

Exploring climate-driven non-economic loss and damage in the Pacific Islands

Karen E McNamara¹, Ross Westoby² and Alvin Chandra^{1,3}



Non-economic loss and damage induced by climate change in the Pacific Islands region has been reported as fears of cultural loss, deterioration of vital ecosystem services, and dislocation from ancestral lands, among others. This paper undertakes an in-depth systematic review of literature from the frontlines of the Pacific Islands to ascertain the complexities of non-economic loss and damage from climate change. We synthesise knowledge to date on different but inter-connected categories of non-economic loss and damage, namely: human mobility and territory, cultural heritage and Indigenous knowledge, life and health, biodiversity and ecosystem services, and sense of place and social cohesion. Identifying gaps and possibilities for future research agendas is presented. Synthesising knowledge to date and identifying remaining gaps about non-economic loss and damage is an important step in taking stock of what we already know and fostering action and support for addressing loss and damage in the years to come.

Addresses

¹ School of Earth and Environmental Sciences, The University of Queensland, Australia

² Griffith Institute for Tourism, Griffith University, Australia

³ Adaptation Division, United Nations Framework Convention on Climate Change Secretariat, Germany

Corresponding author:

McNamara, Karen E (karen.mcnamara@uq.edu.au)

Current Opinion in Environmental Sustainability 2020, 50:1–11

This review comes from a themed issue on **Slow onset events related to climate change**

Edited by **Susana Adamo, Riyanti Djalante, Prabodh GD Chakrabarti, Fabrice Renaud, Amsalu Woldie Yalew, Doreen Stabinsky and Zinta Zommers**

Received: 01 May 2020; Accepted: 27 July 2020

<https://doi.org/10.1016/j.cosust.2020.07.004>

1877-3435/© 2020 Elsevier B.V. All rights reserved.

Introduction

Loss from climate change is already with us [1]: crops, homes and loved ones perish from climatic extremes; unpredictable rains and saltwater intrusion are making it difficult for people to sustain their food and water supplies; and high tides, sea-level rise and storm surges

inundate homes and wash gravesites into the sea. Our understanding of loss and damage, as the irreparable and repairable harms to a society from climate change, respectively, has mostly been focussed on economic loss [2].

In more recent times, there has been an emerging scholarship on the non-economic aspects of loss and damage in domains such as health, mobility, biodiversity, cultural heritage and place, among others [3–5]. These studies have included localised in-depth assessments exploring the NELD implications of displacement such as loss of identity and mental well-being [6]. They have also included global systematic analyses of climate-related intangible harm [7]. This latter study illustrated one thousand ways to experience loss from over 100 case studies from around the world, which highlighted how the things that people value can be eroded or obliterated from their lives. Losses ranged from those to culture and traditions, to physical and mental health, to sense of place and social fabric, to identity and dignity, among many others. While loss and climate change is not a simple causal relationship, given that it is ‘mediated by personal circumstance, culture, and socio-economic context’, this study showcased the ‘numerous lived experiences with climate-related harm’ from around the world to demonstrate how climate change is ultimately an issue of ethics and justice [7: 69].

Synthesising what we already knew about non-economic loss and damage (NELD) is important to identify key insights so far, and to support actions in the areas of slow onset events, human mobility, and comprehensive risk management. For this synthesis, we focus our attention on the Pacific Islands region. This region is at the frontlines of climate change impacts and the subsequent loss and damage that they bring [8]. The Special Report by the Intergovernmental Panel on Climate Change Hoegh-Guldberg *et al.* [76] on the impacts of 1.5°C global warming indicated that for small island developing states (SIDS), including those in the Pacific:

Global warming of 1.5°C is expected to prove challenging for small island developing states (SIDS) that are already experiencing impacts associated with climate change (high confidence). At 1.5°C, compounding impacts from interactions between climate drivers may contribute to the loss of, or change in, critical natural and human systems (medium to high confidence). There are a number of reduced risks at 1.5°C versus 2°C, particularly when coupled with adaptation efforts (medium to high confidence).

Specific observed impacts and projected risks noted for Pacific SIDS include sea-level rise, increases in mean surface temperature, greater frequency of droughts and floods, high numbers of terrestrial animal and plant species threatened by climate change and extreme weather, declining freshwater resources and shortage of fish proteins, among others [76].

It is also important to make mention of the long-fought struggle for developing countries, particularly those in the Pacific, for a concrete international policy to address loss and damage [9]. Modern discussions about reversible and irreversible loss and damage caused by climate change first commenced in the Pacific Islands. In 1991, on behalf of the Alliance of Small Island States, Vanuatu proposed an international insurance pool for low-lying island states to be compensated for loss and damage incurred from climate change impacts, particularly sea-level rise [10]. Despite two decades of advocating for an international policy, the ‘Warsaw International Mechanism on Loss and Damage’ was established at the United Nations Framework Convention on Climate Change (UNFCCC) Conference of the Parties in 2013 with loss and damage to be addressed through Article 8 of the Paris Agreement in 2015.

Given this context, the aim of this paper is to examine the key contributions of academic studies on experiences of NELD in the Pacific Islands region to date, and to identify gaps and opportunities for future research.

Method

We utilised a systematic literature review to synthesise key themes and gaps in our understanding of NELD in the Pacific Islands region. This was undertaken using the systematic literature reviews by Pickering and others as guides (see Ref. [11]). Steps followed in the systematic literature are outlined in Figure 1 below.

Using Scopus, 440 searches were undertaken in February 2020 using ‘climate change’ along with a list of 20 key words for each of the 22 countries and territories of the Pacific. These key words included the following: loss, damage, harm, grief, hope, life, health, mobility, migration, relocation, displacement, territory, biodiversity, ecosystem services, cultural heritage, culture, Indigenous knowledge, local knowledge, social, and place. These terms were searched in item title, abstract and keywords, and only publications in English were considered. Once items were identified ($n = 1513$) and duplicates were removed ($n = 851$), the remaining items ($n = 662$) were manually scanned on an Excel file by two authors to gauge relevance. First, they were screened for relevance based on reading the title and abstract. This resulted in 588 publications being excluded. From this, 74 publications were identified for full text eligibility by all authors with 15 publications excluded and four unable to be accessed.

For both exclusion steps above, the exclusion criteria included: no explicit focus on NELD; no explicit study undertaken to explore experiences of NELD; no explicit focus on the Pacific Islands region or any Pacific Island countries; language (non-English publications were excluded); and no news items or periodicals. From this, 55 publications were determined appropriate for this review.

Brief overview of the review

Growth of publications in loss and damage, especially non-economic aspects, in the Pacific Islands region has been exponential. Figure 2 shows the growth in publications from the earliest identified in 2009 with steep rises in 2018 and 2019.

