed over several generations to coastal living and its advantages, the idea of leaving the coast to move elsewhere is anathemic – and often spawns denial of sea-level rise (Rudiak-Gould, 2014). There are examples of this from island contexts, including a belief that divine providence will not allow coasts to be swamped (Mortreux and Barnett, 2009) to the contention that short-term climate variability explains the current sea-level rise and that this will shortly be replaced by one of sea-level fall that will return the ocean to its "normal" condition (Lata and Nunn, 2012).

Yet as shown by Case Studies 1 and 2 (above), island coasts are particularly sensitive to even comparatively small sea-level changes and livelihoods have sometimes needed to be comprehensively reconfigured in response to these. The current situation on many oceanic islands – as it must be said along many continental coasts – is that both coastal living and livelihoods are being threatened by sea-level rise with the result that the need for effective and sustainable adaptation is becoming ever more urgent. Yet, as elsewhere in the world, the pace and scale of political response is currently inadequate to prevent major disruption to island economies in the next 20-30 years.

4. Special characteristics of island environments and societies

Designing effective and sustainable adaptation strategies for oceanic-island contexts requires an understanding of these that encompasses both environmental and socio-cultural knowledge, localized and culturally grounded, respectively[9]. It also requires an understanding of the diversity of contexts involving a familiarity with the characteristics of the response unit (like a town/village or community), its methods of coping with livelihood stress, and its ability to apprehend and respond appropriately to the long-term challenges that will arise from future climate change. The singular nature of island environments and societies as well as the question of diversity are discussed separately in subsections 4.1-4.3 below.

Superimposed on these issues is the politicization of oceanic-island countries and the effects that this has on environmental governance and sustainability issues, particularly in rural/peripheral contexts (Kelman, 2014). For while the rate of urbanization in many such countries is comparatively high by global norms, most people in most oceanic-island nations live outside cities, typically in villages or communities with some degree of nucleation and centralized decision-making (Connell, 2011; Connell, 2013)[10].

Lacking personnel and funds, most national governments in these countries have insufficient capacity to regulate community-level decision-making, a situation that is unlikely to change for the better in the foreseeable future (Nunn, 2010). Many aid programs provide short-term funding, the cyclic nature of which invariably militates against the long-term sustainability of interventions. The upshot of all this is that in the future, it is likely that most rural communities in many island nations will have to plan and operationalize their own responses to the effects of future climate change. This represents a huge challenge for many community leaders although there is a growing body of research asking how this challenge might be met (Buggy and McNamara, 2016; Nunn *et al.*, 2014).

4.1 Island environments

In island countries, coastal environments are generally the places most favored for settlement because of their potential for (marine and terrestrial) food acquisition; the benefits of the flat terrain for agriculture, settlement, transport, communication and infrastructure and the comparative unattractiveness of most other available (inland) environments. Sometimes of course, island dwellers have no choice but to live along the coast because the islands they occupy are entirely coastal. This situation is quite different to most non-island countries where coastal environments are generally merely one of a number of discrete environmental types with differing management imperatives.

It has been argued that any intervention on oceanic islands by (continental) donor nations "demande en particulier qu'on ne les traite pas comme des milieux continentaux de faible taille; toute catastrophe y a des effets irréversibles"[11] (Doumenge, 1987, p. 15). Islands are not miniature continents, and a failure to recognize their special environmental characteristics has contributed to many intervention failures (Gillis, 2014). At the heart of these has been an insufficient understanding of how island societies interact with the environment and how they invariably view efforts by outsiders to influence those interactions (Section 4.2). But the special nature of island environments, outlined below, is also important.

One widespread issue is "smallness", generally a meaningless concept when applied to island size[12], but one that appears instinctive to continental dwellers when they land on islands for the first time[13]. The precise issue is that in the eyes of the visitors, the land area of the island is smaller (and its surrounding ocean more prominent) than almost anything they have encountered before, so they instinctively regard it as vulnerable, something amplified in their minds by the (apparently) remote location of the island and the number of people living there, often in apparent poverty[14]. A series of similar biases have seen oceanic islands become "small islands" and island countries become "SIDS" in common international usage. Comparatively small land areas are no more challenging to occupy than larger ones. Many oceanic islands support comparatively large population densities well and have done so using ingenious production systems for millennia[15].

