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ORIGINAL ARTICLE

# Heading for the hills: climate-driven community relocations in the Solomon Islands and Alaska provide insight for a 1.5 °C future

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## Abstract

Whilst future air temperature thresholds have become the centrepiece of international climate negotiations, even the most ambitious target of 1.5 °C will result in significant sea-level rise and associated impacts on human populations globally. Of additional concern in Arctic regions is declining sea ice and warming permafrost which can increasingly expose coastal areas to erosion particularly through exposure to wave action due to storm activity. Regional variability over the past two decades provides insight into the coastal and human responses to anticipated future rates of sea-level rise under 1.5 °C scenarios. Exceeding 1.5 °C will generate sea-level rise scenarios beyond that currently experienced and substantially increase the proportion of the global population impacted. Despite these dire challenges, there has been limited analysis of how, where and why communities will relocate inland in response. Here, we present case studies of local responses to coastal erosion driven by sea-level rise and warming in remote indigenous communities of the Solomon Islands and Alaska, USA, respectively. In both the Solomon Islands and the USA, there is no national government agency that has the organisational and technical capacity and resources to facilitate a community-wide relocation. In the Solomon Islands, communities have been able to draw on flexible land tenure regimes to rapidly adapt to coastal erosion through relocations. These relocations have led to ad hoc fragmentation of communities into smaller hamlets. Government-supported relocation initiatives in both countries have been less successful in the short term due to limitations of land tenure, lacking relocation governance framework, financial support and complex planning processes. These experiences from the Solomon Islands and USA demonstrate the urgent need to create a relocation governance framework that protects people's human rights.

**Keywords** Sea-level rise · Climate change · Relocations · Solomon Islands · Alaska

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## Introduction

Rapid climate change impacts on ecosystems, communities and infrastructure are anticipated to be one of the greatest challenges in the coming centuries. Over the coming century, it is expected that the global mean sea-level rise rate will increase from the current rate of 3.4 mm/year to between 5 and 10 mm/year, only if we are successful in limiting emissions to the conservative 1.5 °C scenario (Schaeffer et al. 2012). This translates to a committed or "locked-in" component of 1 m of sea-level rise between now and 2300 in the best case 1.5 °C scenario. By exceeding 1.5 °C, both the rate and committed component of sea-level rise will increase substantially, with several predictions indicating 1 m of sea-level rise by 2100 and 2–3 m in the coming centuries are increasingly likely to occur (Hansen et al. 2016; Jevrejeva et al. 2016). The proportion of the global population to be impacted by sea-level rise will rise substantially if the 1.5 °C scenario is exceeded. How coastal populations respond to these changes through coastal defences, adaptation and retreating is becoming a critical issue for governance agencies globally.

Predictions of more than 1 m of sea-level rise and associated coastal risks such as permanent flooding and accelerated erosion have led several vulnerable nations to start considering and planning for coastal protection, retreat and in some extreme cases relocation. Small island developing states (SIDS) have been on the forefront of the global effort to start the dialogue and planning for possible relocations (Green 2016). Of those SIDS, the low-lying islands in the central and western Pacific such as Kiribati and the Solomon Islands are particularly vulnerable to the effects of sea-level rise and erosion (Biribo and Woodroffe 2013; Albert et al. 2016). Rapid sea-level rise does not simply influence the biophysical system but also has deep and complex interactions with cultural and socio-political factors (Black et al. 2011). Indeed, Fisher (2011) argues that sea-level rise impacts need to be considered holistically with a human security lens.

Over the past two decades, the regional variability in sea-level rise rates has created hotspots of sea-level rise two to three times the global mean has led to numerous coastal communities already relocating (Albert et al. 2016; Hino et al. 2017). Global rates of sea-level rise on the order experienced in the current hotspot areas are now inevitable under a 1.5 °C warming scenario and it is crucial that optimal adaptation strategies are undertaken to minimise the impacts on people's livelihoods. Despite the significance to humanity of the relocation of coastal communities from often poorly resourced developing nations, there remains few assessments of the factors that both facilitate and inhibit relocation. To an extent, lessons of climate relocations have been drawn from institutional driven relocations from development projects such as dams (Nakayama et al. 2016). The trade-off between investing in infrastructure such as seawalls to strengthen the coastline and managed retreat has been the focus of several studies (Mills et al. 2015; Nordstrom et al. 2015; Rulleau and Rey-Valette 2017). However, there remains simplistic debate in the academic literature of the 'best' approach to relocation and, in extreme cases, commentators have labelled relocations as a failure of adaptation (Campbell 2008) whilst others suggest that climate-induced migration can be positive and offer new opportunities when guided by appropriate evidence-based policy (Black et al. 2011).