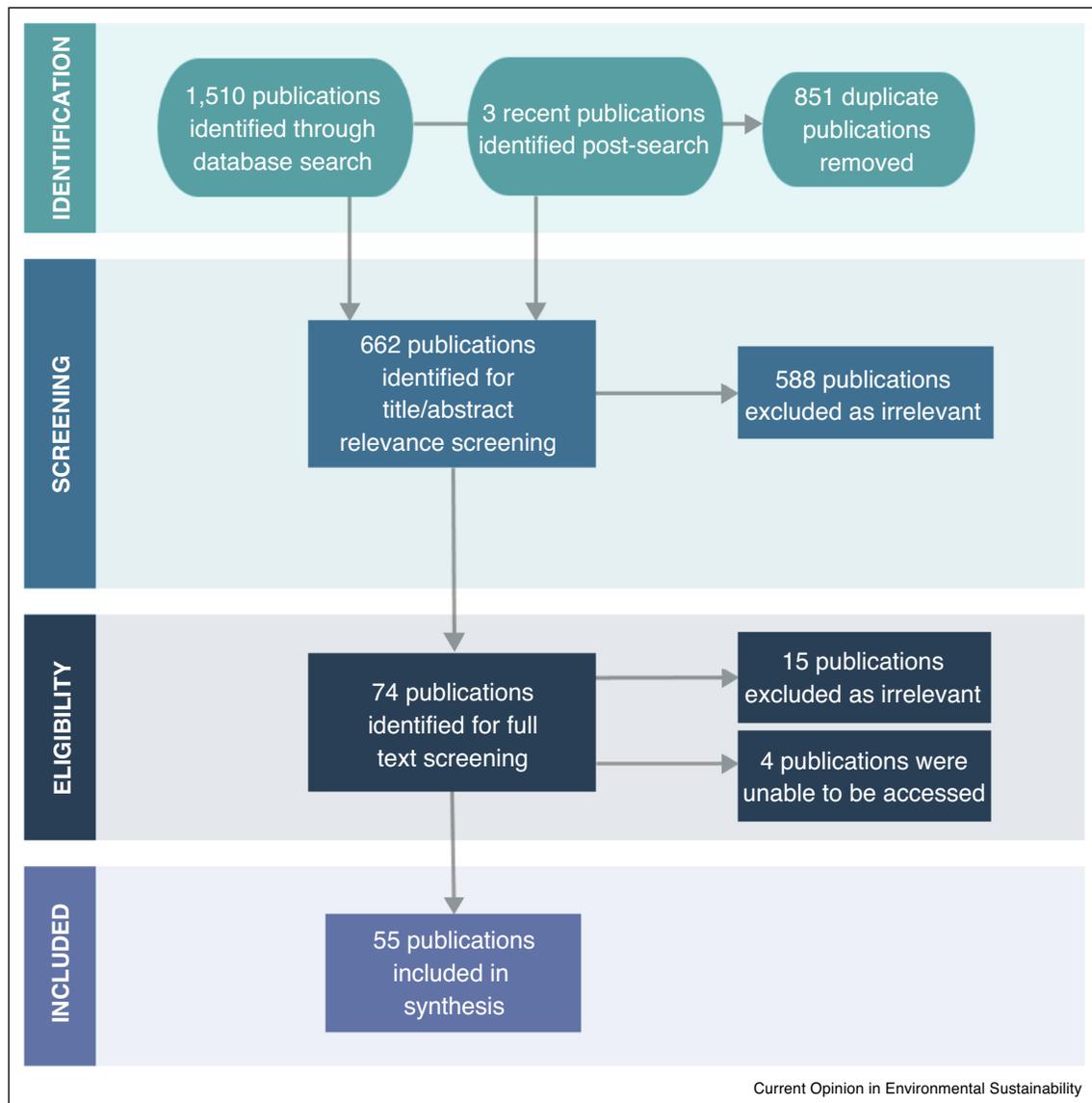
Taking into account the initial search in Scopus, coverage of loss and damage terms were not equally represented, nor was the coverage equal across all 22 countries and territories of the Pacific. Search terms such as grief yielded no results, and terms such as harm ($n = 4$) and hope ($n = 9$) yielded very limited results. Papua New Guinea (PNG; $n = 234$) and Fiji ($n = 218$) were more prominent in publications than smaller countries such as the Pitcairn Islands ($n = 2$) and Wallis and Futuna ($n = 3$). Low-lying countries such as Tuvalu ($n = 154$) and Kiribati ($n = 152$) also yielded higher results.

Given the focus of this paper on the non-economic aspects of loss and damage, we draw on the following categories of non-economic loss from a technical paper produced by the United Nations Framework Convention on Climate Change [12] to guide our analysis: loss of life, health, human mobility, territory, cultural heritage, Indigenous knowledge, biodiversity and ecosystem services. These have been subsequently grouped into pairs depending on whether they affect individuals, society and/or the environment. Sense of place and social cohesion were also added as categories based on suggestions from the literature [13]. Table 1 provides a summary of the thematic areas and associated Pacific Island countries of focus from the 55 publications identified for synthesis. These thematic areas are not mutually exclusive, but rather inter-connected and inter-dependent as discussed below.

Human mobility and territory

Climate-related human mobility in the Pacific is widely discussed by scholars with an overwhelming focus on reduced habitability of low-lying coastal areas [14] resulting in displacement [15], planned relocation [16–18], migration [19–23] and human security issues [24]. Between 1920 and 2004, 33 relocation events have taken place across the region [25]. While earlier mobility decisions were influenced by labour shortages, development, war and disasters, among others, more recent literature suggests that increasing vulnerability to climate change is

Figure 1

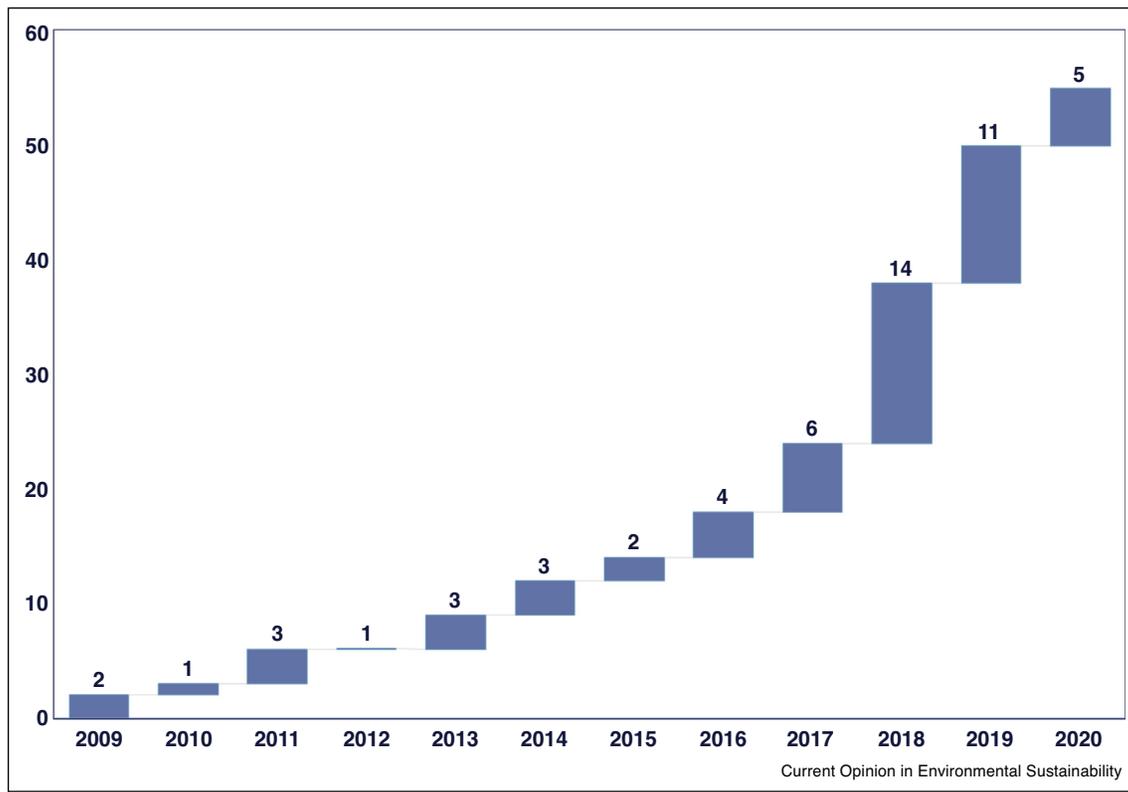


Steps undertaken in the systematic literature review.