Most high islands in tropical oceans are characterized by a high diversity (per total land area) of potential food-production systems, including deep-ocean, reef-lagoon (nearshore), mangroves, estuaries, coasts, river valleys and upland. For many island populations, both today and in prehistory, this diversity supported food security; if one system became depleted, another could be (increasingly) utilized. Yet this diversity is countered on most oceanic islands by comparatively low biodiversities and a heightened vulnerability to invasive species.

The favoring of coastal environments for settlement on oceanic islands and the almost total lack of interaction with inland environments, where these exist, is another point of difference with similarly-sized continental landmasses. While an understandable choice in terms of food availability, coastal living, especially on islands in active geotectonic locations, is more than averagely perilous. Coastal dwellers on such islands are often far more exposed to short-onset environmental changes than people living elsewhere. These changes include those that come across the ocean (tsunamis, storm surges); they include tropical cyclones, which intensify over oceans (and generally lose momentum over large landmasses), as well as those deriving from the land (earthquakes, volcanic eruptions). The potential of extreme events to fundamentally damage an island-coastal society is manifest[16].

4.2 Island societies

Together with their exposure to climate-driven environmental changes, their comparative smallness and remoteness – indeed the insularity – of many oceanic islands contributed to the adaptation of island societies to limited land/nearshore areas and limited resources (often requiring sustained management). Some of these adaptations can be regarded as responses to short-term vagaries of production, many driven by climate change. Responses to longer-term changes, as discussed in Case Studies 1 and 2 above (Section 3), often involved fundamental cultural transformations and may in some cases have led to the collapse of island societies[17].

One cultural legacy of such histories on many islands refers to environmental (and other) governance in rural communities. Commonly hierarchical, rarely democratic or consultative, such decision-making defines many rural Pacific Island communities today. The degree to which this type of traditional island governance is suited to determining the future of rural (subsistence-focused) communities in a globalizing world might be legitimately questioned. Yet in the absence of clear direction from national governments (see above), such questioning of traditional decision-making is beginning to lead to the fracturing of communal responses to the environmental effects of climate change (Janif *et al.*, 2016; Nunn *et al.*, 2014).

And yet, as has been widely acknowledged, the resilience of many island societies – as is evident from their unbroken residence of comparatively small and remote ocean-bounded landmasses often for millennia – has at its core a communal approach to sustainability. In practical terms, this means that communal living is also preferred over smaller nucleated family groups; that is, in times of adversity, resources are generally shared; and that weaker or less fortunate members of the community are looked after by the others (Ravuvu, 1987). This also applies between communities both within the same island or between islands. Some long-distance exchange networks that flourished in the pre-contact Pacific have been reconstructed and were clearly critical to maintaining both kinship ties as well as support mechanisms (Fitzpatrick, 2008)[18].

The attitudes of many island peoples toward nature and environmental conservation differ significantly from many continental dwellers. The influence of islanders' spiritual beliefs in comprehending and shaping responses to climate change – past, present and in the future – is also far higher, something that should be incorporated into strategies for adapting to climate change (Nunn *et al.*, 2016b).

Livelihoods on most oceanic islands depend significantly on the ocean[19]; even in island cities, seafood is more commonly consumed than almost any other protein source (Cleasby *et al.*, 2014). In rural communities, the routine acquisition of food from the ocean, especially from reef-lagoon (nearshore) environments is widespread. Some such interactions on many islands were once sustainably managed with taboos placed on locally diminished resources to permit their recovery when needed (Akimichi, 1986; Johannes, 1978). The spread of the cash economy throughout island countries has led to the unsustainable production of surpluses in many places, especially those close to (urban) markets. While attempts have been made to revive traditional regulatory practices (Aalbersberg *et al.*, 2005; Olds *et al.*, 2014), most recent efforts at establishing sustainability in such communities have been framed in modern/western ways (Cinner, 2007). This illustrates the basic tension between traditional and contemporary demands on such environments, the first designed to be able to sustain island populations and even generate occasional surpluses, the second designed to sustain livelihoods (Campbell, 2015; Lane *et al.*, 2013).

