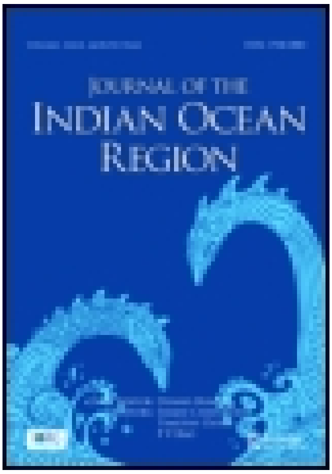

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Understanding the climate-sensitive decisions and information needs of island communities

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Understanding the climate-sensitive decisions and information needs of island communities

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Climate variability and change present significant challenges for island communities in the Pacific and Indian Ocean regions. Understanding how climate science can be useful for island communities requires knowledge of decision-makers, their climate-sensitive decisions, and the context in which the decisions are being made. In this paper we report on an interdisciplinary research and outreach effort called the Pacific Islands Regional Climate Assessment. We describe potential impacts from the changing climate for island communities, including food and water security, disaster preparedness, human migration and national security. We highlight transferable lessons learned related to building resiliency, engaging innovative leadership and supporting integrated research and outreach.

Keywords: climate change; island communities; decision-making; integrated methods

Introduction

Communities living on small islands in the Pacific and Indian Oceans are among the most vulnerable to small changes in climatic variables, especially via changes in rainfall patterns, tropical storm frequency and intensity and sea-level rise (Nurse et al., 2014; Overseas Development Institute and Climate and Development Knowledge Network, 2014). However, these communities show considerable diversity in their vulnerability and preparedness. Vulnerability to climate change encompasses many concepts that reflect a community's predisposition to sustain damage from climate change and is a function of the magnitude and nature of climate change, the sensitivity of the system to changes in climate, and capacity to cope or adapt to the changes (Intergovernmental Panel on Climate Change, 2014). Vulnerability is most notable among low-elevation island communities and those with high population densities and growth rates, scarce natural resources such as land and water, poorly developed infrastructure and a high economic dependency on sectors such as tourism and defence (Finucane, Marra, Keener, & Smith, 2012).

Islands in the Pacific and Indian Ocean regions are important also for people living on continental land masses, due to their critical role in environmental and human security nationally and internationally. These regions host diverse terrestrial and marine ecosystems, including mountainous alpine environments and abyssal environments deep under the ocean. The islands in these regions are home to some of the most pristine habitat in the world and they possess tremendous biodiversity. Thus, the islands provide significant value to all people (Keener, Marra, Finucane, Spooner, & Smith, 2012).

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In this paper, we describe what we have learned from a research programme designed to understand, assess and address the impacts of the changing climate on different sectors, resources and human communities in the Pacific islands region. Our objective is to help inform debates about policies that may impact the very survival of some island communities, regardless of where they are located. In particular, we report on findings from the Pacific Islands Regional Climate Assessment (PIRCA), conducted in support of the Third United States (U.S.) National Climate Assessment (Keener, Marra, et al., 2012; Leong et al., 2014). We highlight lessons learned that might apply also to islands in the Indian Ocean region. Although climate change impacts are broad and complex, we focus on four key issues of most relevance to small island states: (1) food and water security; (2) disaster preparedness; (3) human migration; and (4) national security. These key issues highlight the need for immediate action to be well prepared for a changing environment, the need for multi-level and cross-sectoral planning, and a more holistic and integrated way of thinking about circumstances likely to be faced in the future that have not been encountered before.

Regional context

At 63.8 million square miles, the Pacific Ocean is the largest ocean in the world, covering approximately 33% of the Earth's total surface. The Indian Ocean, at 28.4 million square miles or 20% of the Earth's total surface, is the third largest ocean. Tens of thousands of islands are scattered across these oceans. Many islands are isolated, with hundreds of miles between islands and thousands of miles between island chains. Across the islands of each region are diverse ethnicities and cultures. In addition, these regions are home to unique natural communities of global significance. However, many island species are endangered due to multiple stressors (Parker & Miller, 2012).

The geologic origin of islands in both regions varies widely. They include volcanic islands, atolls, limestone islands and islands of mixed geologic type. We distinguish between 'high' islands (e.g., volcanic islands such as the Big Island of Hawai'i at more than 13,000 feet above present sea level) and 'low' islands (e.g., atolls such as Kwajalein in the Republic of the Marshall Islands (R.M.I.) at little more than 5 feet above present sea level). This high/low distinction is essential for explaining the different climates on islands and the many specialised terrestrial and marine ecosystems that have evolved. The distinction also relates to the varying forms of human communities that are currently supported on the islands (Finucane et al., 2012).