a driver of human mobility in low-lying Pacific islands (i.e. in terms of displacement, migration and relocation). A range of sudden and slow-onset events have triggered emergencies and decisions to move: higher tides, coastal erosion and inundation, flooding, saltwater intrusion, unpredictable rainfall and wind patterns, drought, heat waves, crop failures, salt water intrusion and salination, and cyclones [26]. Climate-induced mobility and non-economic loss are linked twofold: prolonged impacts can trigger loss and damage and therefore decisions to move; and ad hoc and poorly planned mobility decisions can magnify creeping intolerable risks for both mobilised and host communities.

Pacific Island customs and traditions profoundly identify with collective ownership of land, sea and biodiversity (e.g. notion of *Fenua* in Tuvalu and *Vanua* in Fiji). Land is the foundation of cultural, psychological and spiritual well-being of Pacific Islanders. As land engenders a sense of place and identity for Pacific Islanders, the movement of people can disrupt physical, socio-cultural and ancestral connections to land and critical resources [27]. Compromising spiritual connections to land can result in the abandonment of belief systems and kinship, which can subsequently decrease the resilience of affected communities [26,28]. For example, Latai-Niusulu *et al.* [29**] indicated that detaching Samoans from the

Figure 2



Cumulative growth in the number of publications on NELD in the Pacific Islands region from 2009 to 2020.

traditional mores and structures of their home villages can amplify irreparable damage to future traditional adaptive support and consultation (or *faamatai*) mechanisms.

Inter-connected with loss of land and culture are existential risks to territories in the Pacific. Scholars link climate-induced mobility with loss of state sovereignty, identity, rights, survival, security, lifestyle, jurisdiction and territory [15,30]. Many communities are unwilling to leave their islands permanently, invoked by anxieties of loss of ones' nationality, culture, identity, rights to land and being forcefully uprooted from their homelands. Local accounts of anxiety are also replete with stories of doomsday where 'chains of islands [are] submerged . . . the islanders drown, starve or die of thirst, or they are lifted, destitute, to new places, receiving little help from their fellow world citizens' [27: 76]. In the cases of Kiribati, Nauru and Tuvalu, Oakes [31] links complex subjective experiences ranging from fatalistic relocation, in situ adaptation, to mobility as an enabler, all interplaying with religious beliefs. Fears of islanders becoming 'minorities, migrants and second-class citizens' also follow [32: 13]. These narratives have gained political attention in regional and national policies that address the themes of security, territory, adaptation and development.

Non-economic loss is profound in atoll countries including Kiribati, Marshall Islands, Nauru and Tuvalu, where sea-level rise, storm surges and king tides have resulted in irreversible and unavoidable changes [33]. Such prolonged and severe climate impacts have resulted in loss of habitable and productive land, traditional crops, livelihoods, community gardens and fresh water sources. These have further given rise to intolerable risks such as increasing food insecurity, water shortages, livestock deaths and loss of fisheries that can influence decisions in favour of internal and cross-border movements [34]. On the flip side of this, van der Geest *et al.* [35*] notes from a study in Marshall Islands that progressive emigration of Marshall Islanders to the USA has resulted in shortages of skilled labour and a loss of community and social cohesion.

Studies of planned relocation efforts in Fiji, PNG and Solomon Islands indicate renewed sense of hope, dignity, everyday agency and control of fate in local communities ([26,32,36]; also see Ref. [37]). However, despite the growing popularity of relocation as an adaptation option, research also points to creeping intolerable risks and disruption to 'personal and ancestral histories of connection to place' [38*: 289]. These risks are prevalent and

Table 1

Summary of thematic area and location of 55 publications on NELD in the Pacific Islands region (note that some publications appear in more than one thematic area and some publications cover the region as a whole)

NELD thematic area (<i>direct occurrence</i>)	Number of publications	Coverage of Pacific Island countries
Human mobility and territory (<i>individual and society</i>)	24	Fiji, Kiribati, Marshall Islands, Nauru, PNG, Samoa, Solomon Islands, Tuvalu, Vanuatu
Cultural heritage and indigenous knowledge (<i>society and environment</i>)	16	Federated States of Micronesia (FSM), Fiji, Kiribati, Marshall Islands, PNG, Samoa, Solomon Islands, Tuvalu, Vanuatu
Life and health (<i>individual</i>)	13	Cook Islands, FSM, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, PNG, Samoa, Solomon Islands, Tonga, Tuvalu, Tokelau, Vanuatu
Biodiversity and ecosystem services (<i>environment</i>)	13	Cook Islands, Fiji, Kiribati, Marshall Islands, PNG, Solomon Islands, Tuvalu, Vanuatu
Sense of place and social cohesion (<i>individual and society</i>)	9	FSM, Fiji, Kiribati, PNG, Samoa

persistent for the most vulnerable community members, especially women and children. Poorly planned and managed mobility decisions can have long-term negative consequences, such as psychological impacts, erosion of subsistence livelihoods, loss of Indigenous knowledge, susceptibility to domestic conflicts, and loss of traditional roles for displaced and host communities.

Cultural heritage and indigenous knowledge

Numerous studies considered culture and cultural heritage loss in the context of climate change, with many also highlighting the impacts of such loss on mental health. Wewerinke-Singh [39: 194] highlighted how the ‘potential loss of cultural heritage as a result of climate change has significant implications for the enjoyment of human rights’. A study by Gibson *et al.* [40] in Tuvalu revealed how the impacts of climate change on the viability of subsistence-based living and the local economy, along with fears about cultural loss, were resulting in worry, anxiety, disrupted sleep and sadness. People’s faith and communal lifestyles that protect against isolation, and their semi-subsistence lifestyles, were considered the cornerstones of coping with these idioms of distress. A study by du Bray *et al.* [41] explored the emotional responses of people from Fiji, along with other countries in the world, in response to climate change. Fijians hold extensive pride in their cultural heritage and practices such as fishing and farming, and as such the possible loss of these traditions in the face of climate change has resulted in significant levels of sadness.

