The Role of Traditional Knowledge in Building Adaptive Capacity for Climate Change: Perspectives from Vanuatu

AINKA A. GRANDERSON

School of Geography, University of Melbourne, Parkville, Victoria, Australia

(Manuscript received 18 August 2016, in final form 4 March 2017)

ABSTRACT

There is increasing recognition of traditional knowledge as an important store of information and practices for building adaptive capacity for climate change in the Pacific. However, empirical research and documentation of how Pacific Islanders experience climate change, identify relevant adaptation options, and mobilize their adaptive capacity, including traditional knowledge, remains limited. Given this context, indigenous islander perspectives on traditional knowledge and its role in building their adaptive capacity are examined in this article. The author draws on research with the Nakanamanga-speaking peoples of Tongoa Island, Vanuatu. This research documents traditional knowledge relating to weather and climate observations; resource use and management; social networks; local leadership; and values and beliefs in these indigenous communities and reveals differing perspectives about its potential to enhance local adaptive capacity. It highlights indigenous concerns about self-reliance, cultural continuity, and how the transition to a cash economy, the valorization of Western education and lifestyles, and rural–urban migration have had adverse implications for traditional knowledge and its retention. It further reveals potential trade-offs for indigenous communities on Tongoa Island, where traditional governance, tenure systems, and values enable flexibility and collective action that build adaptive capacity but can also promote conservative attitudes and limit uptake of new information and practices.

1. Introduction

In the Pacific Islands, including Vanuatu, there is increasing recognition of traditional knowledge as an important store of information and practices for managing risks from climate change. Archaeological evidence and oral histories indicate that Pacific Islanders have adapted to weather extremes and several sea level changes over centuries through a range of mechanisms, including communal pooling of resources, food and water storage, elevated settlements, and rituals for predicting climatic and environmental variability (Nunn 2007; Campbell 2006, 2009; Mondragón 2015). Attention has consequently turned to how to apply this body of knowledge to build adaptive capacity in the context of climate change in the Pacific (e.g., Government of Vanuatu 2007, 2013; Climate and Oceans Support Program in the Pacific 2012).

Climate change poses a significant risk for Pacific Islands. In Vanuatu, climate models project that surface temperatures will increase by 2.5°C, tropical cyclones will increase in intensity, rainfall variability and extremes will increase, and sea level will rise up to 90 cm by 2100 in Vanuatu (Australian Bureau of Meteorology and CSIRO 2014). New invasive species and ocean acidification also present novel challenges. The potential consequences for its island communities characterized by small size, rapidly growing populations, limited economic opportunities, and heavy reliance on climate-sensitive livelihoods, such as rain-fed agriculture and fishing, are far reaching (Nurse et al. 2014).

While there has been significant research into the impacts of climate change and the vulnerabilities of biophysical systems and various economic sectors in the Pacific Islands (e.g., Bell et al. 2011; Walsh et al. 2012; World Health Organization 2015; Taylor et al. 2016), there has been less focus on how island communities experience climate change, identify relevant adaptation options, and mobilize their capacity to deal with impacts, including traditional knowledge. Research into place-based understandings of climate change, local impacts and vulnerabilities, and adaptive capacity is needed to enable effective adaptation (Barnett and Campbell 2010; Kuruppu and Liverman 2011; Lata and Nunn 2012; McCubbin et al. 2015) and inform efforts to integrate traditional knowledge (Kelman et al. 2009;

Corresponding author: Ainka A. Granderson, ainka.granderson@unimelb.edu.au

DOI: 10.1175/WCAS-D-16-0094.1

Nakashima et al. 2012). Furthermore, the interplay between climate change and wider socioeconomic and cultural changes, such as globalization, demographic changes, and development pressures, needs to be fully considered, as do the effects on adaptive capacity and traditional knowledge within island communities (Campbell 2006, 2009; Connell 2013; McCubbin et al. 2015).

In this article, I seek to address these issues and examine perspectives of adaptive capacity and the role traditional knowledge plays in building this capacity within indigenous island communities in Vanuatu. I focus on how these communities view traditional knowledge, and seek to apply it, in the face of climate change and wider socioeconomic changes. Gaining such insights into indigenous islander perspectives and priorities is critical to better target research and practice to build adaptive capacity. These insights are also critical as the Vanuatu government establishes a national framework safeguarding traditional knowledge and providing guidelines on its collection, storage, and use for climate change adaptation and disaster risk reduction (Government of Vanuatu 2013). Below, I begin with an overview of research on building adaptive capacity and the role of traditional knowledge.

2. Building adaptive capacity for climate change: A role for traditional knowledge?

Adaptive capacity is defined by the Intergovernmental Panel on Climate Change as the "ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences" (IPCC 2014, p. 1758). In the face of uncertainty, adaptive capacity offers a gauge of whether climate change adaptation is possible and likely to be successful. It encapsulates not only the capacity to withstand and recover from current climatic hazards, but to anticipate future changes. Assessing adaptive capacity, and identifying barriers and enablers to building it, has received growing attention in the climate change literature (e.g., Yohe and Tol 2002; Grothmann and Patt 2005; Pelling and High 2005; Pahl-Wostl 2009; Armitage and Plummer 2010; Kuruppu and Liverman 2011). However, the role of traditional knowledge in building adaptive capacity remains relatively underexplored (Smith and Sharp 2012; Pearce et al. 2015).

Traditional knowledge, which is also known as indigenous, folk, or local knowledge, refers to place-based knowledge rooted in the culture and traditions of a particular community. Although it is often discussed as an object, traditional knowledge is dynamic and performative (Ingold 2003; Sillitoe 2007; Berkes 2008). It represents a way of knowing and acting on the world. Berkes (2008, p. 7) describes it as "the cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment."

Over the last 30 years, there has been extensive research into traditional knowledge, which has been pivotal in understanding social and ecological systems at the local scale, establishing baselines to assess change, and providing observational evidence and strategies for environmental management and development. The richness and specificity of traditional knowledge has been highlighted, which enables local communities to detect environmental changes and alter their management practices to support long-term natural resource use (e.g., Berkes et al. 2000; Moller et al. 2004; Berkes 2008). In the context of disasters, researchers increasingly appreciate the importance of traditional knowledge and associated situated practices in preparedness and response (e.g., Ellen 2007; Aswani and Lauer 2014). The importance of traditional knowledge and values in shaping local understandings of and approaches to sustainable livelihoods and development has also been illustrated (e.g., Brokensha et al. 1980; Chambers 1996; Briggs 2005; Sillitoe 2007).

It is only in the last decade though that research has explored traditional knowledge in the context of climate change and building adaptive capacity. While much of this work initially focused on the Arctic (e.g., Berkes and Jolly 2001; Ford et al. 2007; Turner and Clifton 2009; Weatherhead et al. 2010; Pearce et al. 2015), attention has increasingly turned to Africa (e.g., Nyong et al. 2007; Speranza et al. 2010; Naess 2013), Eurasia (Byg and Salick 2009; Marin 2010; Crate 2011), Oceania (e.g., King et al. 2008; Green et al. 2010; Leonard et al. 2013), and the Pacific (e.g., Bridges and McClatchey 2009; Lefale 2010; Mondragón 2015). Across this body of research, it is argued that adaptive capacity for climate change depends on flexibility, the ability to learn and manage uncertainty, and culturally relevant adaptation options and that traditional knowledge influences these factors in a number of key ways. These include 1) identifying climatic changes and their impacts; 2) guiding resource use and management; 3) shaping governance structures and social relations; and 4) promoting cultural values and worldviews that determine local perceptions and responses to changing conditions (see Table 1).

The role of traditional knowledge in observing and forecasting climate variability and extremes locally has been increasingly documented (e.g., Lefale 2010; Marin 2010; Weatherhead et al. 2010; Mondragón 2015), and the potential to integrate such traditional knowledge and Western science to enhance climate monitoring and

TABLE 1. Review of literature on role of traditional knowledge in shaping adaptive capacity for climate change.

