Chapter 11
Adapting to Change? Traditional Knowledge and Water

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Future water adaptation approaches in the Pacific must be informed by traditional knowledge to enable the incorporation of localized, detailed, and historical knowledge and experience into contemporary management regimes.

Abstract Pacific Islander communities need to maintain traditional knowledge and practice about their water systems, despite the ongoing legacy of colonial impact, in order to adapt to climate change where its impacts will significantly impact water quality and reliability. Without healthy water systems, Pacific communities will become increasingly vulnerable. Traditional knowledge has a role to play in building the adaptive capacity of islanders to water shortages and in adapting to climate impacts over time. While colonization, belief in God, and loss of traditional knowledge are barriers to effective adaptation, Pacific Islanders across the region are using existing traditional knowledge in combination with other knowledge systems to build resilience to climate change and innovative adaptation solutions. Approaches informed by traditional knowledge enable the incorporation of localized, detailed, and historical knowledge, and experience into contemporary management regimes, which then enable the development of tailored and appropriate place-based adaptation. Importantly, the use of traditional knowledge also strengthens community receptivity to adaptation initiatives.

Keywords Pacific · Gender · Climate adaptation · Resilience · Water

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11.1 Introduction

Pacific Island Countries and Territories (PICTs) face an uncertain future as they confront the impacts of extreme and rapid onset events such as cyclones, droughts, or heavy rainfall, which have tested past and present coping strategies by Pacific communities to safeguard their water security. Globally, water security is emerging as a major issue: global water demand is increasing at approximately 1% per annum, whilst between 4.8 and 5.7 billion people are projected to live in areas that are potentially water scarce for one month per year by 2050 (UNESCO World Water Assessment Programme 2019). In the Pacific, a dependence on water resources is additionally affected by a combination of structural fragilities which increase population demand for water and heighten inequality and poverty. In this context, climate change will place additional pressure on water resources and amplify water insecurity and risk. This chapter explores the cultural dimension of this challenge for PICTs by exploring how Indigenous and local knowledge (ILK)[1] can be deployed to build water security and resilience. We argue that ILK will be central to future water management and security in the Pacific and to date its historical application has enabled locals to survive, prosper, and live for many generations.

In the Pacific region ILK is being increasingly applied in management projects to combat climate change. For example, in the BoeBoe village, Solomon Islands, integrated traditional and scientific knowledge using participatory three-dimensional modelling (P3DM) is helping build responses to sea level rise (Leon et al. 2015) and in Tuvalu, traditional environmental knowledge has been used to assist policy makers in making adaptive decisions that reflect community risks and priorities, thus increasing the likelihood of community engagement in formal adaptation (Lazrus 2015).

We build on this work but focus on how ILK about water can be used to build water security in a time of climate stress. We note the interconnectedness of water to food and water to energy and that ILK for water is intrinsically tied to traditional agriculture and sustainable use of the local environment. The scope of this chapter focuses on the water aspect of the WEF nexus with context for the WEF approach provided in Chap. 1. We first provide an overview of climate threats for the region, and then provide a range of examples that highlight the use of ILK into water management across the Pacific. Our analysis then reflects on the factors that drive and impact on the success of these water adaptation initiatives. In this section, we argue that while there are many responses to address the climate impacts on water in the Pacific, that adaptation to it is also affected by the historical influence of colonization and Christianity. These two historical factors have not only impacted on Indigenous and local knowledge systems but in reflecting their own knowledge systems, create barriers to community acceptance of water adaptation programs based on climate (and other) science.

Ultimately, we argue that to achieve water security in the region it is crucial to acknowledge that numerous knowledge systems are co-existent in the Pacific:

[1] For this chapter we use the term Indigenous and Local Knowledge (ILK), as employed by the Intergovernmental Panel on Climate Change (IPCC).

ILK, religious (Christian) and Western scientific knowledges. All these knowledges co-exist to a greater or lesser extent depending on the place (island or even village context) and we argue that this represents a diversity which also brings a strength that can be harnessed to redress climate related water security issues into the future.