The most suitable approach to adaptation and/or relocation is highly dependent on local social, economic and geographic factors. These can range from temporary relocations as a result of extreme events to forced permanent migration to neighbouring islands or even other nations (Campbell 2014). Recent work analysing how relocation decisions are made at different scales and how the diversity of approaches can be supported through international mechanisms is starting to provide some guidance (McNamara et al. 2016). In addition, there has been growing awareness that traditional cultural practices can play a significant role in contributing to the adaptive capacity of local communities vulnerable to climate change (Finucane 2009; McNamara and Westoby 2011; Nakashima et al. 2012; Adger et al. 2014). Reflecting this, the climate change adaptation discourse, particularly in relation to small island developing contexts, is taking a discursive turn to viewing locally impacted communities as active agents of change with valuable knowledge and adaptive capacity, rather than victims of climate change (Cochran et al. 2013).

Understanding local community responses to climate-induced coastal risks is a critical element in developing future adaptation strategies (Leon et al. 2015). Also important is creating a governance framework so that communities faced with relocation understand how a government agency may provide funding or technical assistance to support the community's chosen adaptation strategy. However, local and traditional knowledge is often neglected in policy and research with policy makers often turning to science to answer questions of how communities should respond to environmental change and how relocation efforts should be undertaken. Moreover, government-mandated relocations have often eroded the efficacy of traditional practices, as they have shown to undermine traditional structures and community coherence and reduce the viability of some traditional livelihoods (McNeeley 2012; Edwards 2013; Maldonado et al. 2013; Birk and Rasmussen 2014). This is reportedly largely due to government-led initiatives removing options and reducing choices for local communities, thereby undermining their adaptive capacity at the local scale (Nakashima et al. 2012).

In the Pacific Island context, Finucane (2009) argues that scientific knowledge should only be one element of an effective risk management process. Thus, traditional practices ideally should be mutually recognised to increase the effectiveness of communities at the local scale to relocate in response to SLR and climate

change more broadly. Designing a governance framework that recognises traditional practices and provides communities with the decision-making authority to decide whether, when and how relocations need to occur is an important step to ensuring that relocations increase the adaptive capacity of communities (Bronen 2011; Bronen 2015; Ford et al. 2016).

The Solomon Islands presents a particularly pertinent case as it has experienced sea-level rise rates of 7–10 mm/year (three times the global average) over the past two decades, in line with what can be expected globally over the next century (Church et al. 2013). This recent sea-level rise in the Solomon Islands has, in some cases, led to substantial coastal change and displacement of indigenous communities (Albert et al. 2016). Over generations, these communities have lived with considerable and often sudden environmental change, and in response, they have developed skills to adapt to such changes with their ability to adapt determined, in part, by the community's ability to act collectively utilising existing social mechanisms, customary governance structures and traditional land tenure systems (Nakashima et al. 2012; Aswani et al. 2015). These indigenous communities have particularly high levels of social cohesion, with communities in the Solomon Islands depending directly on the local environment and its abundant natural resources for food, shelter, transportation and thus survival.

The indigenous communities in Alaska represent another high-profile case of vulnerability to future climate change (Gorokhovich et al. 2014). Although a debate of the drivers of recent coastal change in Alaskan coastal communities remains, the need for these communities to relocate in response to projected combined pressures of reduced Arctic sea ice, melting permafrost and sea-level rise is becoming clear (Smith and Sattineni 2016). These changes have led to communities making the proactive decision that relocation is the best long-term adaptation strategy (GAO 2009).

Erosion, flooding and sea-level rise threaten the lives, livelihoods, homes, health and basic subsistence of indigenous communities currently inhabiting the Arctic (Archer et al. 2017). In the last half century, Alaska and the Arctic have warmed twice as fast as the global average (NOAA 2016). This has led to shrinkage of summer sea ice, shortening of the snow-covered season, warming and thawing of permafrost, drier landscapes, more extensive insect outbreaks and wildfire. Together, these environmental and ecological changes have altered the structure and function of arctic and boreal ecosystems. Late-summer sea ice extent has declined by 40% relative to the beginning of the satellite record in 1979, so autumn storms produce larger waves and more coastal erosion (NOAA 2016). Coastal bluffs that were "cemented" by permafrost are now thawing in response to warmer air and ocean waters and are therefore more vulnerable to erosion. Standard defensive adaptation strategies to protect coastal communities from erosion such as rock walls and sandbags have been largely unsuccessful (Bronen and Chapin 2013). These climate issues are impacting 184 Alaska Native communities with 31 facing imminent threats from flooding and erosion (Smith and Sattineni 2016). These environmental changes are forcing three Alaska Native communities, Shishmaref, Newtok and Kivalina, to relocate. However, none has yet relocated despite the recognition by federal, state and tribal governments that relocation is the only sustainable long-term adaptation strategy (Bronen and Chapin 2013). This paper will discuss the challenges faced by one of these communities, Shishmaref; however, there will be strong parallels with the relocation of these other communities.