Traditional knowledge categories	Examples related to adaptive capacity for climate change	References
Observations of weather, climate, and environmental changes and their impacts	Observations of seasonal patterns of rainfall, temperature and winds, hydrological cycles, lunar cycles, tides, and ocean currents that form baseline to assess changes Bioclimatic indicators and weather forecasting Early warning systems for climatic hazards Knowledge coproduction and learning based on traditional knowledge (TK) and climate science	Berkes and Jolly (2001); Berkes (2008); Ford et al. (2007); Kelman et al. (2009); Green et al. (2010); Hiwasaki et al. (2015); Lefale (2010); Leonard et al. (2013); Marin (2010); McMillen et al. (2016); Mondragón (2004, 2015); Nakashima et al. (2012); Orlove et al. (2000, 2010); Pearce et al. (2010, 2015); Roncoli et al. (2002); Speranza et al. (2010); Turner and Clifton (2009); Weatherhead et al. (2010)
Resource use and management practices	Community pooling and exchange of labor and resources	Berkes and Jolly (2001); Berkes (2008); Bridges and McClatchey (2009); Campbell (2006, 2009); Crate (2011); Ford et al. (2007, 2010); Hiwasaki et al. (2015); Leonard et al. (2013); McCubbin et al. (2015)
	Conservation/restricted use areas	McMillen et al. (2016); Mondragón (2015); Nakashima et al. (2012); Naess (2013); Pearce et al. (2010, 2015)
	Diversification of subsistence strategies Preservation and storage of food and water Seasonal migration Selection of resistant crop varieties Use of resilient building materials and structures	
Governance, leadership, and social ties	Customary governance and rules related to collective decision-making, conflict resolution, and tenure and use rights Inter-island exchange and trade Kinship and networks of reciprocity Intergenerational ties	Berkes and Jolly (2001); Berkes (2008); Ford et al. (2007, 2010); Howitt et al. (2012); Lane and McNaught (2009); Lata and Nunn (2012); McCubbin et al. (2015); Mondragón (2015); Nakashima et al. (2012); Naess (2013); Pearce et al. (2010); Williams and Hardinson (2013)
Cultural attitudes, identity, values, and worldviews	Oral histories and folklore Religious beliefs Rituals and ceremonies (determining levels of preparedness, respect for nature, and sustainable use)	Berkes (2008); Bravo (2009); Byg and Salick (2009); Crate (2011); Ford et al. (2007); Hiwasaki et al. (2015); Lane and McNaught (2009); Lata and Nunn (2012); Leonard et al. (2013); Mondragón (2015); Petheram et al. (2010); Rudiak-Gould (2012, 2014)

modeling of impacts and build adaptive capacity is seen as significant (Kelman et al. 2009; Nakashima et al. 2012). In the Pacific Islands, Lefale (2010) and Mondragón (2004, 2015) have documented traditional seasonal calendars and the various bioclimatic indicators, including changes in plant and animal behavior, that influence the timing of subsistence activities and ceremonial rites in Samoa and Vanuatu. These local observations are critical, given the limited scientific data, to establish baselines and assess local impacts and vulnerability to climate change within the Pacific Islands (Kelman et al. 2009). Research has also documented traditional knowledge relating to strategies for managing climatic hazards and resource variability in the

Pacific Islands and beyond, such as producing and preserving food surpluses, communal pooling of resources, and constructing wind-resistant houses in response to cyclones (e.g., Campbell 2006, 2009; Bridges and McClatchey 2009; Nakashima et al. 2012). Reviving or building upon these traditional risk management strategies offers an important pathway for adaptation to greater climate extremes.

Traditional knowledge is also embedded within, and reinforces, particular governance and social structures, including local leadership and decision-making, kinship networks, and social obligations (e.g., Nakashima et al. 2012; Naess 2013; Williams and Hardinson 2013). These governance and social structures mobilize adaptive capacity directly by enabling material responses to climate change and indirectly via institutional changes. Customary governance and kinship networks, for example, allow Pacific Island communities to respond to climatic hazards through sharing of resources and labor locally and accessing remittances externally (Campbell 2006, 2009; Kuruppu 2009). However, there has been erosion of these networks of reciprocity via colonial processes, demographic changes, and global market forces, rendering many Pacific communities increasingly at risk to climatic and other environmental changes (Barnett and Campbell 2010; Connell 2013). Traditional systems of governance and norms can also be exclusionary and may not represent indigenous communities' diverse interests (Lane and McNaught 2009; Jones and Boyd 2011; Lata and Nunn 2012). For example, Lane and McNaught (2009) note that women in the Pacific Islands often have limited access to information and income-earning opportunities as a result of patriarchy in traditional governance systems and low mobility because of their domestic and child-rearing roles.

There has been more limited engagement with traditional knowledge and its associated norms and values and how these sociocultural factors can influence adaptive capacity and climate change adaptation in indigenous communities. However, recent empirical research has begun highlighting how the distinct cosmologies and worldviews linked to traditional knowledge influence perceptions of climate change and its risks and motivations to adapt (e.g., Crate 2011; Rudiak-Gould 2012, 2014; Petheram et al. 2010; Leonard et al. 2013; Mondragón 2015). In Vanuatu and elsewhere in the Pacific Islands, Rudiak-Gould (2012) and Mondragón (2015) illustrate that islanders draw on cosmologies that do not distinguish between weather, climate, and their lifeworlds and associate a range of phenomena, including accelerating time, lifestyle changes, and a solar eclipse, with climate change. Consequently, it is not intuitive for them to conceive of climatic changes as purely hydrometeorological phenomena or adaptation as purely a response to specific hazards. These distinct cosmologies linked to traditional knowledge problematize the uptake of Western science in decision-making (Rudiak-Gould 2012) as well as what counts as a risk and appropriate adaptations (Orlove 2009; Leonard et al. 2013; Granderson 2017).

3. Methods

a. Study site

The Republic of Vanuatu is an archipelago of islands in the South Pacific spanning over 1300 km. It comprises 83 islands, of which 65 are inhabited, ranging from low-lying coral atolls to mountainous, volcanic islands. The largely rural population is estimated at 252 763 (World Bank 2013). Indigenous Melanesians, or ni-Vanuatu, constitute around 95% of the population (Government of Vanuatu 2009). Archaeological evidence indicates that ni-Vanuatu inhabited the archipelago from about 3000 BP (Bedford et al. 1998). There is significant cultural and linguistic diversity, with about 113 indigenous language groups across Vanuatu (Tyron 1976).

In this article, I focus on the Nakanamanga-speaking groups of north Tongoa. Tongoa is a hilly, volcanic island in the Shepherds Islands Group in central Vanuatu (see Fig. 1). It covers approximately 42 km^2 and is located about 150 km north of the capital, Port Vila, on Efate Island. Tongoa has a subtropical climate with an average annual rainfall of 2200 mm and air temperature of 26°C. Little natural vegetation remains on Tongoa. A mix of cultivated gardens[1] and secondary forest largely covers the island. Surface water is limited, with no large, permanent rivers. An active submarine volcano lies off Tongoa's northwest coast.

Tongoa's population is estimated at 2300. There are 14 villages, including seven in the north that speak the Austronesian language, Nakanamanga. Agriculture is the mainstay of the semisubsistence economy. Cash income is largely derived, where possible, from sales of crops, livestock, and woven mats to Port Vila markets. There are no paved roads or electricity on the island but villagers can access health clinics, primary and secondary schools, regular airline and shipping services, and Vanuatu's mobile phone networks. Most villages have a large Presbyterian church. However, there are over 10

[1] Gardens (or *karen* in Bislama) refer to cultivated and tended areas in Vanuatu. This term is used instead of farms. Villagers also refer to themselves as "gardeners" rather than farmers.

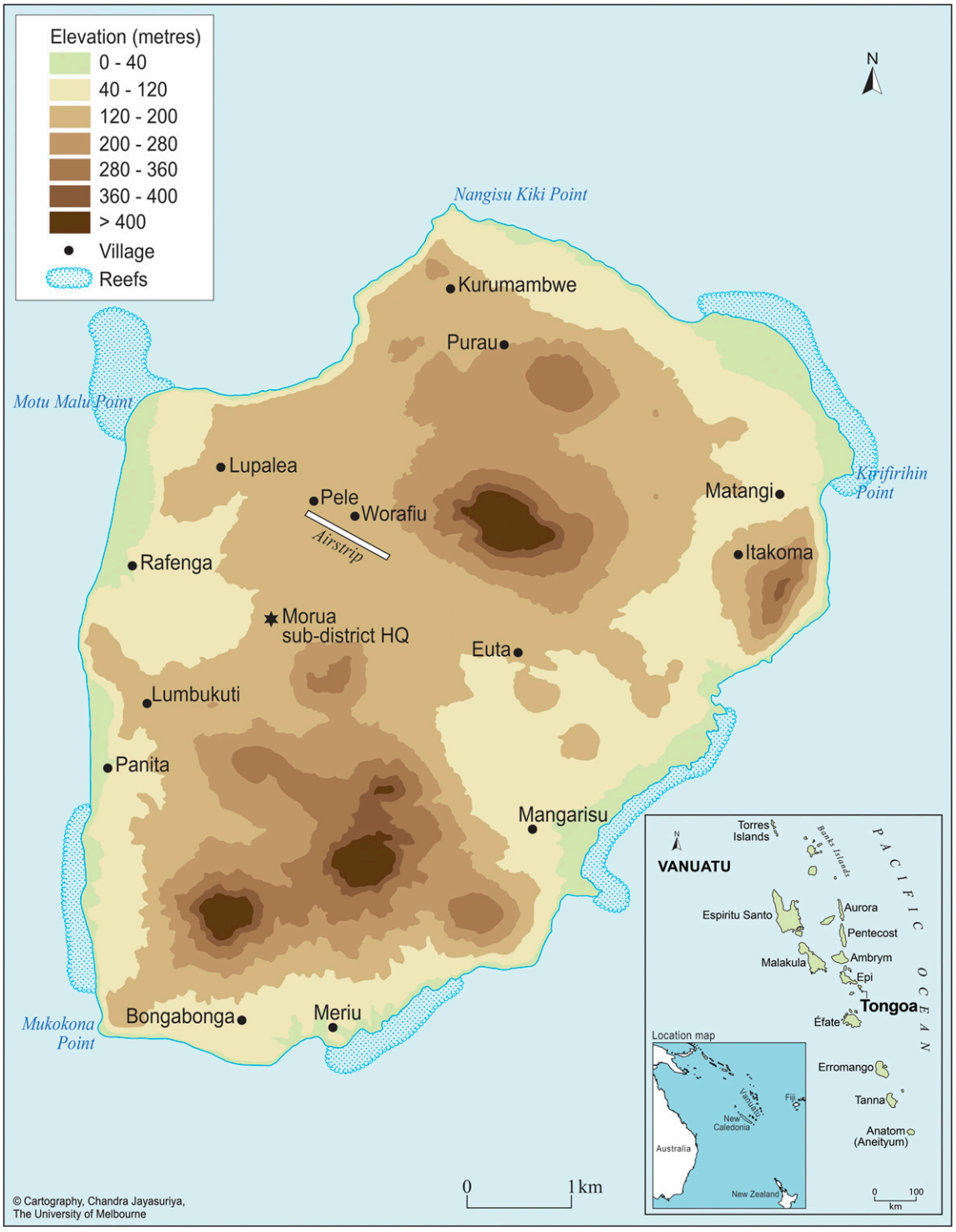

FIG. 1. Map of Tongoa Island, Vanuatu.

denominations on Tongoa, including sizeable populations of Catholics and Seventh-Day Adventists. The local government administration for the Shepherds Islands Group is also based in Morua, Tongoa.

