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Tropical Cyclones in the Southwest Pacific: A Scrutiny of the Past – Insights for the Future

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ABSTRACT

The estimated median value for disaster risk is highest for the continent of Oceania. Six Pacific nations, located in Oceania, rank among the top fifteen considered as having the highest disaster risk worldwide. Globally, three of the seven 'Basins' where cyclones could originate are located in the Southern Hemisphere. The focus of this paper is on the incidence of cyclones, from 2002 to 2018, in the Southwest Pacific. Emergency operations bulletins, data sources such as the Australian Bureau of Meteorology and the Post Disaster Needs Assessment reports were valuable sources of information to ascertain how these countries, or communities within, coped with and mitigated risks when encountering this natural hazard. Strategies that have proven successful in the past, provided invaluable insights to build resilient communities for the future. Bearing in mind the exposure to risk and vulnerability in the Southwest Pacific basin and the current extent of reliance on developed nations for assistance, such insights can promote increased cooperation and confidence among Pacific nations in preventing a natural hazard from escalating into a disaster. Key strategies relate to traditional coping methods, strengthening community resilience, dealing with poverty and inequality, identifying resilient infrastructure and relocating vulnerable communities.

1. INTRODUCTION

A natural hazard evolves into a disaster when an affected country, or communities within, are unable to cope. The ability to cope depends on the severity and frequency of occurrence of the hazard as well as on the vulnerability and resilience of the country and its people.

The 2018 World Risk Index (WRI) [1], which considers both of these aspects, indicates that the estimated median value for disaster risk is highest for the continent of Oceania [1]. Oceania includes Australia, New Zealand (NZ), twelve independent Pacific nations and nine dependent territories. Figure 1 illustrates the location of these nations and territories in Oceania [2].

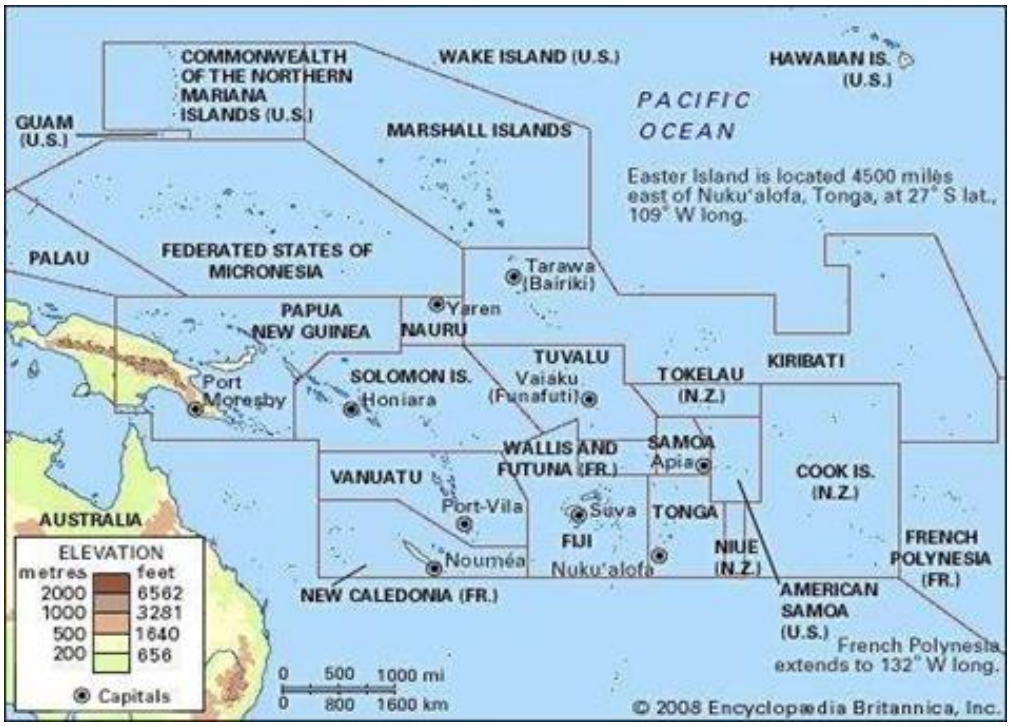


Figure 1. Pacific Islands and Territories [2]

The Pacific Islands Forum (PIF) is the principal organization that represents the economic and political interests of the smaller independent islands and territories that are threatened by climate change in Oceania [3]. At a recent meeting of the Forum, the leaders stressed the need for urgent action on climate change to the United Nations Secretary-General António Guterres. They specifically cited its impact on Tuvalu, where the sea level is likely to continue rising, if no action is taken [4].

The PIF has granted full membership to Australia, NZ and the twelve independent Pacific nations (Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Palau, Papua New Guinea (PNG), Samoa, Solomon Islands (SI) Tonga Tuvalu and Vanuatu). Four territories (Cook Islands, French Polynesia New Caledonia (NCL) and Niue) are also full members. Tokelau, a territory, is an associate member. Observer status has been granted to four other territories (American Samoa, the Commonwealth of the Northern Mariana Islands, Guam and Wallis and Futuna) located in Oceania [3].