11.2 Climate Impacts and Water in the Pacific

PICTs are internationally recognized as highly vulnerable to an array of climate change impacts and related hazards. Systematic observations, research, and modelling have shown a range of climatic trends and associated hazards that have affected the region in recent decades. Such climate impacts are all the more acute given that 55% of the population in these countries live within 500 m of the coast, with 20% of those peoples living within 100 m of the coast. Predictions highlight that temperatures are likely to reach 1.5 °C between 2030 and 2052 (high confidence) (Watanabe et al. 2021; IPCC 2021) and sea level rise is likely to increase 0.5–0.6 m by 2100 compared to 1986–2005 (Australian Bureau of Meteorology and CSIRO 2014; Church et al. 2013). Overall, these impacts will create abrupt changes in the climate variability of the tropical Pacific region (Kleypas et al. 2015) including changes in precipitation (Barnett 2011) and the El Niño Southern Oscillation (ENSO). The ENSO, often referred to as individual La Niña or El Niño events, is a natural multi-year cyclical (as detailed in Chap. 5), but anthropogenic warming of the atmosphere is leading to increased uncertainty in the system and severity of weather-related events (Kumar 2020). For example, severe drought driven by a La Niña event in Tuvalu in 2011 led to a state of emergency, with impacts including groundwater contamination and water rationing (McGree et al. 2016). By contrast, extreme rainfall can cause damaging floods (Kuleshov et al. 2014) with such events forecast to increase with increased rainfall during severe weather events known to be associated with human-induced climate change (Kumar 2020; IPCC 2021). Cyclone frequency globally is projected to increase due to climate change (IPCC 2021, B.24; Christensen et al. 2013), but this trend is not clear for the Pacific. However, it is widely agreed that in the Pacific, and globally, they will be more intense and damaging when they occur (Keener et al. 2013; IPCC 2021). Further, projected ocean warming and acidification (IPCC 2021; Wu et al. 2018) is causing ecosystem vulnerability in the southwest Pacific (Smale et al. 2019). The pH of the tropical Pacific Ocean is decreasing at a rate of 0.02 units per decade: projections estimate this may decrease by 0.15 units relative to 1986–2005 by 2050 (Hoegh-Guldberg et al. 2014). This will cause related impacts such as decline in coral cover (Hoegh-Guldberg et al. 2014), which will in turn impact fishing and greatly reduce food security due to the heavy reliance on marine sourced contributions to Pacific diets (Chap. 4).

There will a number of direct impacts on both people and the environment that will include damages to health, water and other infrastructure, and people. For example, Cyclone Pam in 2015, not only disrupted ecosystems, but also destroyed 21 of the

24 health facilities across the 22 affected islands (Esler 2015) with ongoing indirect impacts including an increase in the geographic ranges of vectors and increased pathogen loads in food and water (McIver et al. 2012). The three global biodiversity hotspots located within the Pacific region will also be affected, causing severe impacts on regional biodiversity (Taylor and Kumar 2016). As Kumar and Tehrany (2017) found in their assessment of 23 countries in the Pacific, 674 of the islands host at least one terrestrial vertebrate species that is either vulnerable, endangered, or critically endangered.

However, notwithstanding the regional trends, it is crucial to recognise that climate risk profiles, as well as water security risk, will vary on an island-by-island basis (Kumar et al. 2020). This variation results from diverse island geography, geology, and topographic characteristics. In relation to water security, the main climate risks to which all islands are exposed are temperature rise, changes to rainfall regimes, and sea-level rise. There are also risks from tropical cyclones and drought, but these do not affect the entire Pacific in the same manner, for the reasons outlined above. Non-climate risks further complicate water security (Chap. 2) and certainty for building resilience against current and future climate change impacts. The main non-climate risks are those due to increasing human demand for water due to the increasing human population increasing demand for water, food, and energy, changes in urban versus rural population demographics, and increased use for industrial and "development" of the country and economy.