Each village in Tongoa has a paramount chief and lesser chiefly titles, which are based on hereditary chiefdoms. Chiefs govern village life. Each village, or chiefdom, also has its own *kastom* (Espirat et al. 1973; Kelly 1999).

Kastom is a term from Bislama, the lingua franca of Vanuatu, that refers to the suite of knowledge, practices, and values originating in the period before colonization in the 1800s. There is no equivalent term in the Nakanamanga language. The term itself appears to have been introduced from English at the turn of the twentieth century. Kastom does not hold the same meaning as its direct English translation "custom," however. It is closer in meaning to "culture" and defines what belongs to a particular group and place, including both symbolic and material aspects (Bolton 2001; Regenvanu 2005).

b. Data collection and analysis

Research occurred over 3 months from August to October 2013. It was part of a wider project to examine local constructions of climate change, its risks and adaptive capacity, and how these affect adaptation planning in rural Vanuatu from 2013 to 2014. Kurumambe and Purau villages were the main focus in north Tongoa. Both villages were actively engaged in climate change and disaster risk reduction initiatives with the international organization Act for Peace.

Mixed methods were used, including semistructured interviews, focus groups, and archival material. Interviews and focus groups relied on narrative inquiry for villagers to "story" their concerns, experiences, and aspirations (see Vaioleti 2006, p. 21). The research questions did not explicitly reference climate change unless villagers themselves used this term. Instead, questions focused broadly on environmental changes, including shifts in weather and seasons. As there was no direct local translation for adaptive capacity, questions also focused on local strategies for managing these environmental changes and associated risks to examine villagers' perceptions of their adaptive capacity and the role of traditional knowledge. Interviews were conducted with 20 households each in Kurumambe and Purau villages (each has a total of 30–40 households). Key informant interviews were done with eight leaders, including chiefs and representatives from village-level disaster and water committees. Table 2 summarizes the demographics of the interview participants.

Focus groups were also conducted, two with women and two with youth (aged 18–25)[2], in Kurumambe and Purau villages. They sought to give voice to women and youth, who are typically marginalized in the patriarchal and hierarchical decision-making systems in rural Vanuatu. Focus groups explored in depth the climate-related changes and risks highlighted in interviews, local adaptation strategies and the role of traditional knowledge. There were six to eight participants in each focus group. Interviews and focus groups were conducted in Bislama, which is spoken by the majority of villagers in addition to Nakanamanga, with the support of a ni-Vanuatu researcher. All interviews and focus groups were digitally recorded and transcribed verbatim in Bislama, and the data were analyzed using NVivo 10.

TABLE 2. Demographics of interview participants from Tongoa Island, Vanuatu.

	Household interviews		Key informant interviews
	Kurumambe	Purau	
Total sample	20	20	8
Sex:			
Male	12	9	7
Female	8	11	1
Age group:			
18–30 yr	6	4	1
31–45 yr	6	9	3
46–65 yr	5	2	3
65+ yr	3	5	1
Education:			
Primary	13	13	3
Secondary	7	7	4
Tertiary	0	0	1
Vocational	0	0	0
Main income:			
Farming/fishing	10	11	2
Salaried work	2	3	5
Small business	4	3	1
Wage labor	1	0	0
Retired/none	3	3	0

4. Results

Villagers in Kurumambe and Purau were ambivalent about their capacity to adapt to climate-related changes, such as coastal inundation, loss of crop productivity with seasonal shifts, and more extreme droughts and floods. This ambivalence reflects diverging views about self-reliance and the significance of *kastom save*[3] (traditional knowledge). Although kastom save was commonly

[2] Youth was a fluid and open category in Vanuatu. I found that persons of a wide age range, including up to 35 years, were active members of youth groups. Ni-Vanuatu, particularly in rural areas, also do not always know their date of birth or their exact age. I therefore chose to work with persons 18–25 years within youth groups that were, typically, unmarried, did not have children and did not hold any leadership roles.

[3] *Kastom save* is a term used in Bislama to specify traditional knowledge and skills versus other forms of kastom, including beliefs, values, rituals, and institutions, that are unique to the people of the place.

referenced in villagers' assessments of adaptive capacity, they attached varying levels of significance to it.

Of the interview participants, 47% perceived high adaptive capacity within their household and the wider village, and they tended to highlight the value of kastom save ($N = 48$). They identified a range of traditional strategies that have been, or could be, implemented to manage changing climatic risks. Self-reliance was a trait that these villagers valued and were proud of. They noted that their ancestors have thrived in the face of a range of climatic and geological hazards on Tongoa Island. In contrast, 35% of interview participants perceived low adaptive capacity, and 18% were unsure. These participants highlighted the erosion of kastom save, along with poor leadership, land disputes, and politics. They argued that these issues had created divisions within their villages and limited the potential for local action. They also argued that their villages could not address risks, such as coastal inundation, without external interventions like reforestation and resettlement schemes. Table 3 outlines the traditional and externally driven strategies for managing changing climatic risks as identified by interview participants.

Below, I unpack villagers' perspectives on the changing role of kastom save and what it means for building adaptive capacity for climate change in Vanuatu. I focus on five aspects of kastom save, which were highlighted in interviews and focus groups, relating to 1) weather and climate observations; 2) resource use and management; 3) social networks; 4) local leadership; and 5) beliefs and values.

a. Observing and predicting weather and climate

An important facet of kastom relates to knowledge and rituals for observing and predicting climatic variability and extremes. The success of subsistence activities, especially agriculture and fishing, demands careful observation of climatic factors, including wind direction, cloud formation, and rainfall. In fact, the year and traditional planting calendar are divided into two "wind" seasons for villagers in north Tongoa [see Espirat et al. (1973) for a detailed planting calendar]. These seasons correspond to the conventional wet and dry seasons in Vanuatu. From November to April the northerly monsoon dominates with erratic winds, heavy rainfall, and high temperatures. Cyclones typically occur during this period. With the onset of the rains, villagers plant yam (*Dioscorea spp.*), a valuable staple and customary crop. Planting ends in December, so crops are established and can withstand cyclones from January to April. Other root crops like manioc and sweet potato are planted at the end of the rains. The southeast trade winds dominate from May to October, bringing a dry spell and cooler temperatures. Crops are harvested during this period, and seas are generally too rough for deep sea fishing. Villagers also observe lunar cycles and phases of the moon because of the effects on tides and access to coastal springs and fisheries in Tongoa.

The knowledge and use of bioclimatic indicators, which link changes in cloud formation, wind direction, tides, and other environmental conditions with the behavior of flora and fauna, enable villagers to trace the progression through the seasons and act accordingly. Such knowledge is an assemblage of personal observations and oral history passed down over generations in Tongoa. Villagers noted the appearance of the Palolo sea worm (*Eunice viridis*) signaling the rains and time to plant yams in Tongoa and other parts of Vanuatu (see Mondragón 2004). The flowering of wild cane (*Miscanthus sp.*) in March signals the spawning of reef fish and ending of the rains (see Hickey 2007). In particular, villagers highlighted bioclimatic indicators in their strategies for predicting climatic hazards. For example, a village leader in Purau described the following:

> . . . in the past, our grandparents and their forefathers had kastom way where they studied the weather, the clouds, and if they found signs like mango trees flowering plenty, they knew there would be a big cyclone. So they announced there would be a disaster. Then the chief would make awareness in the whole community and so everybody would prepare food for this disaster period. They had to prepare legumes that lie down, not plant manioc and other plants that grow up high because there might be a disaster. Cyclones have caused big disasters in Vanuatu many times, and our forefathers knew they had to prepare.

Other hazard indicators include sea birds coming to land and abnormal activity among ants and other insects. Villagers rely heavily on such knowledge to prepare for shortages in food, water, and other resources during extreme events like cyclones, floods, and droughts. They also noted that there is the potential to apply this kastom save to adapt to changing climatic risks, such as more extreme cyclones.