Given that climate-induced relocation is set to become a key challenge for humanity this century, it is critical to begin to document the early case studies under a range of social, economic and cultural scenarios. This study aims to compare and contrast planned and ad hoc driven responses in a developing nation (Solomon Islands) and a developed nation (Alaska, USA) (Fig. 1). The Solomon Islands and Alaska have experienced the globe's highest rates of sea-level rise and warming, respectively, over the recent decades and provide insights to inform future adaptation scenarios in other regions as they undergo similar experiences in a 1.5 °C future. The relocation of populations because of climate change presents a complex challenge to the communities displaced, facing a loss of land and connection to ancestral heritage, and to the governments responsible for protecting climate-vulnerable populations. In both countries, no government agency has the authority, technical expertise, organisational capacity or funding to facilitate a community-wide relocation despite the fact that communities in both countries are deciding that relocation is the best long-term adaptation strategy. In the USA, President Obama's 2014 task force on climate resilience and preparedness recognised the lack of a federal institutional framework to address relocation and recommended that the federal government take a lead role in resolving this issue (The White House 2014). The US Department of the Interior continues this work by facilitating interagency meetings with federal government agencies, such as the Environmental Protection Agency, Housing and Urban Development and Bureau of Indian Affairs. Despite their efforts, no relocation governance framework exists. The result of this governance gap means that relocations within each country are occurring in an ad hoc process.

## Methods

The planned and ad hoc relocation responses of communities were monitored to assess the issues, constraints and progress towards relocation at each of the sites using a combination of focused group discussions, personal experiences, grey literature, involvement in government and community relocation meetings since 2006 and media reports. These findings were validated with local site visits and collated into two broad categories of processes and outcomes. The processes were further divided into facilitators and inhibitors of relocation and the most commonly reported of each were tabulated. A similar approach was taken with outcomes where these were divided into benefits and concerns in moving inland.

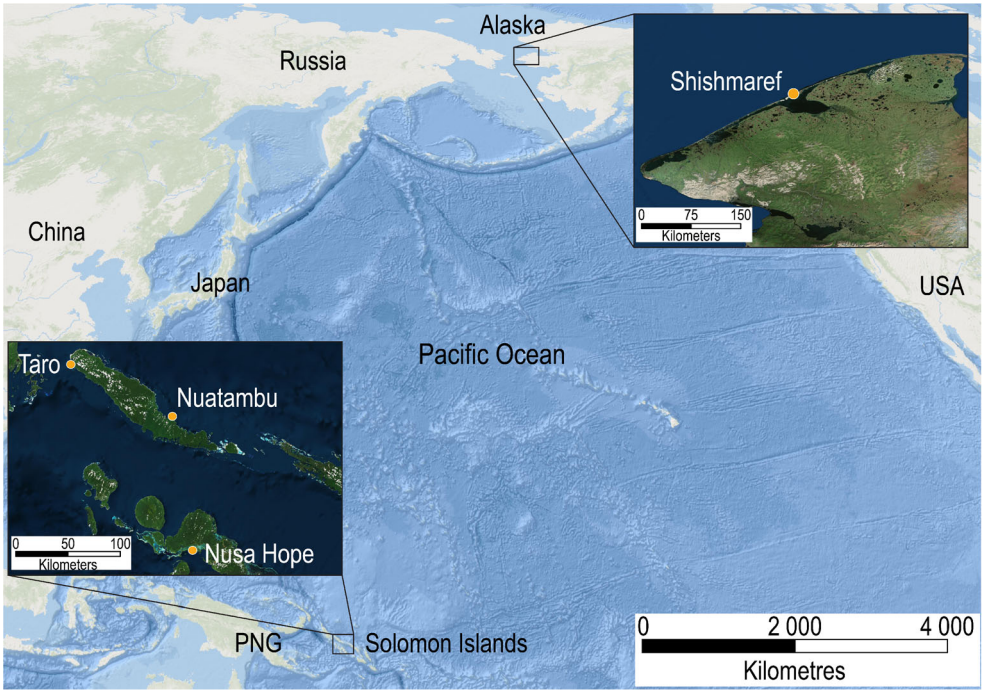


**Fig. 1** Map of study sites in the Solomon Islands and Alaska, USA


**Fig. 2** **a** Focused group discussions and participatory mapping in Nuatambu. **b** Partially constructed house relocated onto steep terrain adjacent to Nuatambu. **c** Drone-based aerial image of Nuatambu in December 2016 showing the area of village lost (left) and remaining houses becoming increasingly vulnerable (right)