For the atoll countries in the Pacific, that do not have strong mountainous features (like some higher volcanic islands), the situation under climate change is especially challenging (Zack and Ronneberg 2003). Fresh groundwater lenses located in the shallow subsurface environment of oceanic carbonate islands and atolls throughout the Pacific represent the only naturally occurring potable water supply, where no rainfall catchment infrastructure exists (Chap. 2). The groundwater lenses have formed from rainfall percolating through the soil to reside in fragile hydrodynamic equilibrium with the underlying saltwater, separated by slight differences in density. During prolonged drought and increased demand for fresh drinking water, the lenses become thinner, and the sustainable withdrawal of fresh groundwater becomes limited by saltwater contamination. In limestone or coralline islands and atolls, such saltwater intrusion is a vertical phenomenon (Polemio and Walraevens 2019). Pumping wells—screened in the freshwater lens—can induce a vertical flow component from the underlying saltwater regions, causing the saltwater to migrate upwards and become intercepted by the pumping well. The development of fresh groundwater supplies under these circumstances has been problematic to island water authorities. Also, saltwater coning during groundwater pumping agitates the interface, further widening the zone of diffusion and dispersion, and ultimately reducing the freshwater lens thickness.

For many atoll countries in the Pacific, freshwater lenses are the only source of water (Chap. 2). Usually less than 15 m deep, they are recharged by rainfall and tend to float on the top of denser seawater (Zack and Ronneberg 2003). Many factors determine the formation of freshwater lenses on islands and atolls, in terms of their distribution, geometry, and permanence. Lenses are thicker on atolls with larger,

more elevated landmasses and those receiving the greatest rainfall, evenly distributed throughout the year. Freshwater lenses are subject to many threats, in particular saltwater intrusion, droughts, storm surges, unsustainable water abstraction, and coastal erosion (Klaver et al. 2019). These factors may change salinity levels of the lenses as well as reduce their size. Climate change will amplify these effects and impact water security (Chaps. 2 and 5).

11.3 Traditional Knowledge in the Pacific

The utility of traditional knowledge for adaptation is increasingly grounded in evidence (Nakashima et al. 2018; Pearce et al. 2015; Nursey-Bray et al. 2020; Bryant-Tokalau 2018; Lebel 2013; Nunn et al. 2014; McNamara et al. 2020; 2016a, b), and internationally, there are calls to embrace Indigenous knowledge (IPBES 2019). The use of ILK can enhance scientific knowledge by revealing details within environmental systems and plays a critical role in enabling resilience and facilitating adaptation to climate change (Finn et al. 2017; Huntington et al. 2017; Plotz et al. 2017). Globally ILK is increasingly recognized as offering the opportunity to create locally appropriate climate adaptation strategies (Ford et al. 2016; Nalau et al. 2018). For example, Indigenous farmers in Bolivia and the Peruvian Andes assisted scientists to discover links between El Niño and tropospheric cloud cover by deploying and sharing their knowledge about how to forecast weather patterns (Orlove et al. 2002). In Mongolia, ILK is being used to respond and adapt to the changes in temperate dryland ecosystems (Tugjamba et al. 2021), and in Australia, there are many examples of how traditional knowledge is progressing adaptation, whether in the north (Leonard et al. 2013a, b; Bird et al. 2013) or the central desert (Nursey-Bray et al. 2013, 2020). Examples of the importance of incorporating ILK into management include the use of Aboriginal fire management approaches in Australia (Bliege Bird et al. 2018), Sami knowledge of reindeer herding (Eira et al. 2013), rainwater harvesting in India (Bhattacharya 2015), and Indigenous farming methods in Africa (Basdew et al. 2017; Faye et al. 2021).