There was concern that this kastom save is eroding. As the quote above suggests, such knowledge was widely held and valued among past generations. However, villagers explained that there are few opportunities for disseminating kastom save to younger generations through oral history and learning by doing as a result of the transition to formal Western education, integration into the capitalist economy, and rural–urban migration. Shifting seasons and baselines due to climate change further compounds the erosion of kastom save. A villager in Kurumambe noted, for instance, the following:

> The old people in the village they can say that clouds or weather like this signals a cyclone. They do not have

TABLE 3. Traditional and externally driven strategies identified by villagers for addressing climate variability and change on Tongoa Island, Vanuatu.

Type of application	Traditional strategies	Externally driven strategies
Weather observations and early warning systems	Traditional climate forecasting using cloud formations, constellations, and winds	Awareness raising and communications (e.g., posters, DVDs, games, and oral presentations)
	Bioclimatic indicators (e.g., heavy flowering of mangoes and no sign of cicadas, and wild pigeons, etc., used as cyclone warning)	Training and capacity-building workshops
		Seasonal forecasts and disaster warnings disseminated to villagers (e.g., radio and text messages)
		Creation of village committees on climate change and disasters
Food security	Place tabu for 1–5 yr to restrict fishing in marine areas or harvesting of fruits and nuts in forests	Permanent marine conservation areas, including no-take fishing zones, with local management committees
	Plant hardy, low-growing "disaster crops" (e.g., legumes)	Technical advice from agricultural extension agents
	Plant surplus crops (tabu garden) for times of crises	
	Request food or remittances from kin relations locally, in urban areas or abroad	
	Food preservation (e.g., dried breadfruit and fish)	
	Traditional pest control (e.g., planting marigolds or sprinkle leaves with water mixed with chili peppers)	
	Wan pikinini, wan karen (one child, one garden) rule	
	Kastom magic	
Water security	Access springs in dry spells	Piped water supply from spring sources
	Place tabu on certain uses of rainwater (e.g., bathing and washing clothes) or on certain activities (e.g., piggeries near water sources)	Rainwater harvesting and storage in cement or poly tanks
	Temporarily relocate nearer to springs and gardens	Creation of village water committees to oversee and maintain water supply
	Request water from kin relations locally or shipments of water from kin in urban areas or abroad	
	Drink green coconuts when poor water supply or quality	
	Kastom magic	
Building construction and hazard management	Build on land away from flood-prone areas	Coastal reforestation with introduced species (e.g., vetiver grass)
	Dig drains around houses to prevent flooding	Build seawall for shoreline protection
	Use traditional styles and materials (e.g., low roofs and wild cane)	Relocate airport, roads, and other public infrastructure inland
	Replanting vegetation for flood and shoreline protection in flood-prone areas	Resettlement of villagers to larger, higher islands
	Relocate villages inland to higher ground or migrating to other islands with relatives	

TABLE 3. (*Continued*)

Type of application	Traditional strategies	Externally driven strategies
Social networks and relations	Strong leadership and rispek for village chiefs and other community leaders	Training on governance, conflict management, etc. for community leaders
	Request assistance or refuge from kin relations and friends	National Malvatumauri policies on chiefly structures and reviving kastom protocols at island and village levels
	Collective action to clear branches, etc., in preparation for cyclone	Promotion of multilevel governance and linkages between village committees, Tongoa area council, and provincial council
	Fundraising or pooling funds to purchase items or services or educate specific villagers	
	Close ties with local officials and political representatives	

radio or mobile phone. All the time the old people are using the weather only to indicate when disaster is coming. But now because of all these changes [in weather] it is disturbing the readings of the old people.

Villagers in Tongoa are finding that established bioclimatic indicators are increasingly out of sync with their associated routines, including customary rituals, fishing, gathering of fruits and nuts, and planting and harvesting of crops. For example, the traditional planting calendar is no longer strictly followed because of shifts in rainfall and temperature regimes. Consequently, villagers felt disoriented and were questioning the value of kastom save.

b. Local resource use and management

The allocation and use of land and marine resources is also a reflection of kastom save and shapes villagers' capacity to adapt to climatic and wider environmental changes. Villagers in Tongoa noted an array of customary rules relating to land tenure, harvesting practices, and sharing, which provide mechanisms for dealing with resource variability. For example, Tongoa is divided into 14 hereditary chiefdoms associated with its villages, including Kurumambe and Purau. These chiefdoms form ''slices'' radiating from the island's center to the shoreline. Each chiefdom is headed by a paramount chief. The chiefdom is comprised of titles, rather than a bounded territory, which are bestowed on small chiefs [see Kelly (1999) for details of chiefly titles]. Fixed plots of land within the chief's domain accompany these titles. These plots of land can be used by the small chief and his kin group, which includes about two to six households of patrilineally related men in Kurumambe and Purau. This kin group represents the key landholding unit that structures subsistence activities.

Typically, each household cultivated three new gardens on their plots every planting season, including a mixed garden with a diversity of crops, a garden of staple foods, such as manioc and sweet potato, and a yam garden. Households also have older gardens with tree crops that they do not actively cultivate and piggeries. Crop diversity provided a constant flow of food over the year. Spatial diversity meant that damage in one part of the island from extreme events, such as cyclones, would not wipe out the entire food supply. Access to spatially diverse plots of land also enables mobility and use of coastal springs in times of water shortage. Villagers noted that households shift temporarily to the coast to access coastal springs and marine resources when rainwater harvesting and gardens fail during extended drought.

Additionally, villagers made frequent reference to customary rules about harvesting practices. In particular, they noted the practice of placing a *tabu* (taboo) on certain areas and resources, such as cultivable land, forests, and fish and shellfish, to ensure recovery of stocks in the face of natural hazards or overexploitation. Chiefs would place a *Namele* leaf [4] to mark areas that were off limits for use for a given time period. This practice is still used today, especially for creating no-take fishing zones. A village leader in Purau explained the following:

There is a ban on the nearshore area. The chiefs have put a tabu for the last two years and the people know that

[4] The leaf from the Namele or Cycad (*Cycas seemanii*) is a symbol of cultural significance. A pair of crossed Namele leaves is a sign of peace and wealth, which is depicted on the Vanuatu flag along with pig tusks. A single leaf is used as a tabu sign. When placed near a beach, building, or fruit trees, it indicates ownership or use rights to that site or item and restricts access to others. Anyone breaking the tabu is liable to a fine, which is enforced by the chief(s) of the village.

> if they break this tabu they will have to pay by offering pigs and cattle. They cannot catch fish, shellfish or any other marine resources. If you want to fish you must go a long way out in the deep water.

Although customary rules persist, villagers noted that changing land relations have increasingly altered patterns of resource use and undermined mechanisms for managing climatic variability and change in the future. Changing land relations are closely linked to changing economic and population pressures. Shifts in land tenure have been precipitated by the establishment of coconut plantations for copra processing and export since the 1940s and tourism and small enterprise development more recently. Plots of land may now be associated with an individual or kin group for longer periods of time than in the past (Kelly 1999). A decline in the number and size of subsistence gardens, and greater intensity of use, has also occurred. A consequence of changing land use has been declining yields and increasing reliance on imports, such as rice, flour, and canned meats, to address food shortages. Energy and water security were also a concern, as changing land use has reduced forest cover, limiting fuelwood and groundwater recharge.

Population pressures have compounded this situation in recent decades, leading to tensions over land allocation and the applicability of customary rules. In Tongoa, population peaked about 15–20 years ago. With high population density came overexploitation and land disputes, which remain a significant issue in Tongoa. A village leader in Purau noted the following:

> Water management is difficult. In many villages in Tongoa, like ours, there are water shortages in dry season. People only have wells [rainwater tanks]. Rural water supply comes in to build a piped water system. But, if there is a land dispute, it stops the project. And it is difficult to resolve the disputes as all of our paramount chiefs are now in Vila.

As this villager highlights, none of the 14 paramount chiefs currently reside in Tongoa. There has been rapid out-migration to urban centers as a result of declining resources (Government of Vanuatu 2009). Their absence undermines the legitimacy of chiefly structures and the ability to enforce customary rules. Depopulation has also thrown the main landholding unit in Tongoa, the kin group, into disarray and problematized use rights as households migrate, abandoning houses, rainwater tanks, and gardens.

c. *Networks of relations and reciprocity*

Villagers also highlighted that *rispek* (respect) is a fundamental part of their traditional strategies for managing climatic and wider environmental changes and building adaptive capacity in Mota Lava and Tongoa. Rispek refers to the socially accepted ways of behaving and relating to others based on rank, status, kinship, and wider networks of exchange (Bolton 2001; Regenvanu 2005). In particular, it was used in conjunction with kastom, indicating deference for traditional knowledge, practices and values. Villagers noted that rispek enabled collective action, the enforcement of customary rules, and reciprocity. This response from a villager in Kurumambe captures this:

> When disasters come we can handle them. Rispek is important here. When every place is cracked [from an earthquake] and some of our gardens are damaged we can get food from other families. When there is flooding we can go stay with other families whose houses were not affected by the flood. And our chiefs speak up and encourage people to work together.