The loss of traditional knowledge in many island communities has been countered by the acquisition of global knowledge. This might be considered a fair trade although global knowledge invariably provides people with information about the mechanics of adaptation but little insight into how to localize this and thereby make it effective. There is good reason to try and conserve traditional knowledge in many rural/peripheral island contexts, even the stories and myths that may have been passed down for generations because this represents an accumulation of wisdom over hundreds, sometimes thousands, of years that often captures the environmental and cultural nuances of living in particular places (Kelman, 2010; Mercer *et al.*, 2007; Nunn, 2014).

Yet, as history has shown in numerous instances, many island societies have been exposed to more profound environmental threats than non-island societies. Sometimes island societies have been transformed, even caused to collapse, by the effects of enduring (climate-driven) environmental change on their resource bases. In the modern era, such details are commonly forgotten in discussions of livelihood sustainability. For instance, it is clear that many atoll islands, currently inhabited, may become uninhabitable in a few decades (Dickinson, 2009). Popularly regarded as unprecedented, an alarming consequence of "climate change", the fact is that most such islands became habitable only a few millennia ago at most (Kench *et al.*, 2014; Nunn, 2015). From a geological perspective, it should therefore come as no surprise that these most transitory and fragile of island types should now be "disappearing".

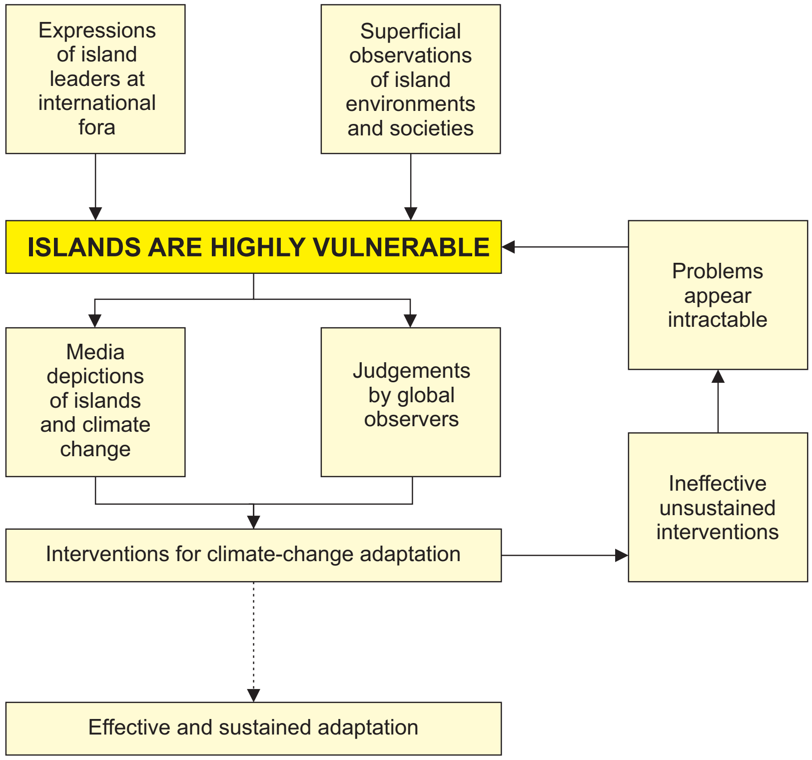
In response to their comparatively high exposure to short-onset extremes, many island societies evolved adaptive/coping mechanisms. These include the identification of event precursors, the development of culturally grounded response strategies (when and where to move), food preservation and an assured supply of surpluses and "cyclone foods" (Aalbersberg *et al.*, 1988; Janif *et al.*, 2016; Johnston, 2014; Lefale, 2010). Some island societies developed cultural attitudes that included a far higher tolerance of such changes than most (continental) cultures elsewhere (e.g. in Vanuatu – Galipaud, 2002).