Two coastal communities in the Solomon Islands that received no external support and have undergone an unplanned relocation process were assessed, Nuatambu and Nusa Hope, each consisting of a population of less than 300 people. Nuatambu is a small (25 ha) island, 100 m offshore on the north coast of Choiseul Island, whilst Nusa Hope is a 1-ha island within Roviana Lagoon, New Georgia. A further two communities were assessed that are in the process of receiving governmental and multi-stakeholder support and undergoing a relatively well-planned process; Taro is a provincial capital of 900 people on a small (40 ha) island, 1 km offshore on the western end of Choiseul Island, the Solomon Islands and Shishmaref, Alaska. Shishmaref is an Inupiat village of around 600 people located on Sarichef Island (barrier island) in the Chukchi Sea, north of the Bering Strait and 50 km south of the Arctic Circle (Fig. 1). The inclusion of the Alaskan community allows the contrasting responses between a developing nation and a developed nation to be made. This is important in light of the global impacts of sea-level rise affecting nations across the development spectrum.

A detailed case study was undertaken for the Nuatambu relocation process in which coastline changes and houses lost were quantified from aerial and satellite imagery (Albert et al. 2016). A series of community meetings was held in December 2016 where large printed maps were displayed and village elders identified house position, family name, house loss date, relocation area and household occupant number for each lost house in the village. Follow-up meetings were then undertaken with relocated families to confirm these findings and better understand the impact of the relocation process (Fig. 2).

## Results

### The Solomon Islands

#### Nuatambu

Progressively, between 2007 and 2016, 133 people from 24 households have relocated from Nuatambu due to destruction of houses from rising seas (Table 1; Fig. 3; Fig. 4). This constitutes 71% of the population relocating over the past decade. These 133 people relocated as family units to 12 separate locations across southeastern Choiseul. Four groups of people (44 in total) moved relatively long distances of up to 120 km by boat from Nuatambu, with one family establishing a new settlement 50 km from Nuatambu. A further 66 people relocated to seven separate locations on the mainland adjacent to Nuatambu, whilst 23 people moved onto higher ground (5–10 m ASL) on Nuatambu. Of these people moving to the mainland adjacent to Nuatambu, four groups of people established separate new settlements (Fig. 4).

With no framework to guide these relocations, decisions of when and where to move have been made on a family-by-family basis. This fracturing of a single community into 13 separate hamlets has had a significant impact on community life. Previously, Nuatambu had been a hub for the immediate community and those tribal members living elsewhere who would coalesce at Nuatambu each Christmas for celebrations and feast. This annual gathering provided a critical mechanism by which culture, history and genealogy were shared and kinship ties were reinforced. Those community members that have remained on Nuatambu expressed their strong 'love' for the island and the need for them to stay as long as physically possible to act as guardians of the island and preservers of the deep cultural importance that it represents.

All families that have relocated from Nuatambu were able to relocate onto customary land for which they had tenure claims over. However, the limited flat land on and adjacent to Nuatambu has in some cases resulted in people relocating into areas vulnerable to landslides and future sea-level rise. Whilst all families that had relocated expressed the necessity for them to relocate and the inevitability that others remaining on Nuatambu will need to follow, there were several key challenges that they had observed with the relocation. Especially in the elderly, the new sites in steep, inland areas posed challenges with sanitation (traditionally, they had used the coast), access to drinking water (centralised villages provide economy of scale for water reticulation services) and transport (coastal villages are able to easily utilise canoe and ship-based transport). These critical aspects of village life that have evolved around coastal villages over the past century will

**Table 1** Number of houses already relocated and still remaining in the four study sites

| | | | Relocated | Remaining | Total |
|---|---|---|---|---|---|
| No support | Nuatambu | People | 133 | 54 | 187 |
| | | Houses | 24 | 10 | 34 |
| | Nusa Hope | People | 261 | 185 | 446 |
| | | Houses | 35 | 22 | 57 |
| Government-supported | Taro | People | 0 | 810 | 810 |
| | | Houses | 0 | 120 | 120 |
| | Shishmaref | People | 0 | 600 | 600 |
| | | Houses | 0 | 141 | 141 |


**Fig. 3** Aerial (1947) and satellite imagery (2011 and 2016) of Nuatambu with 24 houses destroyed over the past decade indicated on 2016 image and 10 houses remaining

require rapid adaptation over the coming decades as increasing numbers of people move inland.

Of the 24 households interviewed who relocated from Nuatambu, none had received any financial assistance related to their need to relocate. In some cases, families were still struggling to save funds (US$1000–2000) to rebuild their houses and living in temporary shelters. However, despite challenges with re-building infrastructure, the people of Nuatambu are profoundly resourceful and resilient. Several families made pre-emptive decisions to move after assessing the erosion rates and understanding the inevitability of the sea-level rise and associated island loss. These families planned ahead by planting gardens on the mainland up to 12 months in advance of relocating their house so that their subsistence food security could be maintained.