Through social cohesion and ties, villagers can more effectively plan for or respond to climatic and other hazards. For example, collective action is required to clear old trees, dig drains, and maintain communal water supply in the village to address risks from more intense cyclones, flooding, and water shortages in the dry season. Kinship ties also play a key role in response and recovery to extreme events, like cyclones, drought, and flooding. Households without their own water tanks or food reserves typically rely on kin in the village or nearby villages to access water and food during shortages, for example. Relatives in the urban centers in Vanuatu or abroad in Australia, New Zealand, or other Pacific Islands will also mobilize to send relief in times of crisis or provide refuge. Remittances are also an important income source for villagers in Tongoa, allowing them to purchase food, medicine, and transport when needed.

Declining rispek, however, is a major concern. With the transition to a cash economy in Tongoa, Western knowledge and values have been promoted. Younger generations increasingly require and value Western knowledge and technology over kastom save. There has also been a shift toward an individualistic mentality, and an unraveling of kinship ties and the wider social fabric, with westernization and the transition to a cash economy. Few villagers are willing to lend a hand if there is no direct benefit for themselves and their households. Trust and reciprocity within communities are undermined, as villagers do not contribute to communal activities and overexploit communal resources for personal gain. Further, village leaders noted that disputes over land, water, and marine resources like fisheries are now commonplace within and between households. Such tensions mean that the extended family and other kin are less likely to share knowledge, pool resources, or come to each other's aid in everyday and crisis situations.

d. Customary governance and leadership

Another important facet of kastom relates to the function and structure of village governance in Tongoa. Governance remains centered on chiefs and their councils, who oversee village life and socioeconomic development. This chiefly system has been formalized within the politico-legal system since independence in 1980. The *Malvatumauri* or National Council of Chiefs was established, which serves as an advisory body to the national government. Local chiefs are elected to this national council as well as councils at the island and provincial levels. In this way, chiefs have been codified as a distinct category and endowed with political authority to rule over their villages. Villagers noted that strong and cohesive leadership by their chiefs and village councils, which include church leaders and representatives from women's and youth groups, enables collective planning and action, effective enforcement of customary rules, and conflict management and so shapes their capacity to manage climatic and environmental changes.

However, while chiefly systems remain intact, their symbolism and function at the village level has changed significantly over the last 50 to 100 years. A village leader in Kurumambe explained:

> In the way of the past, as I remember when I was small, rispek and behaviour towards the chiefs was a big thing. I mean the chief talks and every community member must listen to the chief. But today, for example, the chief talks and other community leaders they can talk straight back to the chief but in the past it was not like that. Now the chief has put a tabu on fishing in this conservation area but men still go fishing at night. Everyone behaved well when they listened to the old chiefs but today plenty changes are coming in. . .

In this quote, the village leader notes that the chief's authority and their system of governance is declining. Presbyterian missionaries have had a major influence. They condemned polygamy and kastom save linked to black magic, for example (Kelly 1999). More recently, rural–urban migration has also led to the paramount chiefs of Tongoa's 14 villages residing in the capital, Port Vila, on Efate Island rather than locally, as noted in section 4c. These paramount chiefs have appointed representatives in each of their villages. The representatives do not command the same level of rispek, however, and villagers felt abandoned by their chiefs. The lack of authority and legitimacy within chiefly structures has adverse consequences for collective action and self-organization. Enforcement of rules and conflict management are also difficult. As the above quote highlights, placing a tabu on natural resources is not always effective, as these restrictions by the chief are not recognized by all the villagers. Similarly, villagers often ignore restrictions on communal water use that the chiefs have put in place to address dry season shortages.

The patriarchal and hierarchical nature of chiefly systems is also highly problematic. It serves to exclude lower status groups, including women, youth, and disabled people, who are often the most vulnerable to climatic variability and change. In focus groups, women noted their exclusion from holding chiefly titles in Kurumambe and Purau villages in Tongoa and the strict rules governing their presence and speech in the *nakamal* (chief's meeting place). Because of the lack of women in leadership positions, women's access to information and opportunities to give input on climate change and wider development issues were constrained.

e. Cultural beliefs and values

Villagers in Mota Lava and Tongoa also highlighted kastom values as shaping their capacity to manage climatic and wider environmental changes. Along with Christian religious values, kastom provides a cultural frame through which they make sense of their lifeworlds and imbue meaning. Together these two value systems represent a set of standards, including assumptions, beliefs, and preferences, which guide villagers' attitudes and behavior to each other and their surroundings.

Villagers cited forward planning, which they described as *futja lukluk*, as an important but declining kastom value that had allowed their parents and grandparents to sustain their subsistence lifestyles and ensure food and water security over the long term. Tied to this, they noted that older generations had a strong work ethic and motivation to be self-reliant. A villager in Kurumambe provided the following example of this culture of proactivity:

> There is a practice we have, like a kastom or lifestyle, that our grandparents had from the past to now. . .If you want to get married they tell you that you must have your own house, a water tank, a garden, all those things firstly. I think if we followed this plan we would not have problems [water shortages]. But, for example, when I got married I claimed the old tank from my parents and I did not build my own.

Shifting attitudes and values mean, however, that villagers are no longer as proactive as in the past, with adverse consequences for their capacity to adapt to climate variability and change. The desire for an easier Western lifestyle, which is based on a cash income, is at odds with the heavy workload required to maintain the traditional gardening system and various techniques for food preservation and disaster preparedness.

Additionally, villagers have busier schedules, including church activities, development projects, and national events and less time for subsistence activities.

Kastom save and beliefs also influence villagers' conceptions of human–environment relations and agency. Tongoa Island's origin story, which was related in interviews and focus groups, affirms the notion that black magic can control hazards, such as the eruption of the Kuwae caldera c. 1425.[5] Such beliefs also extend to hydrometeorological phenomena. Villagers noted that black magic could control cyclones and storms, winds, tides, and seasons. Natural hazards are, therefore, closely linked with human actions. Furthermore, unusual weather patterns and extremes may, in fact, be envisaged as moral retribution for villagers not adhering to kastom and religious ideals (e.g., villagers not respecting chiefs and taboos or adopting Western practices and technologies instead of customary practices). This quote from a Purau villager highlights these concerns:

> I can say that the Digicel [mobile phone] tower is the main cause for these changes that have occurred, like we do not have *lif laplap* [a variety of *Heliconia* leaf used to wrap a starchy pudding]. The leaf does not grow properly. It curls up and dies. Before it was not like this. . .I'm not sure about all these new things like the tower, mobile phones and computers.

Villagers' distinct notions of human–environment relations have a number of potential consequences for adaptive capacity. Placing responsibility for climatic and other hazards locally necessitates a response from villagers, such as adhering to customary rules concerning resource management, and promotes local agency. However, kastom save and beliefs can lead to regimented attitudes that serve as barriers to the adoption of new adaptations. For example, local government officials in Tongoa lamented that villagers were linking crop productivity and the rising incidence of diseases, such as the rust (*Puccinia heliconiae*) affecting lif laplap, with Western technologies, as this led to "little interest in new technologies" and deflected attention away from interventions like controlling disease spread or identifying resistant species.

[5] The kastom story about the eruption of the Kuwae caldera c.1425, which created Tongoa, Epi, and other Shepherds Islands, has been documented by Guiart (1973) and Kelly (1999) and was told to me. The story links the eruption with black magic. This black magic is used by a man, Tompuku, who villagers tricked into committing incest with his mother. He destroys Kuwae as revenge. Villagers now refer to the active submarine volcano off the northwest of Tongoa, which is part of the submerged Kuwae caldera, as Tompuku.

5. Discussion and conclusions

The perspectives from villagers on Tongoa Island, Vanuatu, illustrate the multifaceted nature of traditional knowledge and its varied role in building adaptive capacity for climate change. In particular, these perspectives underline that traditional knowledge represents situated and dynamic ways of knowing (Ingold 2003; Berkes 2009). Traditional systems for observing weather and climate, and managing resource variability and hazards, have been the predominant focus in the context of climate change (e.g., Salick and Ross 2009; Green et al. 2010; Lefale 2010). These facets of traditional knowledge are most compatible with Western science and valued for their potential to inform scientific understanding of local environmental dynamics and responses. For example, the traditional planting calendar in Tongoa provides a baseline for assessing climatic changes. Traditional bioclimatic indicators can also be used in monitoring the local climate or integrated into early warning systems for climate hazards. However, these ways of knowing are embedded in particular relationships, institutions, and value systems. Other facets of traditional knowledge, which concern cultural beliefs, governance structures, and kinship and other networks, must be taken into account. They play an integral role in shaping notions of self-reliance and agency and the potential for collective action and innovation.

In fact, anthropological and geographical research in Tongoa and other islands in Vanuatu documents how traditional strategies for managing resource variability and hazards are heavily influenced by the social and spatial organization of village life (e.g., Campbell 1985, 2009; Kelly 1999; Warrick 2011). Campbell (2009) cautions against assumptions that these strategies were developed intentionally for specific climate hazards. He notes that many of the traditional mechanisms for managing cyclones and other natural hazards in Vanuatu and other Pacific Islands exist as everyday practices within communities. They are often rooted in social or livelihood practices that incidentally address hazards. Food surpluses provide a useful illustration. While surpluses were likely produced and stored to enable ceremonial feasts and networks of exchange, they also guarded against food shortages (Campbell 2009). Examining these social practices, and the wider sociocultural and political contexts in which they are embedded, is therefore imperative to fully grasp traditional knowledge and strategies for managing climate variability and change.