Finally, a global belief in the vulnerability of "small islands" and their inhabitants' livelihoods has driven a massive (and expensive) international effort over the past 25-30 years to embed successful climate-change adaptation. Much has failed to be either effective or sustainable, and it is suggested that this failure has itself helped to sustain, even amplify, the perception of islands as vulnerable (Figure 3).

4.3 Peripherality in island contexts

All nations exhibit peripherality – changes in various societal characteristics between developmental cores (normally the largest cities) and the periphery (Mao *et al.*, 2014; Sofer, 1988). Particularly in archipelagic island nations, core-periphery gradients are steeper than in continental (or single-island) countries because of the presence of multiple ocean gaps. Peripherality is a key variable to inform the precise design of climate-change adaptation strategies (and other plans) for communities in different geographical locations within multi-island countries (Nunn *et al.*, 2014).

At the time when continental powers had colonized many island groups, the diversity of these was often explicit: in fact, often the only available sources of information about the islands and their inhabitants were those that emphasized the diversity of opportunity, especially for (agricultural) production and trade. Post-colonial and modern histories of these island groups became framed within globalized geographies that situate islands within a global interactive web where external interactions are more important than localized diversity. This in turn has informed both bilateral and global engagement with them and is responsible for the "one-size-fits-all" approach that commonly underpins the current characterization of islands in global and regional (super-national) planning[20].



Notes: Based both on the views expressed by many island leaders and on superficial observations of island environments and societies, the belief that islands are highly vulnerable became established. This fueled media depictions of islands as vulnerable and was supported by judgements of global observers, both of which led to interventions for climate-change adaptation over the past 25-30 years. Few of these interventions have proved either effective or have been sustained. The apparent ineffectuality and unsustained nature of interventions has spawned the belief that the challenges confronting island nations may be intractable, a view that feeds into the assumption that islands are highly vulnerable. The reality is different (see text)

Figure 3. Diagram explaining how the failure of interventions for climate-change adaptation in many oceanic-island contexts has amplified and sustained impressions of these as being uncommonly vulnerable

Many authors have concluded that downscaling of global imperatives, whether these are policies or projections, is needed to translate these effectively from the global to the local level (Khalyani *et al.*, 2016). Related to this is the disconnect that commonly exists in island nations between regional/national planning for climate change and the development/adoption of appropriate strategies at local/community level; most rural communities in tropical Pacific Island nations have generally little knowledge of future climate change, no strategies for adaptation, and commonly little awareness of relevant national/regional initiatives (Lata and Nunn, 2012; Nunn *et al.*, 2014). In island countries, as elsewhere, where governments have little influence on environmental governance in rural communities (Section 4), the localizing of such initiatives seems essential to make them acceptable to the communities that will be required to drive them in the future.

One pathway to localization is to understand the singular character of individual (rural) communities, and while this might seem ideal, it is a time-consuming and often non-transferable approach. Better is one that identifies the key characteristics of groups of communities within an (archipelagic) island country. And by analogy with other parts of the world, it seems that such diversity is best measured in geographical segments along core-periphery gradients that exist. This paper suggests that peripherality is therefore a valid proxy for the vulnerability/resilience of each rural community in an (archipelagic) island country.

While research has commenced only recently on the topic of peripherality in island countries, preliminary data suggest that the kind of situation shown in Figure 4 is likely to be widespread. Figure 4(a) shows the core-periphery gradient in an imagined archipelagic country; each island is each assigned to a different segment depending primarily on its geographical location.