Yet, despite the loss of components of ILK, the worldviews and ethics of many Pacific Islanders continue to be shaped by ILK. The Samoan way of life (fa'asamoa) for example, emphasizes the importance of collective wellbeing, the duties and responsibilities individuals possess to one's family (aiga) as well as to their wider community (their village and Church). The practice of reciprocity is critical (Parsons et al. 2017). In other areas of the Pacific, people draw on multiple knowledge systems, particularly Christianity, scientific knowledge, as well as ILK, to explain and interact with the world around them (including their understandings of climate change, and how best to manage the security of their water and food supplies). For the Indigenous people from the small atoll island of Andra in Papua New Guinea, for instance, the Catholic Church now plays a critical role in daily life, beliefs, and feelings of belonging and social networks. In particular, women from Andra Island report that the Catholic Church's women's networks have created strong linkages within and

between island communities and fosters a sense of community cohesion (both intra- and inter-island). The sense of community and shared cultures (across clan and island groups), the women argue, is essential to them being able to work together and provide assistance to one another in times of crisis. In contrast, Andra Island men consider that it is their customary or traditional systems of governance (laws, decision-making processes, and socio-cultural institutions) that underpin their social cohesion (lack of inter-personal conflict and collective distribution of resources). This translates into high social capital. In particular, the men of Andra Island note how one person (known as the hausbois) on the council governs the clan representing each sub-clan group. However, the position of hausbois is restricted to men (as is the role of the chief) and women become excluded from decision-making processes. Accordingly, the Catholic Church's women's group provides women with an avenue to participate in discussions about community matters as well as plan for and respond to crises, including droughts and floods, effectively bypassing the patriarchal clan governance system.

In some parts of the Pacific, particularly in remote locations away from large urban areas and western-style development activities, different communities continue to employ ILK as their central way to monitor environmental conditions, make decisions about natural resource management, and manage environmental risks (Rarai 2018). Farmers in Niue (Fig. 11.1) for example benefitted from inclusion of traditional knowledge (TK) in weather reports. In the Northern area of Pentecost Island (Vanuatu), ILK is still widely employed by Indigenous people to forecast weather conditions, enact natural resource management strategies, and reduce their vulnerability to climate extremes. Individuals carefully observe cloud formations, winds, and waves, as well as the behaviour of plants and animals (all-important environmental indicators) to forecast weather conditions (months, weeks, or days in advance). Such an understanding of the interconnectivity of all living beings underpins Pacific Islander knowledge systems and parallels the holistic nature of ILK more generally as discussed previously by numerous scholars (Berkes 1999; Leonard et al. 2013a, b; Nalau et al. 2018; Nursey-Bray 2016). The next few sections present case studies which shed light on how traditional knowledge is being brought to bear on water management in the context of climate change.

11.3.1 Case Study 11.1. Water Management and the Northern Pentecost Island, Vanuatu

Freshwater management is an ongoing challenge for the Indigenous peoples of Northern Pentecost Island (NP) due to natural variability of precipitation rates as well as increased variability associated with climate change; however, Indigenous communities are successfully employing a variety of ILK-based and western knowledge-based water management strategies to reduce their vulnerability to water insecurity. One issue faced in NP is how to store rainwater for and during drought events (such as associated with El Niño). Historically, the only source of water

Fig. 11.1 Hakupu agriculture show day, Niue. Farmers in Niue benefitted from inclusion of traditional knowledge (TK) in weather reports (© Siosinamele Lui)

when the rivers and streams dried out (during extreme droughts), were the coiled roots of large trees that held water (tumu). Accordingly, many NP people recall the difficulties that they and their ancestors faced with water shortages during droughts. However, NP people traditionally used a variety of methods to store water and manage water usage to prepare for and manage drought conditions, which continue to be utilized to a greater or lesser degree in different villages on Pentecost Island.

These include coiled roots of large trees, coconut stems, and dug ground wells. However, over the last two decades, the introduction of new knowledge about community health (underpinned by scientific knowledge), as well as new technologies to parts of NP resulted in a shift away from water storage techniques based solely on ILK to one that incorporates multiple knowledges and approaches. The local people from Ahivo and Aute districts, for instance, continue to rely on rainwater for their water supplies, but now store their freshwater supplies (used for drinking and cooking only) in cement and plastic water tanks (that can store between 6,000 to 10,000 L of water). These new technologies help local villagers manage water more effectively during droughts, with nearly every household now having water tanks (Rarai 2018). Research participants observe that now, with the water tanks and careful communal management of water usage, villages typically possess enough water to last them throughout the dry season or drought event.