More notably, villagers' perspectives illustrate that different facets of traditional knowledge can serve as

enablers and barriers in building adaptive capacity. Climate change scholarship has focused on the significant opportunities to integrate traditional and scientific knowledges to improve climate forecasting, preparedness, and adaptation at the local level, as aforementioned. However, trade-offs must be acknowledged. Maintaining traditional values, such as self-reliance and a culture of proactivity, enables local adaptive capacity but can also lead to regimented attitudes and wariness toward external information and technologies. There are also trade-offs relating to customary rules and land tenure and how these affect villagers' adaptive capacity. The customary land tenure system in Tongoa, and other parts of Vanuatu, is flexible (Rodman 1987; Kelly 1999; Ward and Kingdon 2007). It allows kin groups to have overlapping use rights to plots that are spatially and ecologically diverse, ranging from coasts to interior mountains. These flexible arrangements enable villagers to manage and adapt to resource variability and climate hazards. They can maintain an array of subsistence activities, gardening, fishing, and hunting and gathering. They can also be mobile, temporarily relocating to the coast or further inland in response to cyclones or other hazards. Yet conflicts also arise as a result of the flexibility of customary land tenure (Rodman 1987; Ward and Kingdon 2007). Villagers tend to be wary of permanent changes in land access and use, such as for construction of disaster shelters, roads, or a piped water supply to address water shortages. Land disputes and tensions over customary land tenure can consequently inhibit infrastructure development and adaptive capacity. Land disputes also weaken social ties and networks of reciprocity within and among kin groups with adverse consequences for adaptive capacity.

Customary governance and leadership structures play a similarly dualistic role in shaping adaptive capacity. In Tongoa's chiefdoms, each paramount chief gains authority and allegiance from resident kin groups through bestowing titles to lesser chiefs and associated lands (Kelly 1999). This title system provides clear protocols and channels for decision-making and conflict resolution. It also creates networks of obligation and enables collective action. It further enables the effective but flexible enforcement of customary rules about land tenure, harvesting, and resource sharing at the level of the kin group and village. Adaptive capacity is clearly aided by strong leadership, enforcement of customary rules, and collective action. However, the patriarchal and hierarchical nature of the customary governance system in Tongoa serves as a potential barrier to building adaptive capacity. The most at-risk groups, including women, youth, and disabled people, are typically excluded within the chiefly system and marginalized in collective decision-making processes within the village. They are unlikely to gain significant access and voice in future planning and decision-making for climate change and other development challenges.

These findings are consistent with recent work focusing on Pacific Island communities, which highlight how customary practices and values serve as both enablers and barriers to building adaptive capacity and reducing vulnerability to climate change. For example, McCubbin et al. (2015) note how communal land tenure and resource sharing once supported adaptation to environmental variability but are increasingly a burden in the urbanizing cash-based economy of communities in Tuvalu. Similarly, Kuruppu (2009) illustrates that religious and customary values and obligations support communal sharing and cooperation but also limit decision-making and available financial resources in Kiribati.

Beyond these trade-offs, villagers' perspectives highlight that adaptive capacity and the role of traditional knowledge cannot be assessed solely in relation to climate change. Climate change intersects with, and compounds, wider economic, political, and sociocultural changes in Tongoa as in other parts of Vanuatu and the Pacific (e.g., Connell 2013; Lauer et al. 2013; Rudiak-Gould 2013; McCubbin et al. 2015). These wider changes, including the transition to a cash economy and Western education system, the rise of Christianity, the valorization of a Western lifestyle, and rural–urban migration, have had significant implications for traditional knowledge and its retention (Kelly 1999; MacClancy 2002). Westernization and the transition to cash economy have brought lifestyle changes, such as dwelling in concrete rather than thatched houses, preference for imported rice over local root crops, and the presence of mobile phones and associated towers. Few villagers in Tongoa now possess the know-how to build traditional wild cane huts or to preserve foods. The church, and more recently the Western education system, has also actively devalued and displaced traditional beliefs and rituals (MacClancy 2002; Regenvanu 2005). With economic and population changes, changing land relations and disputes have placed further strain on customary rules over land tenure and resource use and management in Tongoa (Kelly 1999; Ward and Kingdon 2007). Lack of recognition and enforcement of customary rules undermines traditional governance and value systems.

Connell (2013) further notes that, while the transition to a cash economy has improved access to external information and resources in Vanuatu and other Pacific Islands, villagers are now open to a range of external shocks. Access to markets, such as for copra exports, enables access to cash incomes. However, these incomes are

subject to market volatility. Recent declines in the global price for copra have significantly reduced incomes from coconut plantations in Tongoa (Government of Vanuatu 2009). Structural barriers, such as remoteness, poor transport and communication, and rural underdevelopment, further limit access to markets and villagers' purchasing power. Given limited economic opportunities in Tongoa and urban centers in Vanuatu seasonal and permanent migration to Australia, New Zealand, and other Pacific Islands is on the rise. Migration enables access to information, goods, and other services internationally. It also extends the economic and political reach of villagers through remittance flows, advocacy for development on their home islands, and even the potential to leverage international aid and disaster relief. These extended networks are, however, less reliable than former localized or interisland networks of exchange (Connell 2013). They are also susceptible to external shocks, such as economic and political instability in foreign countries.

Faced with this uncertainty, for the majority of villagers in Tongoa, safeguarding and reviving traditional knowledge remains key. Reviving traditional knowledge does not equate to a return to the old, traditional way of life, however. Villagers are concerned with ensuring cultural continuity and maintaining their sense of identity and autonomy, which is rooted in traditional knowledge, alongside a Western lifestyle and market economy. To address this imperative, efforts to document, store, and promote the use of traditional knowledge must be nuanced and inclusive. In particular, intergenerational transmission of knowledge needs to be emphasized as part of this process. Providing opportunities for older custodians of knowledge to actively engage and share with youth, as well as for women and other vulnerable groups with specialized knowledge, is critical for building adaptive capacity for climatic and other changes, as in other parts of Vanuatu (e.g., Hickey 2006; McCarter and Gavin 2014). There is also scope to revive and experiment with traditional knowledge applications. For example, even with seasonal shifts, bioclimatic indicators may still hold but operate on different timings. Establishing systems for community-based environmental monitoring will be critical in tracking bioclimatic indicators. In this way, indigenous communities in Vanuatu and other Pacific Islands can work toward identifying and maximizing the potential of their traditional knowledge to build adaptive capacity for climate change.

Acknowledgments. I am indebted to the communities of Kurumambe and Purau in Tongoa, Vanuatu, for their hospitality and cooperation and the staff at Act for Peace for enabling my fieldwork. I am also grateful to my local assistant, Viviane Obed, for helping with data collection and transcription. Additional thanks to the University of Melbourne and Climate Adaptation Flagship of the Commonwealth Scientific Industrial Research Organisation, Australia, for funding this research. Three anonymous reviewers also provided valuable feedback on this manuscript.

REFERENCES

Armitage, D., and R. Plummer, Eds., 2010: *Adaptive Capacity and Environmental Governance*. Springer, 307 pp.

Aswani, S., and M. Lauer, 2014: Indigenous people's detection of rapid ecological change. *Conserv. Biol.*, **28**, 820–828, doi:10.1111/cobi.12250.

Australian Bureau of Meteorology, and CSIRO, 2014: Vanuatu. Climate variability, extremes and change in the western tropical Pacific: New science and updated country reports, Pacific-Australia Climate Change Science and Adaptation Planning Program Tech. Rep., 319–340. [Available online at http://www.pacificclimatechangescience.org/wp-content/uploads/2014/07/PACCSAP_CountryReports2014_Ch16Vanuatu_WEB_140710.pdf.]

Barnett, J., and J. Campbell, 2010: *Climate Change and Small Island States: Power, Knowledge and the South Pacific*. Earthscan, 218 pp.

Bedford, S., M. Spriggs, M. Wilson, and R. Regenvanu, 1998: The Australian National University–National Museum of Vanuatu Archaeology Project: A preliminary report on the establishment of cultural sequences and rock art research. *Asian Perspect.*, **37**, 165–193.

Bell, J. D., and Coauthors, 2011: Adapting tropical Pacific fisheries and aquaculture to climate change: Management measures, policies and investments. *Vulnerability of Tropical Pacific Fisheries and Aquaculture to Climate Change*. J. D. Bell, J. E. Johnson, and A. J. Hobday, Eds., Secretariat of the Pacific Community, 803–876. [Available online at http://pubs.iclarm.net/resource_centre/WF_3009.pdf.]

Berkes, F., 2008: *Sacred Ecology: Traditional Ecological Knowledge and Management Systems.* 2nd ed. Routledge, 336 pp.

——, 2009: Indigenous ways of knowing and the study of environmental change. *J. Roy. Soc. N. Z.*, **39**, 151–156, doi:10.1080/03014220909510568.

——, and D. Jolly, 2001: Adapting to climate change: Social-ecological resilience in a Canadian western Arctic community. *Conserv. Ecol.*, **5**, 18, doi:10.5751/ES-00342-050218.