Because it is an example, Figure 4(b) shows a graph for traditional versus global knowledge in particular communities, criteria selected because this information directly informs coping strategies. A (near-core) community with a high awareness of global change is more likely to subscribe to globalized strategies for adapting to climate change than a

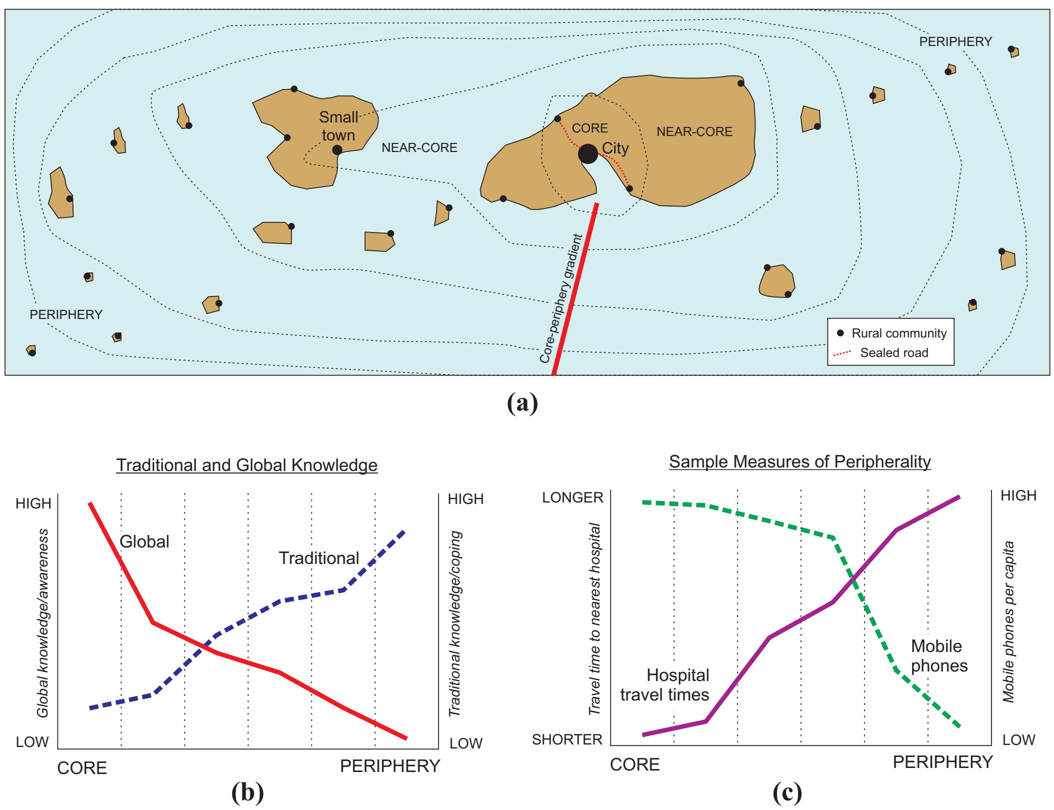


Figure 4.
The concept and measurement of peripherality in an (invented) archipelagic context

Notes: (a) Map of island nation showing the six core-periphery divisions determined by data on non-urban communities similar to that shown in b and c; (b) variations in traditional and global knowledge for communities within each of the six core-periphery divisions; (c) variations in time to nearest hospital and mobile-phone ownership for communities within each of the six core-periphery divisions (peripheral) community with far less such awareness. Conversely, owing to its greater traditional knowledge, a peripheral community is more likely to buy into strategies that are geographically localized and culturally grounded; a near-core community is likely to be significantly less concerned that any coping strategy on offer is either geographically or culturally filtered. Given the importance of localization, it might then be argued that interventions for climate-change adaptation in near-core communities are more likely to fail than those in peripheral communities.