### Nusa Hope

Progressively, since 1998, 261 people from 35 households have relocated from Nusa Hope to adjacent higher ground on surrounding islands and the New Georgia mainland. A further 34 people from 6 households are currently in the process of relocating (Table 1). These 35 households have spread out into 15 different hamlets up to 30 km from Nusa Hope, with families settling onto land they have customary ownership over through genealogical ties. Half of the families relocated to several existing settlements of relatives, whilst the other half established new settlement sites that had not previously been occupied (Fig. 5).

Whilst sea-level rise and extreme events such as tsunamis and king tides were a primary factor for many of the families that relocated, overcrowding in Nusa Hope due to limitations on available land was also a key driver of relocations (Fig. 6b). Unlike Nuatambu, no houses on Nusa Hope were physically washed away by rising seas so families were able to re-use building materials from their existing home and supplement this with traditional building materials (sago leaf, hardwood and palm trunks) from the new settlement sites. None of the families who relocated from Nusa Hope received any government or institutional support.

In addition to a sense of security and safety from rising seas and tsunamis, the new settlement sites provide improved access to fertile garden lands. This has reduced the time required for women (who are the dominant gardeners) to reach the

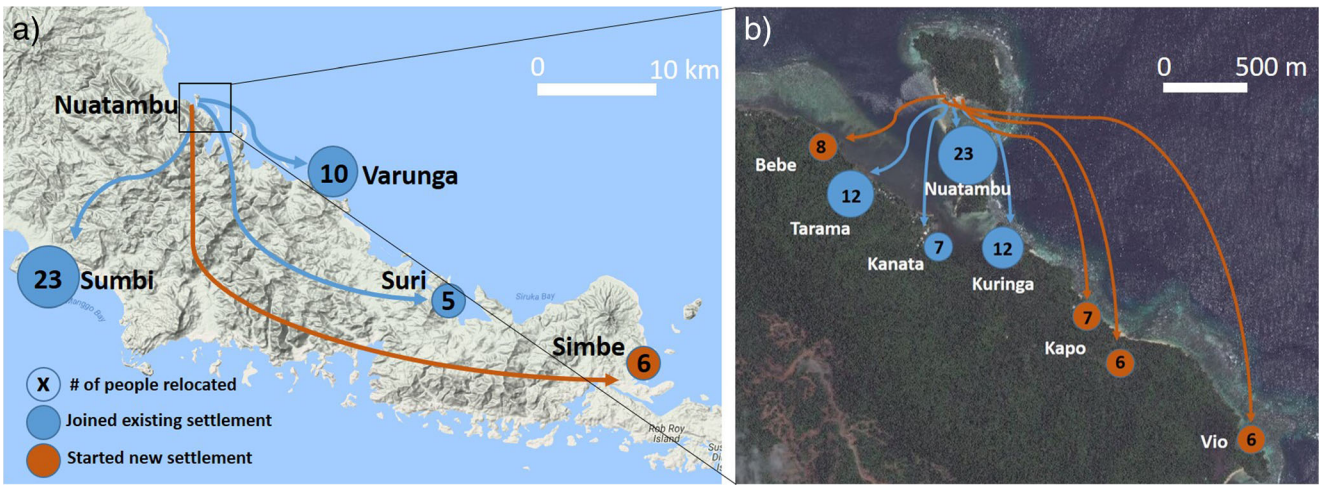


**Fig. 4** **a** Relocation patterns across southeastern Choiseul. **b** Local relocations to higher ground on Nuatambu and adjacent areas on mainland. In total, 133 people have moved from an original population of 187

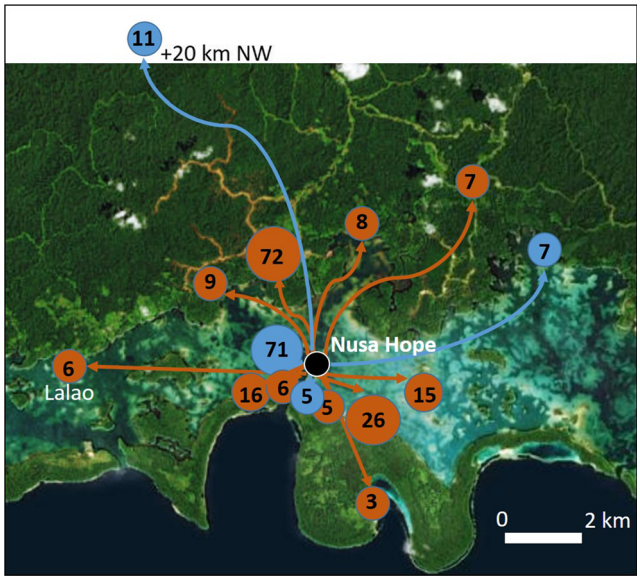


**Fig. 5** Relocation patterns from Nusa Hope to surrounding higher-elevation sites

gardens (by foot or paddle canoe) from over 2 h to 15 min in many cases. Generally, the new relocation sites have better access to clean water from small streams. Although many individuals who have relocated expressed the peace and quiet of the new locations being an advantage, they also feel they are no longer "part" of the Nusa Hope community and have reduced access to community events and church. Furthermore, those families that have moved to new settlement sites indicated they now have limited access to education and health facilities.