Alongside new technologies, residents manage freshwater supplies (particularly during frequent drought events linked to El Niño conditions, worsening because of climate change) using a mixture of western technologies (water storage) and

traditional water management practices. Rather than emphasize individual water rights and usage, water is collectively managed and strictly monitored. Water is also more freely available due to the introduction of western-style portable water tanks and containers. The combination of western water storage techniques and traditional methods of water management has meant that the Pentecost community is better prepared to respond to climate impacts on water.

11.3.2 Case Study 11.2. Water and Food Adaptation Strategies

A range of water adaptation strategies are being used in many regions. Onesomw Island, Micronesia, which is located in the Chuuk State lagoon, has already been affected by climate change, particularly during typhoons and high tide events. Freshwater supplies are affected by coastal flooding, drought, and saltwater intrusion. However, to address these impacts, the Onesomw community has drawn on its ILK and revitalized traditional wells and undertaken a range of management actions including (1) cleaning them, (2) planting buffer strips around them to stabilise banks, and (3) and installing covers on the wells to reduce pollution and contamination (McLeod et al. 2018).

Increasingly, traditional farming practices are also being revitalized. The use of traditional knowledge in this way has enabled Pacific islanders to build food security and combat water insecurity. Some methods include shading crops with palm leaves, maintenance of trees around other plants to make shade and the use of seaweed for compost. For example, the Ahus people of Manus Island in Papua New Guinea have implemented revitalized crop practice, developed raised gardens, and instituted local water collection in drums and small tanks (McLeod et al. 2018). They have diversified their crops and raised beds to avoid saltwater intrusion and initiated aquaculture projects. Elsewhere in Palau, the GEF-SPREP Pacific Adaptation to Climate Change project has supplied and tested various varieties of salt resistant taro. Three national varieties have now been selected for wider use.[2] In the Yap islands, community members have established a nursery using traditional composting techniques and in so doing have reduced reliance on depleted fish stocks, diversified food, and protected water supplies (Nunn et al. 2016a, b). Nalau et al. (2018) highlight extensive application of climate adaptation activities which have a strong ILK focus including crop rotation systems in Tanna Island in Vanuatu and historical climate adaptation in Samoa where traditional water rainwater harvesting has been strengthened to adapt to current challenges. Another example, as illustrated in Fig. 11.2, is in Tonga, where resident farmers are using TK to work out how to predict and manage rainfall and drought.

In Vanuatu, traditional knowledge has been deployed to build an innovative water adaptation program via music (Grant 2019). Port Vila, one of the world's most at risk

[2] See https://www.youtube.com/watch?v=MWXYRq11pZc.

Fig. 11.2 Young man tending his yam and taro patch in Nukualofa, Tonga. Tonga is now incorporating TK in practical outreach to farmers around rainfall predictions and drought (© Siosinamele Lui)

cities from climate change (Komugabe-Dixson et al. 2019) will experience (amongst other impacts) poorer water quality, intrusion of saltwater into freshwater systems and the associated impacts of floods and drought. In order to preserve their *kastom*, villagers relocated to a place called Luganville and decided to protect their knowledge via establishment of the Leweton Cultural Village. This move was meant to "enable and encourage the continued practice in the community, across all generations, of the language and cultural traditions of Gaua and Merelava" (Grant 2019, 44). One of these cultural practices is called "Etetung". This means Vanuatu Women's Water Music and is a form of water percussion. The practice of Etetung has enabled the articulation and keeping of cultural knowledge about water, its importance, and use for generations. It is a:

> sonic way of knowing and understanding the world, an acoustemology….as the women of Leweton represent in the water the sounds familiar to them through their experience of the world…a dolphin, falling rain on taro leaves, thunder, a waterfall, whale fish, skull fish, certain local species of birds, water ebbing back through the rocks at high tide—they manifest 'localized creative dialogue with the specificity of place' through their performance. (Grant 2019, 50)

Today, the Etetung is a top cultural tourist attraction for Vanuatu, but more than that, it enables an active and contemporary expression of traditional knowledge about water. In so doing, the tourism it drives becomes in effect a form of cultural water adaptation for the community. It does so in two ways; first by preserving traditional

knowledge through performance and second, it enables the purchase of important resources that will build ongoing adaptive capacity—financial returns have enabled the building and improvement of water and other infrastructure in the villages. As one of the villagers reflects in the context of the relationship between the Etetung, knowledge and adaptation: "Climate change changes everything about nature and us…if we keep our culture strong, we can keep our nature alive" (cited in Grant 2019).