Figure 4(c) selects two other common measures of peripherality – time to nearest hospital and mobile-phone ownership. Occupants of communities that are comparatively close to hospitals are more likely to depend on the (western) medical treatments they offer and less likely to resort to traditional remedies and vice versa. Communities with more mobile phones per capita are more likely to be nationally/globally engaged, to access information in more diverse ways from more sources than communities with fewer mobile phones. Conversely the latter communities, being less globally informed and unable to access as much non-local information, may be more resilient.

5. Informing future interventions for climate-change adaptation

The high proportion of failed interventions for climate-change adaptation in island contexts over 25-30 years is regrettable and may have exacerbated ongoing global perceptions of the intractability of the challenges facing island nations (Figure 4). Yet as the pace of twenty-first-century climate change accelerates, so the imperative of developing and implementing adaptation in island contexts that is both effective and sustainable is increasing.

In this sense, "effectiveness" means that the proposed solution is appropriate to both the local environment and the local communities that routinely interact with it. In environmental terms, some assessment of the state of the environment and the trajectories of human interactions affecting it is a necessary preliminary. For while many island-coastal environments have been documented as being degraded, many others are not so, and their bioproductivity can be readily optimized, often through subtle changes in management (Albert *et al.*, 2015; Hay, 2013; Lane *et al.*, 2013; Veitayaki *et al.*, 2003). In terms of effectiveness for local communities, there is a need to understand people's attitudes toward the environment and how these might change in the future. Many common solutions – like seawalls (see above) – are unlikely ever to be effective in communities where cash is scarce because of the ongoing need to purchase material to service the solutions.

The emphasis on adaptation that is "sustainable" is also key for, if effective solutions do not endure, their value is slight. Many communities that have received interventions for climate-change adaptation, typically from donor partners, found that when the funding for these ceased – often at the end of a three-year funding cycle – the onus to sustain the intervention shifts to the recipient communities. This is probably the most common reason for failure of climate-change adaptation at community level in Pacific Island nations, and it underscores the common lack of transparency (mutual understanding of expectations) between donor and recipient at the planning stage of the project. There is currently a shift away from the imposition of adaptive solutions to the co-development of these with recipient communities, a process that generally explicitly maps how the solution will be sustained beyond the end of the project. Other lessons around the incorporation of cultural knowledge and beliefs in adaptive solutions, their culturally sensitive communication (including the use of vernacular languages) and the importance of communities "owning" these solutions to ensure their sustainability need to be more widely understood (Nunn, 2009b).

6. Conclusions

The widespread perception of islands and their inhabitants as being especially vulnerable to climate change has some empirical grounding but is also a view that has been exacerbated in recent years by the lack of visible progress toward climate-proofing livelihoods on islands. There is no shortage of photographs of vulnerable island people, no shortage of media stories or indeed vehement expressions of concern by representatives of island countries in international meetings about the experienced and anticipated effects of climate change. What is missing from these narratives is that the situation for most people on most oceanic islands being affected by climate change has not changed in 30 years despite millions of dollars for adaptation having been made available[21]. The ineffectiveness and unsustainability of associated interventions is manifest from this, as well as from the large numbers of "failed" adaptation initiatives, such as the remains of collapsed seawalls that litter the coasts of many tropical Pacific Islands. While criticism of the nature of interventions for adaptation has been growing in the past few years (McNamara, 2013; Nunn, 2009b), this is the first study to argue that adaptation failure is a key factor in sustaining, even amplifying, perceptions of island vulnerability.

All this needs to be contextualized in the context of climate change as a global issue and thereby inherently difficult to localize effectively (Hulme, 2010). Inevitably, it seems, this problem has led to uneven attention being given to climate change in different places; for instance, oceanic islands and the Arctic rather than deserts and mountains, which are more commonly aligned with narratives of sustainable development other than climate change (Orlove *et al.*, 2014). To persuade people across the world of the seriousness and immediacy of climate change, some consider that there is a need for a "poster child" that can be filled by islands: a role embraced by the international media and, it must be said, scarcely resisted by the leaders of many island nations (Chambers and Chambers, 2007; Farbotko, 2010).