Cámara-Leret *et al.* [42**] demonstrated how climate change threatens New Guinea’s biocultural heritage by causing local extinctions of wild foods, medicines and ritual foods, which diminish the well-being and cultural integrity of Indigenous peoples. Hofmann [43] considered the genocidal dimensions of climate change, whereby cultural roots, identity and cultural heritage losses could be considered a form of ‘culturecide’ in Chuuk, FSM. Alongside studies exploring cultural loss was an emerging number of studies that highlighted the importance of culture for adaptive

capacity in communities responding to climate change challenges [23,40,44,45**]. For example, Perkins and Krause [45**] revealed how cultural support networks, group identity, reciprocity and other features of intangible cultural heritage create and sustain social resilience to lessen the effects of climate change.

For several studies, concerns about cultural loss as a consequence of displacement and resettlement (as themes discussed above) were prominent, often because of the severing of ties to place which sustains identity, belonging, culture, lifestyle and family connections [23,33]. Studies demonstrated the social and cultural challenges experienced by communities who are faced with relocation as the only feasible option or have relocated [18,26,36]. Land and sea were prominent in these discussions given their role in cultural identity, way of life, and communal unity and kinship [18,36]. The cultural-spiritual links were also noted as Charan *et al.* [18: 350] described how villagers in Vunidogoloa in Fiji faced a ‘difficult situation to leave the old site where they had lived all their lives, and to go through the harrowing decision to disentomb and shift the remains of their ancestors to a new burial site’. Mobility can, therefore, disrupt people’s cultural bond with land, challenge societal cultural identity and heighten people’s vulnerability.

Studies that focussed on Indigenous knowledge revealed the role and value of such knowledge sets in understanding weather and climate, and in building adaptive capacity; as opposed to losses to Indigenous knowledge [46–48,49*]. Indigenous knowledge, which can also be referred to as local, folk and traditional knowledge, refers to ‘place-based knowledge, rooted in the culture and traditions of a particular community’ [49*: 546]. Lefale [47] explored traditional ecological knowledge of weather and climate in Samoa. Observations of local environmental changes – in plants and animal behaviour – are key indicators to forecast changes in weather and climate. Samoans unique seasonal calendar, along with their extensive knowledge and reading of the sky, clouds

and wind demonstrate the value of Traditional Ecological Knowledge for advancing our knowledge of weather and climate, and our ability to plan for future climate change [47].

Using local and Indigenous knowledge to cope with extreme weather events and enhance adaptive capacity were key messages from these studies in the Pacific. McNamara and Prasad [48] showed how, in Fiji and Vanuatu, planting techniques, innovative water storage practices and food preservation know-how were critical survival tactics when faced with cyclones and droughts. Granderson [49] extended our understanding of Indigenous knowledge as more than just about weather and climate, but also in terms of resource use and management, leadership, social networks and values and beliefs; all of which are critically important to enhancing adaptive capacity. Given this, it is critical that Indigenous knowledge continues to be shared, passed down between generations, practiced and protected.

Life and health

National climate vulnerability assessments and adaptation plans in several Pacific countries identified climate change impacts on health as a result of losses to housing, safe drinking water, food and secure shelter. These are basic human needs that threaten survival. Although the literature has previously focussed on the direct health impacts of climate-related events, in the Pacific Islands region there is a very real concern that climate change may act as a health risk multiplier [50]. Loss of lives and lifestyle is by far the most commonly identified climate-related health impact, with narratives relating to lifelong consequences that cannot be replaced, rebuilt, recovered or valued in monetary terms. In this regard, the literature points to three main trends.

First, although direct impacts on human health will be experienced on an individual level, they will have indirect implications for Pacific societies more widely. A regional assessment indicated that the highest-priority climate-sensitive health risks in the Pacific Islands region are: increasing risks to mortality and trauma from extreme weather events; heat-related illnesses; vector-borne diseases; zoonoses; respiratory illnesses; psychosocial ill-health; and health system deficiencies [51]. While these health effects may be short-term or long-term in individuals, the resulting indirect impacts are likely to be lifelong and intolerable. For countries such as Kiribati, Marshall Islands, Nauru and Tuvalu, declining safety and security of food and water, along with malnutrition, are national security risks [50]. Similarly, place-specific studies point to a common occurrence of non-communicable diseases (NCDs) in the Pacific Islands region. Salt-water intrusion and a lack of fresh water in Kiribati, Marshall Islands and Tuvalu are linked to incidences of NCDs [35,52]. With Pacific Island countries already

experiencing high rates of NCDs, climate change is an additional driver of increased risk by contributing to food insecurity and poor nutrition [51]. These intolerable risks are a potential barrier to the adaptive capacity of Pacific Islanders.

Second, a growing body of evidence highlights the increasing mental health impacts of climate change and disasters, characterised by sadness, anger, anxiety, depression, stress, and loss and grief. In examining the psychological impacts following Cyclone Winston in Fiji, Sattler *et al.* [53] identified an increase in post-traumatic stress symptoms from resource loss due to the cyclone, but also illustrated how this loss activates social norms related to climate change action. While there has been some preliminary research on the mental health impacts of disasters such as Cyclone Winston, research on loss associated with slow-onset events is in its infancy. Concerns about sea-level rise can bring about uncertainty and powerlessness, creating fear and worry at personal, household and community levels [54]. One study in particular also raised the issue of spiritual health and how the impacts of climate change significantly threaten 'people's spiritual well-being', drawing from a case study in five coastal communities in Tongatapu, Tonga [55: 167].

Third, research on the differential impacts of health and well-being on vulnerable groups identified disproportionate impacts on women, children and the elderly, with impacts most felt in rural and remote islands. Case studies from Fiji, Kiribati, Solomon Islands and Vanuatu, among others, reported higher incidences of physical distress, psycho-social ill-health and factors relating to mental health issues amongst women (see Refs. [51,56]). Community relocation, in particular, was found to have a lasting negative mental health impact on women, primarily as a result of losses to livelihood and socio-cultural activities (e.g. weaving, tapa making, traditional textiles, gathering seafood) [26]. Mental health impacts, characterised by sadness, anxiety and stress in women have hindered their effective participation in mobility decision-making in Fiji and PNG [57,58], and fear and worry of relocation and loss of culture can be lifelong. Children will be significantly affected by the impacts of climate change, particularly those in rural and remote areas, due to '... increasing heat-related and extreme weather-related mortality and morbidity and increasing infectious disease incidence and transmission' [59: 185]. Displacement and relocation will also adversely affect the health of children, particularly in terms of the trauma associated with leaving one's home [59]. Furthermore, children displaced by disasters can lose continued access to schools, teachers and the physical places that provide assurances of safety and security [60]. Given the scale and magnitude of climate change impacts, it is understandable that Elders worry about the future of their children and potential losses to life, land and culture.

Biodiversity and ecosystem services

Evidence suggests that climate change will significantly contribute to the loss of biodiversity, future extinctions and the deterioration of vital services that ecosystems provide, both in terrestrial and marine environments [61]. Ecosystem services play a vital role in supporting community resilience both in rural settings but also in the less acknowledged urban and peri-urban settings [62].