11.3.3 Case Study 11.3. Drought Management in Abaiang Island, Kiribati

On the island of Abaiang, Kiribati, a number of villages are vulnerable to the impact of climate related drought. Drought affects village health and well-being because freshwater becomes brackish, and hard to access over time (Sutton et al. 2015). Despite these impacts however, the residents of Abaiang have taken pro-active steps to plan for drought based on a commitment to work with the resources they have to build adaptive capacity. Implemented at village, household, and island levels, drought actions assist villages to make decisions about what they do both prior to and during droughts. This adaptation employs traditional knowledge to help islanders adapt at multiple scales. One strategy is to conserve fresh well water near houses, so that it is protected from contamination and so that during droughts it can be consumed without any adverse health impacts (Sutton et al. 2015). The drought planning for the island is operationalised by an eight-step communications plan, which is implemented via a network of village drought committees that undertake the required actions (Sutton et al. 2015).

Actions at household level include by-laws, water monitoring, and identification of appropriate wells, including those where the owners are willing to share resources. Installation of pipes re-route overflows, and gutter and downpipes are put in and maintained. At community level, actions include the repair of leaks, weekly inspections, and community by laws to ration freshwater (Sutton et al. 2015).

At an island scale, water is transported to vulnerable communities, people are temporarily relocated to areas of low vulnerability, and funds are allocated to improve and repair water systems overall (Sutton et al. 2015). Collectively, this case study reflects how groups of people work together to bring their knowledge and know-how to the mutual endeavour of protecting and maintaining their water supplies amidst climate-related drought events (Sutton et al. 2015). The actions taken by islanders in this case, show the capacity to respond and build adaptive capacity by harnessing existing resources in a creative and effective way.

11.4 Discussion: Water Security in the Pacific—Barriers to Change

It is clear that across the Pacific, different peoples are not only experiencing climate-related water insecurity, but also using their ILK systems to address them. However, there exist other factors that affect contemporary adaptation in practice, and which need to be acknowledged before adaptation can fully occur. One of these factors is the legacy of colonization in the Pacific, and by association, the introduction of Christianity. This needs consideration in three ways: (1) the impact of colonization on ILK and traditional knowledge (TK), (2) the specific and lived reality of Christianity today, and (3) the privileging of Western knowledge and science (imported by colonization) which has occurred. All three elements shape and affect traditional approaches to a challenge like water security.

In parts of the Pacific for example, Euro-Western imperialism and colonialism (be it British, French, Australian, New Zealand, United States, German, Spanish, or Japanese) as well as the arrival of Christianity since the eighteenth century onwards has caused massive changes to Pacific knowledge systems, laws, governance, and management approaches, and ways of life. The arrival of, and conversion to Christianity in much of the Pacific significantly altered ILK both in terms of its intergenerational transmission and day-to-day usage. Some places saw substantive reduction in the use of ILK as missionaries and Christian leaders sought to restrict or ban the use of what was called then "heathen" knowledge. Despite these impacts, it is important to recognize that Christianity is now an embedded and important part of many Pacific Island cultures, and an active living knowledge system in its own right. As such, Christianity is deployed as an additional knowledge system that is exercised alongside ILK. However, at times, these knowledges conflict as climate change becomes explained by and within religious, rather than traditional norms. For example, while many Islanders might attribute various impacts to climate change, they in turn attribute climate change per se to 'God's will', believing it is 'God's punishment', or a warning from God to behave better. Some see climate change as the harbinger of the end of times spoken about in some Christian traditions (Janif et al. 2016). In the Fijian village of Nawairuku, for example, the Bible remains a key authority and informs current adaptive strategies to climate change—sometimes supporting them and at others acting as a barrier to change (Currenti et al. 2019). The influence of religion is overlain in turn by the predominance of Western science and processes, which as another competing knowledge system, has similarly overtaken traditional ones. In being prioritized and valorized by the colonizers, Western scientific knowledge has become entrenched in contemporary environmental and policy management modes. ILK and ways of doing things is not accorded automatic space to flourish. In practice, the parallel existence of Christian and Western scientific knowledge systems (effectively the living legacy of historical colonization) with ILK, fractures opinion and ideas around how to manage for the latest challenge—climate change.