Key findings from the Pacific Islands Regional Climate Assessment

Through an interdisciplinary collaboration of scientists and community leaders from diverse sectors in government and non-government organisations, the PIRCA was initiated in 2011 to assess climate challenges in the Pacific islands region over three technical focal areas: freshwater resources and drought; sea-level rise and coastal inundation; and aquatic and terrestrial ecosystems. The PIRCA is an ongoing process of assessment and information exchange among scientists, natural and cultural resource managers, public agencies, private businesses and community groups. About 100 scientific experts and practitioners were involved in multiple dialogues, workshops and literature reviews to facilitate sharing, analysing and reporting on scientific consensus, knowledge gaps, sectoral needs, and adaptive capacity for addressing the impacts of the changing climate on the Hawaiian archipelago and US-Affiliated Pacific Islands (USAPIs). An integrated report, based largely on published research and reviewed by experts independent of the PIRCA process, was published in 2012. In this section we summarise some of the key findings of the assessment (for details, see the full PIRCA report; Keener, Marra, et al., 2012).

The Pacific islands region faces many impacts from the changing climate. As average, maximum and minimum temperatures continue to rise across the entire region, observed annual rainfall and drought patterns are changing. From 1950 to 2010, available data show that islands in east Micronesia are getting significantly drier, while those in west Micronesia have gotten slightly wetter (Lander, 2004; Lander & Guard, 2003). In the Hawaiian Islands, annual precipitation has decreased significantly in the past 30 years and there have been greater numbers of consecutive dry days and few days of intense rainfall (Keener, Izuka, & Anthony, 2012). In addition, base flow in streams in Hawai'i has shown significant downward trends of 20–70% in the past 100 years (Bassiouni & Oki, 2012; Oki, 2004). Pacific islands have limited and fragile freshwater resources and when rainfall and streamflow decline, freshwater supplies are threatened.

A second major climate challenge for Pacific islands is increasing average sea level. Since the 1990s, the rate of globally averaged sea-level rise has been about 0.13 inches per year (Nerem, Chambers, Chloe, & Mitchum, 2010). Climate model projections are for a 15–24 inch rise in mean global sea level by 2100 (Intergovernmental Panel on Climate Change, 2013). However, sea-level rise is non-uniform and non-steady, with the highest rates occurring in the western Pacific, largely due to natural variability. Higher average sea-level results in more frequent extreme sea-level events, which occur when high tides combine with non-tidal changes in water level. Consequently, there will be increasing stress on western Pacific islands as sea-level rise continues to rise, combined with seasonal high tides, the occurrence of La Niña and storm events and waves (Marra, Merrifield, & Sweet, 2012).

A third major challenge for Pacific islands is warming ocean temperatures. As a result, habitats will shift throughout the food chain and the distribution of regional coastal and pelagic fisheries will change. Some countries' fisheries will prosper from these shifts and some will be negatively impacted (Bell, Adams, Johnson, Hobday, & Sen Gupta, 2011; Polovina, Dunne, Woodworth, & Howell, 2011). The warming oceans also mean that by 2050 many coral reefs may bleach annually, leading to a change in coral species composition, coral disease, coral death and habitat loss (Burke, 2011).

Cross-cutting issues in the Pacific islands region

In this section, we describe impacts of the changing climate on the Pacific islands region, including food and water security, disaster preparedness, human migration and national security.

Food and water security are threatened

Warmer, more extreme conditions along with sea-level rise pose a big threat to food and water security. As the recent droughts and high water events in R.M.I. have demonstrated, crops such as banana and breadfruit can be completely destroyed with only a few concurrent climate stressors, placing more pressure on subsistence fisheries and relief provided by federal and international aid agencies (United States Agency for International

Development, 2013). Severe drought has immediate impacts on the water security and health of islanders relying on water catchment systems, but it can also have long-term impacts on the water stored in aquifers on high volcanic islands as found in Hawai'i. Sea-level rise also affects the amount and quality of ground and surface water available, which in turn affects local farms and ranches. Inundation from storm surge compounds the problems of higher sea levels, making prime agricultural land and wells unusable.