### Taro

Taro, the provincial capital of Choiseul Province in the Solomon Islands (Fig. 6a), is considered the first provincial capital to be relocating due to sea-level rise threats (Albert et al. 2016). The process is government-led and has been in planning stages for over 20 years. Despite the population of Taro being less than 1000 people, the complexities and costs associated with relocating critical services such as education, medical, government, retail and communications have proven challenging to date. Choiseul is a high volcanic island with a population density of less than people in 1 square kilometer and on face value would provide numerous relocation sites resilient to future changes in sea level. However, the customary land tenure across the majority of mainland Choiseul has severely restricted the areas available for relocation of the Taro township to small parcels of state-owned or formally registered land. The only available formally registered land in close proximity to Taro that the government was able to acquire for relocation is a largely low-lying area adjacent to a mangrove swamp, which has required careful planning to ensure the relocated township will be resilient to future climate scenarios (BMT WBM 2014). This lack of access to customary land of the residents of Taro has prevented the sorts of ad hoc relocation that has occurred elsewhere in the Solomon Islands. So whilst we consider customary tenure to have enhanced adaptive capacity of community-driven relocations in Nuatambu and Nusa Hope through rapid access to higher elevation relocation sites, customary tenure regimes on Choiseul have been restrictive in government-driven relocation efforts.

Although the Solomon Islands government views climate relocation as a critical issue, there is currently no effective policy or legislation to guide relocation of human settlements. Investigation of previous resettlement schemes within the Solomon Islands suggests that relocation must be considerate and cohesive with local communities' traditional needs. In addition, the Solomon government recognises that the sensitivities around relocation onto customary tribal land will require extensive consultation across all levels of governance (both state-based and traditional governance).

### Alaska

The dramatic environmental changes over the recent decades in Alaska have had a profound impact on the health and safety of community residents. In addition to the tremendous danger community residents face when autumn storms occur because of the loss of sea ice that previously protected the coastline from high-energy waves, more people are getting ill from water-borne diseases, are being stung by insects, and have suffered from allergies that result from increases of certain


**Fig. 6** **a** Aerial view of Taro Island with relocation site in upper right. **b** Low-lying houses in Nusa Hope

plants (Chapin et al. 2014). In addition, the changing migration patterns of subsistence food sources are affecting diet and cultural traditions.

Warmer temperatures impact subsistence harvests by changing the distribution and abundance of wild foods, which affect the ability of the Alaska Native population to gather their traditional subsistence foods (Chapin et al. 2014). Extensive wildfires and altered snow and sea ice conditions also affect the capacity of local people to access these resources. Subsistence food gathering is central to the culture and survival, and the primary livelihood, of Alaska Native communities. Village life revolves around subsistence activities, with the resources obtained from the natural environment forming the basis for community cohesion, social identity, livelihoods and cultural events (Bronen 2011; Bronen and Chapin 2013). Villages have small cash economies, with limited work opportunities. Store-bought food is expensive due to the high cost of transporting food to rural communities. Hence, subsistence harvests are critical to food security.

Between 1973 and 2013, ten flooding events were recorded in Shishmaref, seven of them declared state emergencies and three federal emergencies. Erosion and littoral drift are causing Sarichef Island's footprint, the island where Shishmaref is located, to move. Since 1969, the island has lost an estimated 60 m of land (AECOM Technical Services 2016). Between 1973 and 2015, 11 erosion-related events occurred in the village, 4 of them declared state disasters and 2 federal disasters.

Erosion has undermined buildings and infrastructure, causing several structures to collapse into the sea (Fig. 7). Protection measures have been ineffective in anything but the short term. Numerous control and facility relocation projects have been undertaken in an attempt to protect the community in place and provide more time to relocate it. Between 1973 and 2009, the state, federal and tribal governments invested about US$16 million in shoreline protection (SERC 2002; GAO 2009). However, around a third of the village, including the airport, homes and community infrastructure, remain exposed. Due to the incomplete shoreline protection, severe damage is expected by 2019, with the cost of relocation estimated at US$180 million (USACE 2009; Gregg 2010).