In the Pacific Islands region, extreme weather events place significant pressure on ecosystems and endemic biodiversity, and then on the subsistent livelihoods that these ecosystems support [63]. Cámara-Leret *et al.* [42**], based on work in PNG, argued that climate-induced local extinctions are already taking place on wild foods, medicine and ritual plants. They argued that this is not only resulting in diminishing ecosystem services but the well-being and cultural integrity of PNG biocultural heritage. Similarly, in Fiji, Cyclone Winston destroyed significant portions of the local ecosystem [64] and a range of crops such as coconut trees [53]. The impacts of that same cyclone in a study by Thomas *et al.* [65*] saw mangrove habitats destroyed and a deterioration in the services these mangrove habitats played for fisherpeople, especially people collecting mud crabs. Biodiversity loss from extreme weather events, therefore, significantly affects livelihoods and food availability.

Slow-onset events such as droughts are also prevalent in the Pacific. A number of studies highlighted that droughts were being exacerbated and placing greater pressure on ecosystem services [35*,66]. Plants and crops often perish during droughts and water as a resource becomes scarcer, placing burdens on individuals and communities to prioritise this scarce resource. Additionally, there is evidence that trees, both native and non-native species, do not produce fruit during times of drought, adding to community food insecurity.

The intensified degradation of marine and reef systems in the Pacific is the product of pressures from human activities such as overfishing as well as sea temperature rises due to climate change [67]. Continued marine biodiversity loss and reduced ecosystem services is inevitable as density, diversity and habitat complexity diminish [68], and these losses will significantly affect the communities that are reliant on the reef's services for fishing, subsistence and tourism [52]. Consequently, domestically caught fish will decline, resulting in food security issues in countries such as Fiji, Solomon Islands and Vanuatu [67]. Additionally, and connecting with the theme of human mobility above, according to Dannenberg *et al.* [60: 8] these pressures on fisheries resources, food, water and land availability will force managed retreats over time through acute and gradual loss in habitability. The consequence of this is that 'habitability thresholds' might be exceeded [14]. Other studies do exist [69,70], among

others, outside this review that explore marine loss to subsistence and small-scale artisanal fisheries and impacts on important protein intake in the Pacific, in a growing recognition of the fragility and importance of the Blue Economy to the region.

Sense of place and social cohesion

Sense of place denotes the identity, including constructed meanings, values and emotional bonds, which one tends to form around their local environment [71]. Sense of place is strong in the Pacific and inter-linked with connections to land and sea. Singh *et al.* [26] argues, for example, that land in Fiji is more than just land; it is intimately linked to traditional and emotional well-being. In Kiribati the term '*aba*' has a dual meaning of 'land/people' [21: 240]. Loss of land due to inundation and the loss of burial sites of ancestors are seen as having a major impact on people's sense of place and associated identities [18]. Very few scholars discuss this 'spiritual bond and connection' as often these cannot be translated easily outside of cultural contexts.

Loss of sense of place through relocation was documented in Fiji and included the disruption of personal and inter-generational histories of attachment to place [38*]. According to Hofmann [43: 33], in FSM:

While resettlement itself does not necessarily lead to the extinction of a culture, it tends to restructure and accommodate cultural values appropriating them to the new locale, carrying the potential to leave people not just displaced but, more importantly, very much misplaced.

While sense of place is often eroded or lost during relocation, social cohesion may in fact be strengthened. In a study by Piggott-McKellar *et al.* [36] in two relocation sites in Fiji, there was a strengthened sense of community in Vunidogoloa and a strengthened sense of cohesion amongst women in Denimanu post the relocation process.

Social cohesion '... refers to the extent of connectedness and solidarity among groups in society. It identifies two main dimensions: the sense of belonging of a community and the relationships among members within the community itself' [72: np]. There was limited literature to date on the loss of social cohesion due to climate change in the Pacific. This is unsurprising as community life in the Pacific is rich and grounded in customary political, social and economic life, with high levels of social resilience. Although acknowledging the processes of exclusion that can and do take place, the resilience generated through strong social cohesion, albeit varying across communities, is often a missed source for potential and real opportunity in the face of challenges such as climate change. Only one publication directly drew links between social cohesion being eroded due to climate change impacts. Cumulative impacts in Milne Bay, PNG

including population growth, resource depletions, rising sea levels, and extreme cyclones and droughts have resulted in a loss documented by Mitchell and Aigoma [73**] of ‘*Yakasisi*’ which translates into respect. This respect includes respect for elders, respect for customary ecological knowledge and its use, and respect for the environment.

Several studies, however, also contrast this loss with significant opportunity. Gharbaoui and Blocher [74], reflecting on their work in Fiji and PNG, argued that while community cultural cohesion and social norms have the potential to constrain and undermine future needs to adapt, they do provide support systems in times of need, particularly following extreme weather events. They argued that land tenure systems tied up in customary ways of life may provide flexibility for the future when further issues such as relocation become a reality. Similarly, Latai-Niusulu *et al.* [29**] argued that, in the face of adversity such as extreme weather events in Samoa, there is evidence of the development of varied and ‘tighter’ types of social connections and stronger and more diversified networks. Such networks hint at social cohesion being reinforced during times of stress as people support each other. Food is shared and cohesion is strengthened in times of stress through ‘... the organization and governance of the *aiga* (extended family unit) and the *nuu* (village) [which] is based upon *faamatai*, a cultural framework that ensures participation by all related members’ [29**: 45].

Discussions and future research directions

The non-economic aspects of loss and damage are often underacknowledged in climate change discussions. The reasons for this could be varied: from difficulties in quantifying intangible losses, to limited empirical reporting on how they manifest, to being a relatively new field of inquiry. This systematic literature review on NELD in the Pacific Islands sheds light on some of these unknowns about what observed and experienced NELDs are in the region, what we know about them, and what knowledge gaps remain to direct future research.

Here is what we know: human mobility is the most prominent NELD theme discussed. Studies show how sudden and slow-onset events have triggered decisions to move. The movement of people through relocation or migration disrupts physical, socio-cultural and ancestral connections to land, spiritual links to lands and people’s resilience. Concerns about the existential and security risks to territory for some Pacific Island countries were also raised. Of note is the extensive work on low-lying atolls such as Kiribati and Tuvalu. Culture and cultural heritage loss were also raised as key concerns in studies. Indigenous knowledge and social cohesion was considered as key strengths – less so as a loss *per se* – in responding to climate change. Scholarship on life and

health offered three main health trends: health impacts are experienced individually but they impact Pacific society broadly; rising climate-induced mental health impacts; and the disproportionate health impacts on women, children and the elderly. Losses to biodiversity, and the deterioration of ecosystem services and sense of place were noted in several studies. The interconnections between these NELD themes emphasise the need to not treat these categories independently given that one aspect relates to another, for example, relocation poses a risk of losing ones’ sense of place and culture.

This systematic literature review has revealed several gaps. There is a lack of studies that look at losses to Indigenous knowledge. Whether the lack of studies is indicative of the rich work being undertaken in the Pacific to safeguard and tap into Indigenous knowledge as a key resource in adaptive capacity or whether genuine NELDs are transpiring as a result of slow-onset climate change is a question worth pursuing. Few studies directly address biodiversity and ecosystem services loss, which would have direct and indirect impacts on Pacific Islanders well-being, livelihoods and culture. Research that begins to explore notions of grief and mourning is also worth pursuing. Additionally, sense of place is a research area that future studies could examine and how it might overlap with health issues, particularly in relation to concepts such as ‘solastalgia’, which is the ‘distress that is produced by environmental change impacting on people while they are directly connected to their home environment’ [75: S95]. Finally, voices of Pacific Islanders around NELD could be amplified through more diverse research methodologies, utilising more Indigenous methodologies and branching out to various creative methodologies. Overall, more nuanced research could look at the interconnectedness between all NELD themes to gain a clearer picture of the extent of the loss already being experienced across the Pacific.