To illustrate, most experts agree that the water use allowed by existing permits for O'ahu, the most populated island in the Hawaiian archipelago, is close to the maximum sustainable yield of the Pearl Harbor aquifer which serves the island (Wilson Okamoto Corporation, 2008). Yet demand for water is expected to increase with anticipated population growth and economic development. In the long term, greater water use will result in a decline in water levels, increasing the risk of saltwater intrusion and reducing the natural groundwater discharge to streams and the ocean. A survey of planners and policy makers (from government and non-government organisations) who are responsible for O'ahu's freshwater resources showed that although they were well informed about climate variability and change, they reported problems accessing and using climate information in adaptation planning decisions (Finucane et al., 2013).

To respond effectively to the threat of climate change to food and water security, planners and policy makers need information addressing questions such as:

- How much water will be available where and when in the future?
- What natural resource management strategies will be most effective in remote areas?
- Are existing laws and policies sufficiently adaptive for managing freshwater resources?

Downscaling of global and regional projections to the island level is necessary, particularly for islands with complex topography as is found in Hawai'i, but just sharing information is not sufficient for an effective response. Planners and policy makers in Hawai'i have indicated that they need an assessment of the inevitable uncertainties that accompany any climate change projections and information about both most-probable and worst-case scenarios (Finucane et al., 2013). They are also very interested in location-specific vulnerability assessments and information about climate change impacts on runoff, pollutant loads, salinity and water supply. In addition, a whitepaper by Wallsgrove and Penn (2012) examining the current law and policy framework for freshwater management in Hawai'i in the face of climate change demonstrated a need for information and tools that can help to develop policies that are forward-looking, flexible, integrated and iterative. The authors highlight the importance of a multi-level, integrated and adaptive response, using comprehensive planning and policy tools, sound and effective regulatory tools, and market-based tools to ensure a conservation signal is being imparted.

Disaster preparedness, response and rebuilding needs improvement

Island communities are no strangers to dealing with extreme weather. Climate-related disasters for islands come from several events including hurricanes, extreme water levels, drought and flooding. Since island communities are coastal communities, extreme water level events pose a serious risk of inundation which contributes to coastal erosion. This in turn can lead to saltwater intrusion, which damages freshwater sources and agricultural crops; damage to roads, houses, airports and other infrastructure; and destruction of critical habitat and the loss of the ecosystem services provided by coastal areas.

A needs assessment conducted in 2010 by the National Disaster Preparedness Training Center (led by the University of Hawai'i, in partnership with many other organisations) identified several key needs for improving disaster preparedness, response and rebuilding across the Pacific islands region. First, concern that the public is unprepared and has unrealistic expectations of government's capacity to respond to natural disasters, mean that awareness of natural hazards needs to be increased at all levels of government and the public. Second, non-governmental organisations and the general public need to be included in trainings, and training for public communication and awareness of natural disasters needs to be increased. While there is often a strong focus on disaster management training at the state and federal level, local government and non-government entities may be less likely to provide courses relevant to disaster management. Finally, disaster practitioners need to address training barriers, including high staff turnover and low cultural awareness and contextual competency of non-residents who are leading or supporting disaster relief and recovery services.

An example of how climate forecasts can be used to protect human health is the case of a commercial landfill operated by the PVT Land Company (see case study 2-2 in Keener, Izuka, et al., 2012). The landfill is located in Nanakuli, Hawai'i, a dry area that usually receives about 254–356 mm (10–14 inches) of rain annually. When the Vice President of the PVT Land Company heard a briefing in October 2010 by the Honolulu Weather Forecast Office that indicated a moderate-to-strong La Niña developing in the Pacific and expectations of above average winter rainfall, he immediately took steps to mitigate the climate risks by prioritising the upgrade of infrastructure that would divert and hold large amounts of storm water. In January 2011, Nanakuli received about 356 mm (10 inches) in a single storm. Other local landfills were not prepared to handle the storm's intense rainfall and closed for an extended period; they also released hazardous untreated water and waste onto local beaches. In contrast, the PVT Land Company was open for business the next day, with estimated savings of about US$1 million in gross sales, potential damage to infrastructure and the environment and lost salaries. This case demonstrates the value of using the best available climate information to support disaster and risk management decisions.