## Discussion

The diversity of responses across the four case studies provides critical insight into anticipated environmental responses to a 1.5 °C warming over the coming century such as a 1-m rise in sea level and increased coastal erosion and flooding. Exceeding the 1.5 °C target will substantially increase the coastal populations that will be forced to relocate from accelerated sea-level rise. By analysing the facilitators and inhibitors of the process of relocation and also the concerns and benefits associated with the outcome, we can learn valuable lessons to guide future relocation efforts (Table 2).

Shishmaref has been planning for relocation since 1976 and residents voted to do so in 2002 (Bronen and Chapin 2013). Two years later, the Shishmaref Erosion and Relocation Coalition (SERC) chose Tin Creek, around 20 km from the village's current location, as its preferred relocation site. In 2007, the community reiterated its decision to relocate to its preferred site of Tin Creek, and again in 2016, a community-wide vote was decided in the affirmative to relocate from Shishmaref (Demer 2016). Despite these proactive efforts by the community and detailed technical assessments of over 127 possible relocation sites, there remain questions over the long-term suitability of Tin Creek due to risks of thawing permafrost (AECOM Technical Services 2016). Furthermore, despite the high-profile nature of Shishmaref, there is no clear commitment of government resources to facilitate the complex relocation of essential services, infrastructure and housing to the new site.

In November 2007, Tony Weyiouanna, Shishmaref's representative from the Shishmaref Erosion and Relocation Coalition, ended his presentation to federal and state government agencies focused on responding to the immediate actions needed to protect the community by saying:

> The no action option for Shishmaref is the annihilation of our community… We are unique, and need to be valued as a national treasure by the people of the United States. We deserve the attention and help of the American people and the federal government.

> [We request] that Shishmaref be used as a state/federal demonstration project with maximum flexibility to determine what changes need to be made to lower the cost and impact of relocation, identify a state or federal champion to facilitate state and federal agency coordination for relocation of communities… Shishmaref, we are worth saving.
> (IAWG 2007).

The government-supported relocation efforts in both Shishmaref and Taro involve a high level of planning that will ideally provide a mechanism for these communities to relocate as an intact unit. However, in the short term, the cost has been these communities have not yet relocated and hence remain vulnerable to climate threats.

On the other hand, community-led relocations without government support in the Solomon Islands have been ad hoc to date with movements and decisions primarily made based on customary tenure and traditional knowledge of suitable sites at

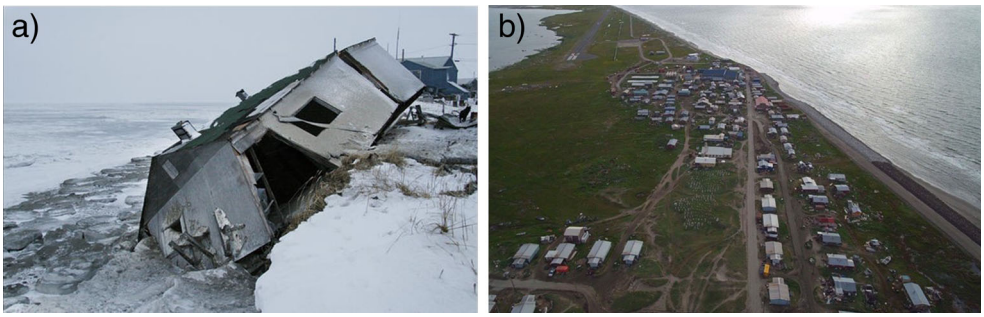


**Fig. 7** **a** Coastal erosion at Shishmaref leading to loss of residential house in 2005 (photo: Diana Haecker). **b** Aerial view of Shishmaref (photo: Dennis Davis)

a family level rather than broad community-level planning. Whilst the end results of these efforts have reduced the exposure to climate change risks of the families that have moved, there has been a significant cost in terms of the

**Table 2** Summary of collated findings from relocation communities with no support (Nuatambu, Nusa Hope) and those with government support (Taro, Shishmaref)