In practical terms, this paper offers two ways forward for the island peoples who will need to adapt their ways of life to a future environment forever altered by climate change. First, there is a need to ensure that islander values and aspirations are at the heart of future adaptation planning and that this is environmentally appropriate as well as communicated in culturally acceptable ways. This will ensure that the two pillars required for successful climate-change adaptation – that it is effective and sustainable – are both met. Second, having dismissed the idea that island environments are merely continental environments in miniature, there needs to be a widespread appreciation of the diversity of island communities, particularly in archipelagic SIDS, through segmentation of the core-periphery gradient. The idea that "one size fits all" in terms of community intervention should be replaced by one that acknowledges the differing exposure to traditional and global knowledges as well as the differing coping abilities of communities with varying degrees of peripherality. Such would set many island communities on the path of a more sustainable future.

Notes

1. For example, ocean distances of at least 1,750 km were involved in the regular movement of fine-grained basalt well suited to stone-tool manufacture from Eiao Island in the Marquesas group (French Polynesia) (Weisler, 1998). Similar distances are likely to have been involved in the export of *kava* from Vanuatu to Tonga between about AD 1200-1447 (Luders, 1996).

2. Among these characteristics were an apparently perpetual state of warfare, manifested as aggression toward outsiders and even perhaps spawning cannibalism and headhunting (Nunn, 2007b). Traits of many island societies that involved "infanticide, abortion, and other methods of

population control" (McNeill, 1994, p. 310) can also be seen as responses to resource depletion forced by variable and extreme climate during the Little Ice Age.

3. Severe Tropical Cyclone Winston in February 2016 became the strongest ever recorded to have affected Fiji with winds as much as 325 km/h recorded.
4. Some of these were elaborate. Those described on Aneityum Island (Vanuatu) may be more than 1,000 years old and not only involved irrigation networks but also via ducts transporting water from one valley to another (Spriggs, 1997).
5. Many of the earliest written accounts of New Caledonia described impressive irrigated systems of taro terracing as well as the use of mounds (to retain water in the dry season) for yam cultivation, both sophisticated responses to feeding growing populations in a seasonal climate context (Barrau, 1967).
6. There has been considerable regional variation in the rates of sea-level rise in recent decades. In the Pacific, for example, sea-level rise has averaged around 3-4 mm/year over the past few decades, but in island groups of the western Pacific (like those in the Federated States of Micronesia, Palau and Solomon Islands), this rate has been closer to 10 mm/year. No net sea-level rise has been recorded around island groups of the eastern Pacific (like the Galapagos) within this period (Becker *et al.*, 2012).
7. The IPCC 5th Assessment (2013) considered that global sea-level rise for 2081-2100 will (relative to 1986-2005) be 52-98 cm high for the RCP8.5 scenario. A 2016 recalculation of the upper limit suggests that sea level may in fact be 130 cm higher by the end of this century (Mengel *et al.*, 2016). This upper limit may in fact be much higher, perhaps 190 cm (Jevrejeva *et al.*, 2014).
8. There are increasing numbers of such over-sea resettlement in the Pacific Islands. One that occurred decades ago was the removal of Banaban people from Kiribati to the island of Rabi in Fiji (Kempf, 2003); a more recent example, clearly fuelled by rising sea level, is from the Carteret atolls to nearby high Bougainville Island in Papua New Guinea (Connell, 2016). Yet much international migration from island countries claimed to have been driven by 'climate change' is more likely to have been for economic or other reasons (Locke, 2009).
9. An attempt at understanding cultural attitudes towards coastal change to design effective and sustainable future strategies for climate-change adaptation was recently made in the islands of the Federated States of Micronesia (Nunn *et al.*, 2016c).
10. The percentage of urban dwellers in selected Pacific Island countries (from www.spc.int in August 2016) is as follows: Federated States of Micronesia (22 per cent), Fiji (51 per cent), Samoa (20 per cent), Solomon Islands (20 per cent), Tonga (24 per cent) and Vanuatu (24 per cent). The Pacific average is 23 per cent. Fiji is exceptional in that its comparatively large number of urban centres present considerable employment opportunities which account for its comparatively high urban population.
11. "Requires particularly that one does not treat them [island environments] as simply continental environments on a small scale; a disaster here may have irreversible consequences", a point also made by Nunn (1987).
12. When applied to an island, the adjective 'small' is meaningless. Its wide usage in international discussions reflects assumptions of mostly continental dwellers that pieces of land in the middle of the oceans are generally 'small' and therefore vulnerable. Unsurprisingly, island dwellers generally dislike the pejorative connotations of the sobriquet 'small' (Nunn, 2004). That said, when 'small' is quantified as part of a classificatory system (as in Nunn *et al.*, 2016a), its use is justified.
13. "Western civilization is landlocked, mentally if not physically" (Gillis, 2013, p. 7).
14. A point reinforced recently by Fitzpatrick *et al.* (2016, p. 156) who wrote that "on a global scale and for a very long time, scholars and layman have generally perceived of islands as marginal environments".