This shift in emphasis on what is 'useful' knowledge and the fact all knowledges compete now for attention in the contemporary world, has meant that local and traditional knowledge in some regions have experienced large scale decline in use as well as deterioration in content (Campbell 1990; Hetzel and Pascht 2017; Hofmann 2017; Kuruppu and Liverman 2011). Many Samoans, for instance, do not widely employ ILK-based environmental information to forecast weather conditions and make decisions about natural resource management, even though they may be aware of such knowledge. Instead, they rely on the weather forecasts and hazard warnings produced by government or news media (which they receive via the internet, TV, and radio) (Lefale 2010; Mow et al. 2017; Nalau et al. 2017; Parsons et al. 2017).

Such loss of ILK (particularly of environmental information) because of the introduction of new knowledge systems, economies, technologies, educational curricula, and modes of living is commonplace. Indeed, the movement of people (temporarily or permanently) from rural to urban areas, people's exposure to new ideas, technologies, and knowledges, as well as the adoption of different livelihoods, individually and cumulatively, result in people being less likely and less able to engage with their local environments (Davies 2015; Gharbaoui and Blocher 2016; Granderson 2017; Hetzel and Pascht 2017; Kuruppu 2009). Further, lack of interactions with local environments (and unfamiliarity with environments particularly in the case of migrants) means that the information that used to be shared by elders is no longer accessed, especially their knowledge of how to monitor environmental conditions and formulate forecasts about weather conditions. Crucial information is thus not being applied to decision-making about how to maintain human security (food, water, physical safety) and responding to environmental risks (Carson et al. 2018; Haynes et al. 2011; Leonard et al. 2013a, b).

In other instances, the reliance on just *one* knowledge system can have maladaptive impacts. For example, the reliance on Western water technologies and approaches, and their implementation via top-down approaches mitigate their effectiveness on the ground. Without taking account of local knowledge about people's way of life (e.g., gender roles, see Chap. 13), ways of managing and governing for, their understanding of and values about water, there is an implicit assumption from many donors that one size fits all. As a result, throughout the Pacific, adaptation strategies have often failed to reduce community vulnerability to variable water supplies (Le Dé et al. 2018; Pearce et al. 2018). Not only does the reliance on technology mean there is diminished use of ILK, but that when there is a drought, local peoples suffer more than they would have in the past as they have stopped or lost the knowledge about traditional water conservation techniques. They are therefore more at risk such as when drought or a saltwater intrusion event occurs.

Another significant dimension to achieving effective water adaptation is the fact that women's ILK receives little attention. In many parts of the Pacific women hold unique ILK and it is essential for and tied to water and land security. Yet the imposition of colonization has changed male/female roles to privilege men. For instance, in many parts of Micronesia, land tenure is passed down the female line and a substantive amount of ILK is held by women, whereas men's ILK is associated with the sea and ocean and fishing/harvesting. Yet, men are the ones who the colonizers mandated

Table 11.1 Diversity of adaptations by Pacific women at various scales

Palau	When citting grass, women leave parts of it to protect the ground
Kosrae	Palms leaves laid over soil
Republic of Marshall Islands	Mangroves and pandanus planted to prevent coastal erosion
Kosrae and Chuuk	Women rely on traditional knowledge and practice to manage drought including the drying and fermenting of breadfruo to offset food insecurity
Pohnpei	Knowledge held by women of locations of traditional wells, supports them to find potable water and build new shallow wells (summarised from McLeod et al. 2018)

with positions of authority as government leaders or chiefs meaning that men occupy positions of power and women were (and still are) predominantly excluded from formal decision-making processes (at higher levels for both government and tribal). It is critical for those undertaking or supporting ILK projects (be it research institutions, NGOs, governments) to include a diversity of participants within and across Indigenous communities (Aikman 2019; Berkes 1999; Ohmagari and Berkes 1997; Voeks 2007).