What we can glean from this review is the significant social networks and capital that are present and strong in the Pacific. Place attachment is also significant and central to Islanders sense of being and cannot be substituted with relocation and migration options. These values place Islanders in good stead as they are key sources of adaptive capacity in a changing climate. This review also points towards NELD in the Pacific as a double whammy, meaning what is being lost is such a key resource for adaptive capacity. Should social cohesion be stretched too far and the bonds and bridges that bind people are broken, then further negative feedbacks of increasing NELD in the Pacific are likely consequences, which could further erode Pacific Islanders adaptive capacity. What has been discussed here is what has already been observed and experienced. With worse projected risks and impacts still yet to come, the non-economic dimensions of loss and damage are only expected to increase. It

is imperative that we continue to document losses as well as strengths, understand them, and identify ways of best minimising the harm caused by them.

Disclaimer

The views expressed in this paper are those of the authors and do not necessarily reflect those of the United Nations.

Conflict of interest statement

Nothing declared.

Acknowledgement

Karen McNamara was funded under the Australian Research Council study FT190100114.

References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- of outstanding interest

1. IPCC et al.: In *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Edited by Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC. Cambridge, United Kingdom and New York, NY, USA: White Cambridge University Press; 2014.
 2. McNamara KE, Jackson G: **Loss and damage: a review of the literature and directions for future research**. *WIREs Clim Change* 2019, **10**:e564.
 3. Barnett J, Tschakert P, Head L, Adger WN: **A science of loss**. *Nat Clim Change* 2016, **6**:976-978.
 4. Preston CJ: **Challenges and opportunities for understanding non-economic loss and damage**. *Ethics Policy Environ* 2017, **20**:143-155.
 5. Serdeczny OM, Bauer S, Huq S: **Non-economic losses from climate change: opportunities for policy-oriented research**. *Clim Dev* 2018, **10**:97-101.
 6. Ayebe-Karlsson S, Kniveton D, Cannon T: **Trapped in the prison of the mind: notions of climate induced (im)mobility decision-making and wellbeing from an urban informal settlement in Bangladesh**. *Palgrave Commun* 2020, **6**:1-15.
 7. Tschakert P, Ellis NR, Anderson C, Kelly A, Obeng J: **One thousand ways to experience loss: a systematic analysis of climate-related intangible harm from around the world**. *Global Environ Change* 2019, **55**:58-72.
 8. Nunn PD: **The end of the Pacific? Effects of sea level rise on Pacific Island livelihoods**. *Singapore J Trop Geogr* 2013, **34**:143-171.
 9. Roberts E, Huq S: **Coming full circle: the history of loss and damage under the UNFCCC**. *Int J Global Warm* 2015, **8**:141-157.
 10. INC: *Vanuatu: Draft Annex Relating to Article 23 (Insurance) for Inclusion in the Revised Single Text on Elements Relating to Mechanisms, A/AC.237/WG II/Misc.13*. Available: Geneva: Intergovernmental Negotiating Committee for a Framework Convention on Climate Change; 1991 <https://unfccc.int/resource/docs/a/wg2crp08.pdf>.
 11. Pickering C, Grignon J, Steven R, Guitart D, Byrne J: **Publishing not perishing: how research students transition from novice to knowledgeable using systematic quantitative literature reviews**. *Stud High Educ* 2015, **40**:1756-1769.
 12. UNFCCC Secretariat: *Non-economic Losses in the Context of the Work Programme on Loss and Damage, Technical Paper, FCCC/TP/2013/2*. UNFCCC; 2013.
 13. Morrissey J, Oliver-Smith A: **Perspectives on noneconomic loss and damage. Understanding values at risk from climate change**. In *Loss and Damage in Vulnerable Countries Initiative Report*. Edited by Warner K, Kreft S. 2013. Retrieved from <http://loss-and-damage.net/download/7308.pdf>.
 14. Stege MHN: **Atoll habitability thresholds**. In *Limits to Climate Change Adaptation. Climate Change Management*. Edited by Leal Filho W, Nalau J. Cham: Springer; 2018.
 15. McLeman R: **Migration and displacement risks due to mean sea-level rise**. *Bull At Sci* 2018, **74**:148-154.
 16. Böge V: **Challenges and pitfalls of resettlement: Pacific experiences**. In *Disentangling Migration and Climate Change: Toward an Analysis of Methodologies. Political Discourses and Human Rights*. Edited by Faist T, Schade J. Dordrecht/Heidelberg/New York/London: Springer; 2013.
 17. Albert S, Bronen R, Tooler N, Leon J, Yee D, Ash J, Boseto D, Grinham A: **Heading for the hills: climate-driven community relocations in the Solomon Islands and Alaska provide insight for a 1.5°C future**. *Reg Environ Change* 2018, **18**:2261-2272.
 18. Charan D, Kaur M, Singh P: **Customary land and climate change induced relocation: a case study of Vunidogoloa Village, Vanua Levu, Fiji**. In *Limits to Climate Change Adaptation. Climate Change Management*. Edited by Leal Filho W, Nalau J. Cham: Springer; 2018.
 19. Connell J: **Last days in the Carteret Islands? Climate change, livelihoods and migration on coral atolls**. *Asia Pac Viewp* 2016, **57**:1-15.
 20. Constable AL: **Climate change and migration in the Pacific: options for Tuvalu and the Marshall Islands**. *Reg Environ Change* 2017, **17**:1029-1038.
 21. Hermann E, Kempf W: **Climate change and the imagining of migration: emerging discourses on Kiribati's land purchase in Fiji**. *Contemp Pac* 2017, **29**:231-263.
 22. Luetz J, Havea PH: **"We're not Refugees, We'll Stay Here until We Die!" – Climate change adaptation and migration experiences gathered from the Tulun and Nissan Atolls of Bougainville, Papua New Guinea**. In *Climate Change Impacts and Adaptation Strategies for Coastal Communities. Climate Change Management*. Edited by Leal Filho W. Cham: Springer; 2018.
 23. Perumal N: **"The place where I live is where I belong": community perspectives on climate change and climate-related migration in the Pacific island nation of Vanuatu**. *Island Stud J* 2018, **13**:45-64.
 24. Chou C: **An emerging human security threat on Pacific Island states: analyzing legal and political implications of territorial inundation**. In *Human Security*. Edited by The Cheng Guan B. Dordrecht: Springer; 2012.
 25. Campbell JR, Goldsmith M, Koshy K: *Community Relocation as an Option for Adaptation to the Effects of Climate Change and Climate Variability in Pacific Island Countries (PICs). Final report for APN project 2005-14-NSY-Campbell*. Tokyo, Japan: Asia-Pacific Network for Global Change Research; 2007.
 26. Singh P, Charan D, Kaur M, Railoa K, Chand R: **Place attachment and cultural barriers to climate change induced relocation: lessons from Vunisavisavi Village, Vanua Levu, Fiji**. In *Managing Climate Change Adaptation in the Pacific Region. Climate Change Management*. Edited by Leal Filho W. Cham: Springer; 2020.
 27. Stratford E, Farbotko C, Lazrus H: **Tuvalu, sovereignty and climate change: considering Fenua, the archipelago and emigration**. *Island Stud J* 2013, **8**:67-83.
 28. McMichael C, Katonivualiku M, Powell T: **Planned relocation and everyday agency in low-lying coastal villages in Fiji**. *Geogr J* 2019, **185**:325-337.
 29. Latai-Niusulu A, Binns T, Nel E: **Climate change and community resilience in Samoa**. *Singapore J Trop Geogr* 2020, **41**:40-60.
- Using a cultural ecological lens to overcome critiques of resilience being rooted in Western science and neo-classical economics, this paper illustrates that island nations are highly dynamic and are undergoing