| | | No support | | Government support | |
|---|---|---|---|---|---|
| | | Nuatambu | Nusa Hope | Taro | Shishmaref |
| PROCESS | **Facilitators of relocation** | | | | |
| | Customary land | ■ | ■ | | |
| | Able to rely on household finances | ■ | ■ | | |
| | Household level decision making | ■ | ■ | | |
| | Threat of tsunami | | ■ | ■ | |
| | Lack of available land | | ■ | | |
| | Decision making framework | | | ■ | ■ |
| | Relocation site identified | | | ■ | ■ |
| | Understanding risk | | | ■ | ■ |
| | Institutional support | | | ■ | ■ |
| | Accelerated rates of erosion destroys houses | ■ | | | ■ |
| | **Inhibitors of relocation** | | | | |
| | Complex multi-stakeholder planning | | | ■ | ■ |
| | Lack of available land | | | ■ | ■ |
| | Relocation site subject to future climat hazards | | | ■ | ■ |
| | Attachment to "place" | ■ | ■ | | ■ |
| | Lack of resources to facilitate relocation | ■ | ■ | ■ | ■ |
| | Loss of Kinship and cultural connections | | | | ■ |
| | Loss of livelihood | | | | ■ |
| OUTCOME | **Benefits of moving inland** | | | | |
| | Closer proximity to fertile soils | ■ | ■ | ■ | |
| | Peace and quiet | ■ | ■ | | |
| | Improved infrastructure | | | ■ | ■ |
| | More space for expansion | ■ | ■ | ■ | ■ |
| | Feel safe from rising seas/tsunami | ■ | | ■ | ■ |
| | Closer to terrestrial resources | ■ | ■ | | |
| | Community able to stay together | | | ■ | ■ |
| | **Concerns with moving inland** | | | | |
| | Fractured community | ■ | ■ | | |
| | Reduced access to infrastructure | ■ | ■ | | |
| | Access to sanitation | ■ | | | |
| | Reduced access to marine resources | ■ | ■ | ■ | ■ |
| | loss of livlihoods | | | | ■ |
| | Reduced access to services (eg church, education) | ■ | ■ | | |
| | Limted flat land (landslide risk) | ■ | | | |
| | Reduce involvement in cultural events | ■ | ■ | ■ | |

fracturing of the community into small hamlets. Developing government frameworks that can draw on the strengths of the community-led approaches to relocation whilst also providing a mechanism for communities to stay intact will be an important step forwards for SIDS facing these climate pressures.

The common discourse that SIDS are the most vulnerable communities to sea-level rise is overly simplistic. If we consider vulnerability a function of exposure, sensitivity and adaptive capacity (Smit and Wandel 2006), certainly, the Solomon Islands is both highly exposed and sensitive. However, the case studies presented in this paper indicate, in some cases, there is a high level of inherent adaptive capacity. As observed during temporary community relocations in response to natural disasters, the inherent adaptive capacity to relocate is linked to the customary land tenure system where access to land and resources is controlled by lineage and kinship (Lauer et al. 2013). In Nuatambu and Nusa Hope, this tenure system allowed for access and the eventual voluntary movement to new areas through the heredity rights. Of course, any such movement typically requires a process of consultation and negotiation with leaders (e.g. "chiefs") deeply knowledgeable of local land tenure. An individual's level of knowledge of genealogy, *kastom* (traditional) stories and historical movements will dictate their ability to negotiate and consolidate their ability to relocate to and access resources in new areas. This process to secure land tenure over relocation sites would typically be conducted slowly over a period of years to allow consensus building amongst all stakeholders. However, in the case of Nuatambu, the rapid rate of coastal erosion and destruction of houses required families to relocate over a period of months, and hence, the customary tenure processes occurred rapidly. In some cases, this has led to conflict over customary ownership of relocation sites in Nuatambu.

Other communities in the Solomon Islands such as Sikiana, Ontong Java, Walande and Fanalei without access to high-elevation land through hereditary rights have faced significant challenges with relocation despite government efforts to find suitable land (Rasmussen et al. 2009; Birk and Rasmussen 2014; Monson and Foukona 2014). Marriage has long been a powerful tool for Pacific Island societies to strengthen links to essential resources (Bennett 1987). In the context of rapid sea-level rise, high-elevation land may become an essential resource for which strategic inter-marriage with inland "bush" tribes becomes the only viable means for which to ensure the survival of some coastal people. This has led to some communities in the Solomon Islands suggesting the promotion of inter-marriages, especially between small atoll island groups and those of high volcanic islands, as an adaptation option in cases of extreme sea-level rise vulnerability.

As these relocations become more common and depend on greater levels of government and international resources, an integrated approach that combines formal planning and suitability assessments with traditional knowledge may be useful (Albert et al. 2013; Leon et al. 2015). In Fiji, government-level resourcing and facilitation combined with availability of nearby customary land enabled a village to relocate as an intact unit (McNamara and Des Combes 2015; Charan et al. 2017). Whilst the per capita costs of relocation will not always be able to be externally financed, consideration can be given to the role of labour migration to provide both pathways for permanent relocation to neighbouring countries and cover financial costs of relocation through remittances to adjacent higher ground (Ash and Campbell 2016).

Each of the case studies presented provides lessons for facilitators and inhibitors of the process of relocation and also the concerns and benefits associated with the outcome. Developing mechanisms that can draw on the positives of these case studies will be critical as these relocations become more common under conservative 1.5 °C scenarios. A hybrid model to guide relocation of indigenous SIDS communities would build on the strengths of the customary land tenure system and the inherent adaptive capacity of local communities whilst providing a government-led framework that can provide access to resources and limit the tendency for communities to fracture whilst relocating.

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