15. A good example is the *ahupua'a* (or integrated land-ocean production systems) of Hawaii "represented the foundation of the agricultural economies of the island of Hawai'i and parts of Maui in the centuries before European contact" (Kagawa and Vitousek, 2012, p. 161).
16. The traditional history of Pukapuka Atoll (Cook Islands) is divided by an event known as *te mate wolo* (the great death) in the early seventeenth century when a tsunami washed over the island leaving only a handful of survivors (Beaglehole andhx0026; Beaglehole, 1938). Tropical Cyclone (Hurricane) Ivan affected 81,553 residents (79 per cent) on Grenada Island (Caribbean) of whom 18,000 were evacuated or resettled (Manuel-Navarrete *et al.*, 2007). Tropical Cyclones Pam (March 2015) and Winston (February 2016) caused massive damage to islands in Vanuatu and Fiji, respectively; both were Category 5 storms with wind gusts of more than 300 km/h (Anonymous, 2016).
17. Climate change is implicated in the much-vaunted collapse of Easter Island society about AD 1400 (Hunter-Anderson, 1998) as well as others (Nunn & Carson, 2015a). The existence in the tropical central and eastern Pacific of 'mystery islands', which were uninhabited at the time of their first documented discovery yet contained evidence of former occupations, also points to collapse leading to abandonment (Di Piazza and Pearthree, 2001; Weisler, 1996).
18. Perhaps the two best-known examples are that of the Kula Ring that operated in the outer islands of Papua New Guinea (Esser, 2011) and the *sawei*, described as a "system of tribute offerings, gift exchange and disaster relief", that operated in the Caroline Islands and centred on the islands of Yap (Hunter-Anderson & Zan, 1996, p. 1). As Connell notes, on islands "survival necessitated external ties. Small islands could not afford to be insular" (Connell, 2015, p. 15).
19. FAO data show that "the contribution of fish to dietary animal protein can reach [. . .] up to 90% in small island developing states" (Heath *et al.*, 2014, p. 132).
20. For climate-change exposure, several attempts have been made over the past 20 years to come up with a simple measure for island countries that intentionally glosses over internal diversity. For example, the Environmental Vulnerability Index (Kaly *et al.*, 2004) has been applied to island countries and elsewhere and, while it seems unable to "fully describe the environmental vulnerability of a country with diverse and rapidly changing conditions" (Skondras *et al.*, 2011, p. 1705), the independent corroboration of its results for Pacific island countries shows that it has some validity at a crude scale (Nunn *et al.*, 2016b).
21. This realization has implications for the future. International meetings, particularly the UN Climate Change Conferences (COP series), have voted millions of dollars to continue to support climate-change adaptation in island nations despite clear evidence that this approach has in the past failed to achieve the desired goals. A good example is the Kiribati Adaptation Plan (KAP), funded by the World Bank, that is currently in its second phase (Dean *et al.*, 2016).

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