persistent adaptation. Drawing from fieldwork in Samoa, the authors argue that *faamatai* a multi-layered arrangement of extended families, villages and churches have strengthened social resilience, facilitated adaptation and enabled planning for future changes.

30. Farbotko C, Stratford E, Lazrus H: **Climate migrations and new identities? The geopolitics of embracing or rejecting mobility.** *Soc Cult Geogr* 2015, **17**:533-552.
31. Oakes R: **Culture, climate change and mobility decisions in Pacific Small island developing states.** *Popul Environ* 2019, **40**:480-503.
32. Tabe T: **Climate change migration and displacement: learning from past relocations in the Pacific.** *Soc Sci* 2019, **8**:1-18.
33. Mortreux C, Barnett J: **Climate change, migration and adaptation in Funafuti, Tuvalu.** *Global Environ Change* 2009, **19**:105-112.
34. Campbell JR: **Climate-change migration in the Pacific.** *Contemp Pac* 2014, **26**:1-28.
35. van der Geest K, Burkett M, Fitzpatrick J, Stege M, Wheeler B: **Climate change, ecosystem services and migration in the Marshall Islands: are they related?** *Clim Change* 2020, **161**:109-127 <http://dx.doi.org/10.1007/s10584-019-02648-7>.
The authors give a comprehensive overview survey and a geo-spatial analysis of flood extent and migration rates to study the relationship between climatic events, ecosystem services and migration in the Marshall Islands. The paper concludes that in addition to education, health care, work and family visits, the impacts of climate change on livelihoods, health and safety are key migration drivers at the household level.
36. Piggott-McKellar AE, McNamara KE, Nunn PD, Sekinini ST: **Moving people in a changing climate: lessons from two case studies in Fiji.** *Soc Sci* 2019, **8**:133-150.
37. Pill M: **Planned relocation from the impacts of climate change in small island developing states: the intersection between adaptation and loss and damage.** In *Managing Climate Change Adaptation in the Pacific Region. Climate Change Management.* Edited by Leal Filho W. Cham: Springer; 2020.
38. McMichael C, Katonivualiku M: **Thick temporalities of planned relocation in Fiji.** *Geoforum* 2020, **108**:286-294.
This paper highlights that residents of relocated villages make sense of different temporalities and timescales, where climate impacts and adaptation disrupt personal and intergenerational histories of attachment to place. The paper asserts that planned relocation is best approached as a process that ought to connect to people's pasts and imagined futures under climate change.
39. Wewerinke-Singh M: **Climate migrants' right to enjoy their culture.** In *Climate Refugees: Beyond the Legal Impasse?*. Edited by Behrman S, Kent A. London: Routledge; 2018.
40. Gibson K, Haslam N, Kaplan I: **Distressing encounters in the context of climate change: idioms of distress, determinants, and responses to distress in Tuvalu.** *Transcult Psychiatry* 2019, **56**:667-696.
41. du Bray MV, Wutich A, Larson KL, White DD, Brewis A: **Emotion, coping, and climate change in island nations: implications for environmental justice.** *Environ Justice* 2017, **10**:102-107.
42. Cámara-Leret R, Raes N, Roehrdanz P, De Fretes Y, Heatubun CD, Rooble L, Schuiteman A, van Welzen PC, Hannah L: **Climate change threatens New Guinea's biocultural heritage.** *Sci Adv* 2019, **5**:1-9.
Analysing 2353 endemic plant species distributions in New Guinea, the authors found that 63% of species are expected to have smaller geographic ranges by 2070. As a result, ecoregions may have an average of -70 ± 40 fewer species by 2070 and the authors argue that priority sites for protected area expansion are needed for safeguarding these precious species.
43. Hofmann R: **Culturecide in changing micronesia climates? About the unintentionality of climate change.** *Int J Hum Rights* 2014, **18**:336-349.
44. Kuruppu N, Liverman D: **Mental preparation for climate adaptation: the role of cognition and culture in enhancing adaptive capacity of water management in Kiribati.** *Global Environ Change* 2011, **21**:657-669.
45. Perkins RM, Krause SM: **Adapting to climate change impacts in Yap State, Federated States of Micronesia: the importance of environmental conditions and intangible cultural heritage.** *Island Stud J* 2018, **13**:65-78.
Sea levels are severely impacting on food and water security in the Federated States of Micronesia. This paper explores how local cultures are responding, in particular how complex protocols of resource management, social structure, land tenure and norms of reciprocity create and sustain social resilience.
46. Bridges KW, McClatchey WC: **Living on the margin: ethnoecological insights from Marshall Islanders at Rongelap atoll.** *Global Environ Change* 2009, **19**:140-146.
47. Lefale PF: **Ua 'afa le Aso stormy weather today: traditional ecological knowledge of weather and climate. The Samoa experience.** *Clim Change* 2010, **100**:317-335.
48. McNamara KE, Prasad SS: **Coping with extreme weather: communities in Fiji and Vanuatu share their experiences and knowledge.** *Clim Change* 2014, **123**:121-132.
49. Granderson AA: **The role of traditional knowledge in building adaptive capacity for climate change: perspectives from Vanuatu.** *Weather Clim Soc* 2017, **9**:545-561.
This paper documents local, Indigenous knowledge of weather and climate observations, resource use and management, social networks, local leadership, and values and beliefs. Importantly, the author emphasises the importance of this knowledge for building adaptive capacity to climate change.
50. McIver L, Bowen K, Hanna E, Iddings S: **A 'Healthy Islands' framework for climate change in the Pacific.** *Health Promot Int* 2017, **32**:549-557.
51. McIver L, Kim R, Woodward A et al.: **Health impacts of climate change in Pacific Island countries: a regional assessment of vulnerabilities and adaptation priorities.** *Environ Health Perspect* 2016, **124**:1707-1714.
This paper finds that the highest-priority climate-sensitive health risks in Pacific Island countries include, among others, trauma from extreme weather events, heat-related illnesses, compromised safety and security of water and food, noncommunicable diseases, and health system deficiencies. The paper contributed to World Health Organization's report in 2016 on the current state of knowledge of health and climate change in the Pacific Islands.
52. Fisher PB: **Climate change and human security in Tuvalu.** *Global Change Peace Secur* 2011, **23**:293-313.
53. Sattler DN, Whippy A, Graham JM, Johnson J: **A psychological model of climate change adaptation: influence of resource loss, posttraumatic growth, norms, and risk perception following cyclone Winston in Fiji.** In *Climate Change Impacts and Adaptation Strategies for Coastal Communities. Climate Change Management.* Edited by Leal Filho W. Cham: Springer; 2018.
54. Asugeni J, MacLaren D, Massey PD, Speare R: **Mental health issues from rising sea level in a remote coastal region of the Solomon Islands: current and future.** *Australas Psychiatry* 2015, **23**:22-25.
This paper contributes to the emerging discussion on mental health issues and responses to climate change impacts in the Pacific Islands using community-level evidence from East Malaita, Solomon Islands.
55. Havea PH, Hemstock SL, Jacot Des Combes H, Luetz J: **'God and Tonga Are My Inheritance!' – climate change impact on perceived spirituality, adaptation and lessons learnt from Kanokupolu, 'Ahau, Tukumonga, Popua and Manuka in Tongatapu, Tonga.** In *Climate Change Impacts and Adaptation Strategies for Coastal Communities. Climate Change Management.* Edited by Leal Filho W. Cham: Springer; 2018.
56. Currenti R, Pearce T, Salabogi T, Vuli L, Salabogi K, Doran B, Kitson R, Ford J: **Adaptation to climate change in an interior Pacific Island village: a case study of Nawairuku, Ra, Fiji.** *Hum Ecol* 2019, **47**:65-80.
57. Schwerdtle P, Bowen K, McMichael C: **The health impacts of climate-related migration.** *BMC Med* 2018, **16**:1-7.
58. du Bray M, Wutich A, Larson KL, White DD, Brewis A: **Anger and sadness: gendered emotional responses to climate threats in four island nations.** *Cross Cult Res* 2019, **53**:58-86.