Climate change will force migration

Currently, island communities are facing an immense and unprecedented loss of homeland across thousands of low-lying islands and atolls. Loss of land from sea-level rise and coastal erosion, combined with food and water insecurities, mean that many islands have or will become uninhabitable. Coastal communities in the Western North Pacific are particularly vulnerable due to their low elevation, small land mass, geographic isolation and limited potable water sources and agricultural resources (Barnett & Adger, 2003). Sea-level rise and more frequent inundation by king tides and tropical cyclones may not only contaminate groundwater and overcome basic sanitary systems but also wipe out agricultural resources. In 2007, for instance, taro crops on Lukunoch Atoll, Chuuk State, Federated States of Micronesia (F.S.M.), were destroyed by saltwater inundation. Giant swamp taro (*Cyrtosperma*) is a staple crop in Micronesia that requires a two- to three-year growing period from initial planting to harvest. Since it takes about two years of normal rainfall to flush brackish water out of a taro patch, there will be a five-year gap before the first harvest after an inundation event, assuming no further saltwater inundation occurs (Hezel, 2009). Such devastation to drinking water, food supplies and infrastructure means that some island communities may need to relocate because their land is uninhabitable well before it is submerged.

Even though the Intergovernmental Panel on Climate Change first identified climate-induced human migration as a grave issue in their First Assessment in 1990, there is still no single legal entity that governs climate-induced migration. Projections of the number of climate migrants by 2050 range from 25 million to 1 billion (International Organization for Migration, 2009). This large range demonstrates both the potential magnitude of the problem, but also the lack of appropriate data on which to base estimates. Unlike other populations facing climate-induced migration, islanders from some countries such as R.M.I. will not be able to migrate domestically because their entire country is only few feet above sea level (e.g., Namdrik Atoll has a land area of 1.1 square miles and a maximum elevation of 10 feet). In such cases, the whole country conceivably needs to migrate. Although these climate migrants may permanently lose their entire homeland, current international law is unclear about whether they will retain an array of legal benefits and other economic rights to the area of ocean their country once inhabited (Burkett, 2011).

Given the Compact of Free Association between the U.S. and R.M.I., the F.S.M. and the Republic of Palau (renewed for 20 years in 2003 for R.M.I. and F.S.M.), island residents are allowed to travel and live in the U.S. Hawai'i is a logical first choice because of its proximity and similar Pacific island culture. In addition to the legal and governance issues, policy makers need to think about the health, education, social and economic needs of migrating communities as well as the impacts on receiving communities. And of course identity issues will loom large for migrants who lose their ties with traditional lands and cultural practices.

Climate change will impact the security environment, roles, strategy and infrastructure

The United States Pacific Command (U.S. PACOM) is headquartered in Hawai'i and has forces stationed and deployed throughout the Asia-Pacific and Indian Ocean regions. U.S. PACOM's Area of Responsibility encompasses about half the earth's surface, stretching from the waters off the west coast of the U.S. to the western border of India, and from Antarctica to the North Pole.

A key focus for U.S. PACOM is the Strait of Malacca, which connects the Pacific and Indian Oceans and every day accommodates about one third of world trade, half of the world's oil, and 70,000 ships per year. The U.S. Navy also operates the Naval Support Facility Diego Garcia in the central Indian Ocean, providing a large naval ship and submarine support base, military air base, communications and space-tracking facility and an anchorage for pre-positioned military supplies for regional operations. Many other countries also have a military presence in the Indian Ocean region, including but not limited to countries around the region's rim.

The effects of climate change will adversely impact military readiness and natural and built defence infrastructure in both the Pacific and Indian Ocean regions. Considerations of future climate conditions need to be incorporated into the planning, design and operations of military facilities, as well as into the strategic infrastructure decisions facing the military services. For instance, about 10% of the U.S. Department of Defense's coastal installations and facilities (e.g., training/testing lands, piers, roads, water and electricity systems) are located at or near sea level. These assets are already vulnerable to flooding and inundation. Rising sea levels and more intense heavy downpours will make these conditions worse.

Military operations may depend also on civil infrastructure, such as drinking well water, transportation and utility corridors, all of which are vulnerable to the impacts of climate change. These impacts could affect force deployment and other operational issues. In addition, the nature of regional conflicts may change with changes in food and water security, human migration patterns and the occurrence of disasters, resulting in concomitant changes in military attention that may be required.

Climate challenges for islands in the Indian Ocean region

Island communities in the Indian Ocean region are facing climate change challenges similar to those described above for the Pacific Ocean region. For instance, in coastal areas of countries such as the Republic of Mauritius, sea-level rise combined with extreme tides and storm surge exacerbates the loss of lowland through submergence, beach erosion, damage to coastal infrastructure and loss of wetlands (Ragoonaden, 1997) and the flooding of local housing, tourism and infrastructure facilities and agricultural land (Beebeejaun, 2000). In addition, for many countries, such as the Seychelles where the main industries of tourism and fishing depend heavily on healthy coral ecosystems and the broader marine environment, any climate-related impacts have implications for the islands' long-term prosperity and survival (Brown, Kebede, & Nicholls, 2011; Hoegh-Guldberg, 1999; Lajoie, 2000).