There are several strategies by which this may be enacted—specific ILK held by women could be recognised and supported more by governments, researchers, and NGOs for a start (Mcleod et al. 2018). Pacific women are involved in adaptation projects at multiple levels and scales as shown in Table 11.1.

However, getting Pacific women involved in such existing and new adaptation projects requires increased access to climate change funding and support from organizations to allow them to meet the requirements of international climate change grants (McLeod et al. 2018). Aid organizations need to ensure they are not just talking the talk but walking the walk in offering the appropriate assistance. Women from Pacific small island developing states could also be offered specific education and training to women's groups to allow them to create strategic action plans, mission statements, learn financial reporting requirements, as well as general leadership and institutional training (Mcleod et al. 2018).

11.5 Moving Forward: Co-existence of Knowledge for Water Security

Different islands face different climate challenges, and have each experienced, and manifest a diverse composite of knowledge production and dissemination. Today, as a result of the long history of Christianity and colonization, multiple knowledges exist and are juggled in the Pacific—traditional (ILK), religious (Christianity), and Western scientific. In the Marshall Islands for example, climate change is understood as a blend between clan magic, biblical exegesis, and scientific knowledge

(Rudiak-Gould 2013). In others, as is the case in Tuvalu, climate change is an abstract concept, not real, too distant to worry about, or—as it is based in Christian belief—perhaps beyond one's control anyway (Mortreux and Barnett 2009). Moving forward, we suggest that building water security in the Pacific will require the delicate balancing of multiple knowledges and ontologies. Taking a nexus approach to build this security across water, energy, and food systems places increased reliance in ILK as part of the balancing act, in recognition of these interconnected systems and their traditionally interconnected management and understanding, before colonialization and outside knowledge systems. As Barnett (2010) asserts, adaptation approaches require acknowledging of the plurality of perceptions and approaches about climate change so that they can enable the creation of locally appropriate responses that are sustainable over time and space.

11.6 Conclusion: Recommendations for Ways Forward

The future will continue to bring many challenges to PICTs and, as we have explored on a case-by-case basis, how these challenges are experienced will be differentiated and place-based. Water security, access to it, its quality and use will all be affected by climate change, but as we have shown, also by the ways in which historical and new knowledges work together to produce solutions. As with many other regions, there is a clear need to build adaptation—in this case for water—in ways that are tailored to local cultures and communities and align with cultural ways of knowing and being. In this context, adaptation approaches need to recognize that knowledge itself is a differentiated and sophisticated entity, with multiple knowledge systems vying for attention. Adaptation programs that create the entry point to allow a flexible weaving between and within different knowledges will work to their strengths, to create more robust adaptation overall. To ensure effective implementation however, working out 'how' to do it is not enough: working out 'who' will be implementing it will be of equal importance. In this context, developing effective, culturally appropriate—and palatable—modes of governance, will be essential, and ideally, will include local peoples so that local voices can be heard and represented in decision making processes. Building local agency in this way will have benefits in the water adaptation frameworks that will evolve. Finally, it is important to remember at all times that climate change as it manifests today, is a new challenge for us all. As such, enabling Pacific Islanders to be trained and equipped in how to adapt to this change in both Western scientific, as well as cultural management approaches will enable all parties, from local community groups, to international NGOS, politicians, and policy makers, to face climate change together. As such, we recommend the following for consideration in future planning for water adaptation in the Pacific.

- That water adaptation programs are tailored to the local conditions and specific likely and predicted climate impacts.

- That Indigenous and local knowledge systems are recognized and appropriately incorporated into water policy and planning.
- That local governance arrangements include local people who can actively participate in and bring their own perspectives and knowledges into the water adaptation and policy.
- That Pacific Islanders are trained in scientific management and knowledge so as to strengthen opportunities for integrated water planning.

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