59. Britton E, Howden-Chapman P *et al.*: **The effect of climate change on children living on Pacific Islands**. In *Climate Change and Rural Child Health*. Edited by Bell E. New York, USA: Nova Science Publishers; 2011.
60. Dannenberg AL, Frumkin H, Hess JJ, Ebi KL: **Managed retreat as a strategy for climate change adaptation in small communities: public health implications**. *Clim Change* 2019, **153**:1-14.
61. Hoegh-Guldberg O, Mumby PJ, Hooten AJ, Steneck RS, Greenfield P, Gomez E, Harvell CD, Sale PF, Edwards AJ, Caldeira K *et al.*: **Coral reefs under rapid climate change and ocean acidification**. *Science* 2007, **318**:1737-1742.
62. Komugabe-Dixon AF, de Ville NSE, Trundle A, McEvoy D: **Environmental change, urbanisation, and socio-ecological resilience in the Pacific: community narratives from Port Vila, Vanuatu**. *Ecosyst Serv* 2019, **39**.
63. Goulding W, Moss PT, McAlpine CA: **Cascading effects of cyclones on the biodiversity of Southwest Pacific islands**. *Biol Conserv* 2016, **193**:143-152.
64. Sattler DN: **Climate change and extreme weather events: the mental health impact**. In *Climate Change Adaptation in Pacific Countries*. *Climate Change Management*. Edited by Leal Filho W. Cham: Springer; 2017.
65. Thomas AS, Mangubhai S, Vandervord C, Fox M, Nand Y: **Impact of tropical cyclone Winston on women mud crab fishers in Fiji**. *Clim Dev* 2019, **11**:699-709.
- This study focuses on post-cyclone impacts and the recovery of community fisheries, an underresearched area. Using a value-chain analysis survey conducted in 2015, the authors found that post-cyclone, 52% of fishers had stopped harvesting crabs due to the need to rebuild homes, and for those who did harvest, crabs were smaller and fewer and 65% were sold onto local traders rather than consumed.
66. Pearce T, Currenti R, Mateiwai A, Doran B: **Adaptation to climate change and freshwater resources in Vusama village, Viti Levu, Fiji**. *Reg Environ Change* 2018, **18**:501-510.
67. Valmonte-Santos R, Rosegrant MW, Mohan Dey M: **Fisheries sector under climate change in the coral triangle countries of Pacific Islands: current status and policy issues**. *Marine Policy* 2016, **67**:148-155.
68. Salinger MJ, Bell JD, Evans K, Hobday AJ, Allain V, Brander K, Dexter P, Harrison DE, Hollowed AB, Lee B, Stefanski R: **Climate and oceanic fisheries: recent observations and projections and future needs**. *Clim Change* 2013, **119**:213-221.
69. Asch RG, William WL, Cheung GR: **Future marine ecosystem drivers, biodiversity, and fisheries maximum catch potential in Pacific Island countries and territories under climate change**. *Marine Policy* 2018, **88**:285-294.
70. Hanich Q, Wabnitz CCC, Ota Y, Amos M, Donato-Hunt C, Hunt A: **Small-scale fisheries under climate change in the Pacific Islands region**. *Marine Policy* 2018, **88**:279-284.
71. Stedman RC: **Is it really just a social construction? The contribution of the physical environment to sense of place**. *Soc Nat Resour* 2011, **16**:671-685.
72. Manca AR: **Social cohesion**. In *Encyclopedia of Quality of Life and Well-Being Research*. Edited by Michalos AC. Dordrecht: Springer; 2014.
73. Mitchell DK, Aigoma G: **'Yakasisi' in planning for a more sustainable future of coastal communities impacted by climate change, Milne Bay, Papua New Guinea**. In *Climate Change Impacts and Adaptation Strategies for Coastal Communities*. *Climate Change Management*. Edited by Leal Filho W. Cham: Springer; 2018.
- In Milne Bay Province, PNG a loss of 'Yakasisi' which translates into respect – a respect for elders, a respect of ecological and environmental knowledge, and a respect of kinship arrangements – was identified by authors. Recognition of a renewal of 'Yakasisi', along with current knowledge, will better equip the clan for future environmental changes was identified.
74. Gharbaoui D, Blocher J: **Limits to adapting to climate change through relocations in Papua New Guinea and Fiji**. In *Limits to Climate Change Adaptation*. *Climate Change Management*. Edited by Leal Filho W, Nalau J. Cham: Springer; 2018.
75. Albrecht G, Sartore G-M, Connor L, Higginbotham N, Freeman S, Kelly B, Stain H, Tonna A, Pollard G: **Solastalgia: the distress caused by environmental change**. *Austral Psychol* 2007, **15** (Suppl):S95-98.
76. Hoegh-Guldberg O, Jacob D, Taylor M, Bindi M, Brown S, Camilloni I, Diedhiou A, Djalante R, Ebi KL, Engelbrecht F *et al.*: **Impacts of 1.5°C global warming on natural and human systems**. In *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. Edited by Masson-Delmotte V, Zhai P, Pörtner H-O, Roberts D, Skea J, Shukla PR, Pirani A, Moufouma-Okia W, Péan C, Pidcock R. Bonn, Germany: Intergovernmental Panel on Climate Change; 2018.