——, J. Colding, and C. Folke, 2000: Rediscovery of traditional ecological knowledge as adaptive management. *Ecol. Appl.*, **10**, 1251–1262, doi:10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2.

Bolton, L., 2001: *Unfolding the Moon: Enacting Women's "Kastom" in Vanuatu.* University of Hawai'i Press, 236 pp.

Bravo, M. T., 2009: Voices from the sea ice: The reception of climate impact narratives. *J. Hist. Geogr.*, **35**, 256–278, doi:10.1016/j.jhg.2008.09.007.

Bridges, K. W., and W. C. McClatchey, 2009: Living on the margin: Ethnoecological insights from Marshall Islanders at Rongelap Atoll. *Global Environ. Change*, **19**, 140–146, doi:10.1016/j.gloenvcha.2009.01.009.

Briggs, J., 2005: The use of indigenous knowledge in development: Problems and challenges. *Prog. Dev. Stud.*, **5**, 99–114, doi:10.1191/1464993405ps105oa.

Brokensha, D., D. Warren, and O. Werner, 1980: *Indigenous Knowledge Systems and Development.* American University Press, 466 pp.

Byg, A., and J. Salick, 2009: Local perspectives on a global phenomenon—Climate change in Eastern Tibetan villages. *Global Environ. Change*, **19**, 156–166, doi:10.1016/j.gloenvcha.2009.01.010.

Campbell, J. R., 1985: Population and change: Human–environment interrelations on Mota Lava, Northern Vanuatu. Ph.D. dissertation, University of Hawai'i, 245 pp.

——, 2006: Traditional disaster reduction in Pacific Island communities. Institute of Geological and Nuclear Sciences Tech. Rep. 2006/38, 46 pp.

——, 2009: Islandness: Vulnerability and resilience in Oceania. *Shima: Int. J. Res. Isl. Cult.*, **3**, 85–97.

Chambers, R., 1996: *Whose Reality Counts? Putting the First Last.* Intermediate Technology, 297 pp.

Climate and Oceans Support Program in the Pacific, 2012: Traditional knowledge. [Available online at http://cosppac.bom.gov.au/traditional-knowledge/.]

Connell, J., 2013: *Islands at Risk? Environment, Economies and Contemporary Change*. Edward Elgar Publishing, 368 pp.

Crate, S. A., 2011: A political ecology of "water in mind": Attributing perceptions in the era of global climate change. *Wea. Climate Soc.*, **3**, 148–164, doi:10.1175/WCAS-D-10-05006.1.

Ellen, R. F., Ed., 2007: *Modern Crises and Traditional Strategies: Local Ecological Knowledge in Island Southeast Asia*. Berghahn Books, 288 pp.

Espirat, J. J., J. Guiart, M. S. Lagrange, and M. Renaud, 1973: *Système de Titres Électifs ou Héréditaires, dans le Nouvelle-Hébrides Centrales d'Efate aux îles Shepherd.* Mémoires de l'Institut d'Ethnologie, Book 10, Institut d'Ethnologie, Musée de l'Homme, 491 pp.

Ford, J. D., T. Pearce, B. Smit, J. Wandel, M. Allurut, K. Shappa, H. Ittusujurat, and K. Qrunnut, 2007: Reducing vulnerability to climate change in the Arctic: the case of Nunavut, Canada. *Arctic*, **60**, 150–166.

——, ——, F. Duerden, C. Furgal, and B. Smit, 2010: Climate change policy responses for Canada's Inuit population: The importance of and opportunities for adaptation. *Global Environ. Change*, **20**, 177–191, doi:10.1016/j.gloenvcha.2009.10.008.

Government of Vanuatu, 2007: National Adaptation Programme for Action (NAPA). National Advisory Committee on Climate Change, Port Vila, 56 pp.

——, 2009: 2009 National census of population and housing: Summary release. National Statistics Office, Port Vila, 29 pp.

——, 2013: Draft guidelines for the collection, use and access to traditional knowledge for climate change and disasters. National Advisory Board on Climate Change and Disaster Risk Reduction and Vanuatu Cultural Centre, Port Vila, 12 pp.

Granderson, A., 2017: Value conflicts and the politics of risk: Challenges in assessing climate change impacts and risk priorities in rural Vanuatu. *Climate Dev.*, doi:10.1080/17565529.2017.1318743, in press.

Green, D., J. Billy, and A. Tapim, 2010: Indigenous Australians' knowledge of weather and climate. *Climatic Change*, **100**, 337–354, doi:10.1007/s10584-010-9803-z.

Grothmann, T., and A. Patt, 2005: Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environ. Change*, **15**, 199–213, doi:10.1016/j.gloenvcha.2005.01.002.

Guiart, J., 1973: Le dossier rassemble. *Système de Titres Électifs ou Héréditaires, dans le Nouvelle-Hébrides Centrales d'Efate aux îles Shepherd*, J. J. Espirat, J. Guiart, and M. S. Lagrange, Eds., Mémoires de l'Institut d'Ethnologie, Book 10, Institut d'Ethnologie, Musée de l'Homme, 49–273.

Hickey, F. R., 2006: Traditional marine resource management in Vanuatu: Acknowledging, supporting and strengthening indigenous management systems. *Tradit. Mar. Resour. Manage. Knowl. Inf. Bull.*, **20**, 11–23.

——, 2007: Traditional marine resource management in Vanuatu: Worldviews in transformation. *Fishers' Knowledge in Fisheries Science and Management*, N. Haggan, B. Neis, and I. G. Baird, Eds., United Nations Educational, Scientific and Cultural Organisation Publishing, 147–168.

Hiwasaki, L., E. Luna, Syamsidik, and J. A. Marcal, 2015: Local and indigenous knowledge on climate-related hazards of coastal and small island communities in Southeast Asia. *Climatic Change*, **128**, 35–56, doi:10.1007/s10584-014-1288-8.

Howitt, R., O. Havnen, and S. Veland, 2012: Natural and unnatural disasters: Responding with respect for indigenous rights and knowledges. *Geogr. Res.*, **50**, 47–59, doi:10.1111/j.1745-5871.2011.00709.x.

Ingold, T., 2003: Two reflections on indigenous knowledge. *Nature Knowledge: Ethnoscience, Cognition, and Utility*, G. Sanga and G. Ortalli, Eds., Berghahn, 484 pp.

IPCC, 2014: *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects*. Cambridge University Press, 1132 pp. [Available online at http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-PartA_FINAL.pdf.]

Jones, L., and E. Boyd, 2011: Exploring social barriers to adaptation: Insights from Western Nepal. *Global Environ. Change*, **21**, 1262–1274, doi:10.1016/j.gloenvcha.2011.06.002.

Kelly, S. K., 1999: Unwrapping mats: People, land and material culture in Tongoa, Central Vanuatu. Ph.D. dissertation. University College London, 714 pp.

Kelman, I., J. Mercer, and J. J. West, 2009: Combining different knowledges: Community-based climate change adaptation in small island developing states. *Participatory Learning and Action 60: Community-based Adaptation to Climate Change*, R. Hannah, et al., Eds., International Institute for Environment and Development, 41–54.

King, D. N. T., A. Skipper, and W. B. Tawhai, 2008: Maori environmental knowledge of local weather and climate change in Aotearoa—New Zealand. *Climatic Change*, **90**, 385–409, doi:10.1007/s10584-007-9372-y.

Kuruppu, N., 2009: Adapting water resources to climate change in Kiribati: The importance of cultural values and meanings. *Environ. Sci. Policy*, **12**, 799–809, doi:10.1016/j.envsci.2009.07.005.

——, and D. Liverman, 2011: Mental preparation for climate adaptation: The role of cognition and culture in enhancing adaptive capacity of water management in Kiribati. *Global Environ. Change*, **21**, 657–669, doi:10.1016/j.gloenvcha.2010.12.002.

Lane, R., and R. McNaught, 2009: Building gendered approaches to adaptation in the Pacific. *Gender Dev.*, **17**, 67–80, doi:10.1080/13552070802696920.

Lata, S., and P. D. Nunn, 2012: Misperceptions of climate-change risk as barriers to climate-change adaptation: A case study from the Rewa Delta, Fiji. *Climatic Change*, **110**, 169–186, doi:10.1007/s10584-011-0062-4.

Lauer, M., S. Albert, S. Aswani, B. S. Halpern, L. Campanella, and D. La Rose, 2013: Globalization, Pacific Islands, and the paradox of resilience. *Global Environ. Change*, **23**, 40–50, doi:10.1016/j.gloenvcha.2012.10.011.

Lefale, P. F., 2010: Ua 'afa le Aso stormy weather today: Traditional ecological knowledge of weather and climate. The

Samoa experience. *Climatic Change*, **100**, 317–335, doi:10.1007/s10584-009-9722-z.

Leonard, S., M. Parsons, K. Olawsky, and F. Kofod, 2013: The role of culture and traditional knowledge in climate change adaptation: Insights from East Kimberley, Australia. *Global Environ. Change*, **23**, 623–632, doi:10.1016/j.gloenvcha.2013.02.012.