Overall, a growing body of peer-reviewed and other literature underscores the importance of improving understanding of the vulnerabilities and adaptive capacities of Indian Ocean islands and their communities. Fortunately, many efforts have been established already to fill knowledge gaps and address the challenges. Intergovernmental partnerships such as the Indian Ocean Islands Commission, the Western Indian Ocean Coastal Challenge, the Global Island Partnership, and many other organisations are mobilising and coordinating resources to address the impacts of the changing climate. As researchers and decision-makers at varying levels expand their collaborations, examining the experiences of other similar communities around the globe can facilitate development of responses in the face of profound uncertainty (Ferguson, Finucane, Keener, & Owen, in press).

Transferrable lessons learned

Our research on the climate challenges facing Pacific island communities suggests several lessons learned about climate-sensitive decisions and information needs that may be relevant to island communities in the Indian Ocean region. These lessons relate to building resiliency, engaging innovative leadership and supporting integrated research and outreach.

Build resilient island communities

First, community leaders need to prioritise policies that contribute to building resilient communities. Multiple guidelines highlight key principles of resiliency (National Oceanic and Atmospheric Administration and U.S. Army Corps of Engineers, 2013; President's State Local and Tribal Leaders Task Force on Climate Preparedness and Resilience, 2014; United Nations Department of Economic and Social Affairs, 2014) such as comprehensive, forward-looking and science-based analysis that addresses physical, social, health, economic, environmental and cascading impacts; environmentally sustainable and innovative solutions; long-term efficacy and fiscal sustainability of activities; and regional collaboration across all levels of governance and across relevant jurisdictions. But putting these principles into practice is not necessarily a simple undertaking. In particular, intra- and inter-regional partnerships must navigate the complex challenges posed by diverse languages, cultural values and practices, governance systems, socio-economic disparities and development contexts. Resilience efforts need to be implemented in a systematic and transparent way and evaluated so that opportunities and challenges can be identified and appropriate revisions made.

Engage innovative leadership

The second lesson learned is that community leaders need to be innovative in how they tackle climate challenges that are unlike anything that has been experienced in the past. Leaders need to build partnerships among academic, public and private organisations that help to identify priority concerns and ways to address those concerns. Leaders also need to identify creative solutions that reflect multi-level, multi-sectoral approaches to solving what social planners call 'wicked problems' – problems that are incomplete, with contradictory and changing requirements that are often difficult to recognise. Leaders can be helped by key individuals who are willing to champion the message of resiliency and innovation and engage individuals and groups at all levels to work together and leverage resources. Overall, innovative approaches need to couple top-down and bottom-up strategies that facilitate success, enhance community buy-in and generate rapid uptake of climate-resilient adaptation practices.

Support integrated research and outreach

The third lesson learned is that support is needed for integrated research and outreach that brings together scientists and decision-makers and uses an interdisciplinary approach. Programmes such as the Pacific Regional Integrated Sciences and Assessments (RISA) provide an example of an integrated effort that effectively conducts use-inspired research and delivers climate information and decision support services to diverse stakeholders (Ferguson et al., in press). In general, the RISA teams have been highlighted as innovators in 'organizing the dialogue between scientists and practitioners' (Pulwarty, Simpson, & Nierenberg, 2009, p. 379) to generate science 'that is usable in specific decision contexts' (National Research Council, 2008, p. 30). Additional funding and in-kind support from a range of public and private sources will help to expand use-inspired, problem-focused, stakeholder-driven and iterative approaches to improve our understanding of the climate-sensitive decisions and information needs of island communities. Such efforts enhance the likelihood of building climate resilience across the Pacific and Indian Ocean regions.

Conclusions

The climate challenges facing island communities are multiple and daunting. However, sharing lessons learned across the Pacific and Indian Ocean regions can facilitate planning and responses that lead more quickly to climate resilience. By identifying common and unique challenges across islands, we can ensure efficient and wise investment of scarce resources. Similarly, identifying opportunities for mutually beneficial partnerships will help to establish regional assessment processes and products that are useful for diverse audiences. Exchanging information between the Pacific and Indian Ocean regions will facilitate the rapid uptake of relevant science into policy making. Ultimately, synthesising and sharing lessons learned from regional climate assessments will support global efforts to build climate-resilient island communities capable of using climate information to manage risks and make practical decisions.

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