MacClancy, J., 2002: *To Kill a Bird With Two Stones: A Short History of Vanuatu*. Vanuatu Cultural Centre, 167 pp.

Marin, A., 2010: Riders under storms: Contributions of nomadic herders' observations to analysing climate change in Mongolia. *Global Environ. Change*, **20**, 162–176, doi:10.1016/j.gloenvcha.2009.10.004.

McCarter, J., and M. C. Gavin, 2014: In situ maintenance of traditional ecological knowledge on Malekula Island, Vanuatu. *Soc. Nat. Resour.*, **27**, 1115–1129, doi:10.1080/08941920.2014.905896.

McCubbin, S., B. Smit, and T. Pearce, 2015: Where does climate fit? Vulnerability to climate change in the context of multiple stressors in Funafuti, Tuvalu. *Global Environ. Change*, **30**, 43–55, doi:10.1016/j.gloenvcha.2014.10.007.

McMillen, H., T. Ticktin, and H. K. Springer, 2016: The future is behind us: Traditional ecological knowledge and resilience over time on Hawai'i Island. *Reg. Environ. Change*, **17**, 579–592, doi:10.1007/s10113-016-1032-1.

Moller, H., F. Berkes, P. O. Lyver, and M. Kislalioglu, 2004: Combining science and traditional ecological knowledge: Monitoring populations for co-management. *Ecol. Soc.*, **9**, 2–13, doi:10.5751/ES-00675-090302.

Mondragón, C., 2004: Of winds, worms and *mana*: The traditional calendar of the Torres Islands, Vanuatu. *Oceania*, **74**, 289–308, doi:10.1002/j.1834-4461.2004.tb02856.x.

——, 2015: *Un Entramado de Islas: Persona, Medio Ambiente y Cambio Climático en el Pacífico Occidental*. El Colegio de México, 472 pp.

Naess, L. O., 2013: The role of local knowledge in adaptation to climate change. *Wiley Interdiscip. Rev.: Climate Change*, **4**, 99–106, doi:10.1002/wcc.204.

Nakashima, D., K. Galloway McLean, H. Thulstrup, A. Ramos Castillo, and J. Rubis, 2012: *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation.* United Nations Educational, Scientific and Cultural Organization, 122 pp.

Nunn, P. D., 2007: Holocene sea-level change and human response in Pacific Islands. *Earth Environ. Sci. Trans. Roy. Soc. Edinburgh*, **98**, 117–125, doi:10.1017/S1755691007000084.

Nurse, L. A., R. F. McLean, J. Agard, L. P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, and A. Webb, 2014: Small islands. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects*, V. R. Barros et al., Eds., Cambridge University Press, 1613–1654.

Nyong, A., F. Adesina, and B. Osman Elasha, 2007: The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel. *Mitigation Adapt. Strategies Global Change*, **12**, 787–797, doi:10.1007/s11027-007-9099-0.

Orlove, B., 2009: The past, the present and some possible futures of adaptation. *Adapting to Climate Change: Thresholds, Values, Governance*, W. N. Adger, I. Lorenzoni, and K. L. O'Brien, Eds., Cambridge University Press, 131–163.

——, J. H. Chiang, and M. A. Cane, 2000: Forecasting Andean rainfall and crop yield from the influence of El Niño on Pleiades visibility. *Nature*, **403**, 68–71, doi:10.1038/47456.

——, C. Roncoli, M. Kabugo, and A. Majugu, 2010: Indigenous climate knowledge in southern Uganda: The multiple components of a dynamic regional system. *Climatic Change*, **100**, 243–265, doi:10.1007/s10584-009-9586-2.

Pahl-Wostl, C., 2009: A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environ. Change*, **19**, 354–365, doi:10.1016/j.gloenvcha.2009.06.001.

Pearce, T., B. Smit, F. Duerden, J. D. Ford, A. Goose, and F. Kataoyak, 2010: Inuit vulnerability and adaptive capacity to climate change in Ulukhaktok, Northwest Territories, Canada. *Polar Rec.*, **46**, 157–177, doi:10.1017/S0032247409008602.

——, J. Ford, A. Cunsolo Willox, and B. Smit, 2015: Inuit traditional ecological knowledge (TEK), subsistence hunting and adaptation to climate change in the Canadian Arctic. *Arctic*, **68**, 233–245, doi:10.14430/arctic4475.

Pelling, M., and C. High, 2005: Understanding adaptation: What can social capital offer assessments of adaptive capacity? *Global Environ. Change*, **15**, 308–319, doi:10.1016/j.gloenvcha.2005.02.001.

Petheram, L., K. K. Zander, B. M. Campbell, C. High, and N. Stacey, 2010: 'Strange changes': Indigenous perspectives of climate change and adaptation in NE Arnhem Land (Australia). *Global Environ. Change*, **20**, 681–692, doi:10.1016/j.gloenvcha.2010.05.002.

Regenvanu, R., 2005: The changing face of ''custom'' in Vanuatu. *People Cult. Oceania*, **20**, 37–50.

Rodman, M., 1987: *Masters of Tradition: Consequences of Customary Land Tenure in Longana, Vanuatu*. University of British Columbia Press, 198 pp.

Roncoli, C., K. Ingram, and P. Kirshen, 2002: Reading the rains: Local knowledge and rainfall forecasting among farmers of Burkina Faso. *Soc. Nat. Resour.*, **15**, 409–427, doi:10.1080/08941920252866774.

Rudiak-Gould, P., 2012: Promiscuous corroboration and climate change translation: A case study from the Marshall Islands. *Global Environ. Change*, **22**, 46–54, doi:10.1016/j.gloenvcha.2011.09.011.

——, 2013: *Climate Change and Tradition in a Small Island State.* Routledge Studies in Anthropology, Vol. 13, Routledge, 244 pp.

——, 2014: Climate change and accusation: Global warming and local blame in a small island state. *Curr. Anthropol.*, **55**, 365–386, doi:10.1086/676969.

Salick, J., and N. Ross, 2009: Traditional peoples and climate change. *Global Environ. Change*, **19**, 137–139, doi:10.1016/j.gloenvcha.2009.01.004.

Sillitoe, P., 2007: Local science vs global science: An overview. *Local Science vs Global Science: Approaches to Indigenous Knowledge in International Development*, P. Sillitoe, Ed., Berghahn Books, 1–22.

Smith, H. A., and K. Sharp, 2012: Indigenous climate knowledges. *Wiley Interdiscip. Rev.: Climate Change*, **3**, 467–476, doi:10.1002/wcc.185.

Speranza, C. I., B. Kiteme, P. Ambenje, U. Wiesmann, and S. Makali, 2010: Indigenous knowledge related to climate variability and change: Insights from droughts in semi-arid areas of former Makueni District, Kenya. *Climatic Change*, **100**, 295–315, doi:10.1007/s10584-009-9713-0.

Taylor, M., A. McGregor, and B. Dawson, 2016: *Vulnerability of Pacific Island Agriculture and Forestry to Climate Change.* Pacific Community, 573 pp.

Turner, N., and H. Clifton, 2009: ''It's so different today'': Climate change and indigenous lifeways in British Columbia,

Canada. *Global Environ. Change*, **19**, 180–190, doi:10.1016/j.gloenvcha.2009.01.005.

Tyron, D., 1976: *New Hebrides Languages: An Internal Classification*. Pacific Linguistics Series, Vol. 50, Department of Linguistics, Research School of Pacific Studies, Australian National University, 545 pp.

Vaioleti, T., 2006: Talanoa research methodology: A developing position on Pacific research. *Waikato J. Educ.*, **12**, 18–30.

Walsh, K. J. E., K. L. McInnes, and J. L. McBride, 2012: Climate change impacts on tropical cyclones and extreme sea levels in the South Pacific—A regional assessment. *Global Planet. Change*, **80–81**, 149–164, doi:10.1016/j.gloplacha.2011.10.006.

Ward, R. G., and E. Kingdon, Eds., 2007: *Land, Custom and Practice in the South Pacific*. Cambridge Asia-Pacific Studies, Cambridge University Press, 308 pp.

Warrick, O., 2011: Local voices, local choices? Vulnerability to climate change and community-based adaptation in rural Vanuatu. Ph.D. dissertation, University of Waikato, 400 pp.

Weatherhead, E., S. Gearheard, and R. G. Barry, 2010: Changes in weather persistence: Insights from Inuit knowledge. *Global Environ. Change*, **20**, 523–528, doi:10.1016/j.gloenvcha.2010.02.002.

Williams, T., and P. Hardinson, 2013: Culture, law, risk and governance: Contexts of traditional knowledge in climate change adaptation. *Climatic Change*, **120**, 531–544, doi:10.1007/s10584-013-0850-0.

World Bank, 2013: Vanuatu data and statistics: Countries and economies. World Bank, accessed 3 February 2016. [Available online at http://data.worldbank.org/country/vanuatu.]

World Health Organization, 2015: *Human Health and Climate Change in Pacific Island Countries.* World Health Organization Regional Office for the Western Pacific, 172 pp.

Yohe, G., and R. S. J. Tol, 2002: Indicators for social and economic coping capacity—Moving toward a working definition of adaptive capacity. *Global Environ. Change*, **12**, 25–40, doi:10.1016/S0959-3780(01)00026-7.