Considering all natural hazards linked to climate change on this continent, tropical cyclones (TCs) are the most frequent, being a seasonal event. Globally, there are seven 'Basins' where TCs could originate, with three located in the Southern Hemisphere [5]. In the Southwest Pacific Basin (SWP), typically, cyclones occur between the months of November and April. Climate change, causing sea surface temperatures to increase, results in TC activity [6], which is accompanied by damage to the natural and built environments, coastal flooding and storm surges. In addition, sea level rise as a result of melting glaciers exacerbates the impact of storm surges on flooding [7], especially in the low-lying atolls of island nations.

Cyclones vary in intensity between category 1, causing minimum damage, to an extremely dangerous category 5. Categories 3, 4 and 5 are classified as severe storms resulting in fatalities and causing extensive damage regardless of the intensity of the cyclone [6]. In 2003, category 3, cyclone Ami caused extensive damage to vital infrastructure and agriculture in various regions of Fiji and 19 fatalities were reported in total [8]. However, cyclone Pola, in 2019, though it intensified to a category 4 and caused heavy rainfall, drifted away from New Caledonia without causing much damage or deaths [9]. Further, although early warning systems are in place to monitor and predict the cyclone track, the countries that are in imminent danger and the likely severity of damage, there is no certainty that the predictions will materialize.

The focus of this paper is on the incidence of cyclones, during the period 2002 to 2018, in Fiji, Vanuatu, SI, PNG, Tonga, Samoa, Tuvalu, New Caledonia and Kiribati. These are small island nations or territories, except for PNG, the eastern half of New Guinea. PNG is the largest and most populous nation among these nations. Fiji's economy and infrastructure is the most developed, though still classified as a developing nation along with the other countries.

The purpose of this review is to ascertain how these PIF countries cope with and mitigate risks, while in pursuit of improving community resilience, as they continue to encounter this seasonal natural hazard. Exploring strategies that have proven successful in the past, in a particular milieu, could provide invaluable insights to build resilient communities for the future.

These countries are located in the vicinity of the Pacific 'ring of fire' and are identified as vulnerable to climate change. The high exposure to risk in the SWP is unlikely to decrease and vulnerability in this region is likely to increase. Contemplating the extent of reliance, especially of the smaller islands and atolls, on developed nations for assistance, such insights can promote increased cooperation and confidence among affected Pacific nations and in their communities, to manage the task of preventing a natural hazard from escalating into a disaster.

The methodology involves a review of emergency operations bulletins (e.g., UNOCHA – UN Office for the Coordination of Humanitarian Affairs), various data sources (e.g., the Australian Bureau of Meteorology) and the Post Disaster Needs Assessment reports that are prepared by each country to appeal for funding after a major storm. These are rich sources of information on past cyclone activity. The analysis that follows illustrates the exposure to risk and extent of vulnerability of the selected countries. A scrutiny of past cyclone activity and resulting fatalities begins with an overview of traditional coping strategies that are still in practice in the SWP, which have been highlighted in academic literature. Recent strategies that have proven successful relate to traditional coping methods, strengthening community resilience, dealing with poverty and inequality, identifying resilient infrastructure and relocating vulnerable communities. In conclusion, key insights are debated for the feasibility of adaptation and/or adoption by these SWP nations in managing natural hazards and increasing their resilience.

2. EXPOSURE TO RISK AND VULNERABILITY IN OCEANIA

Six countries in Oceania, as seen in Table 1, rank among the top 15 countries in the world categorized as having the highest overall disaster risk. Overall disaster risk is a product of exposure to risk of natural disasters (e.g., cyclones, earthquakes) and the vulnerability of a country. Based on the quantile method with a maximum of 100 per cent, estimated indices for 172 countries are listed in the WRI [1].

Table 1. Overall risk, exposure to risk and vulnerability

Country	Overall risk rank	Index value
Vanuatu	1	50.28 very high
Tonga	2	29.42 very high
SI	4	23.29 very high
PNG	6	20.88 very high
Fiji	10	16.58 very high
Kiribati	15	15.42 very high
Samoa	76	6.71 medium
Country	Exposure rank	Index value
Vanuatu	1	86.46 very high
Tonga	2	55.92 very high
SI	9	37.81 very high
PNG	14	31.05 very high
Fiji	10	35.51 very high
Kiribati	18	26.37 very high
Samoa	76	14.12 medium
Country	Vulnerability rank	Index value
Vanuatu	44	58.15 high
Tonga	58	52.61high
SI	38	61.59 very high
PNG	20	67.24 very high
Fiji	77	46.68 medium
Kiribati	43	58.47 high
Samoa	72	47.53 medium

As evident in Table 1, overall disaster risk for these six countries is classified as very high, falling within the range of 10.44 – 50.28 [1]. Overall disaster risk in Samoa is classified under medium risk (5.46 – 7.13). Tuvalu (no data available) and New Caledonia (a French territory) are not listed.

Vanuatu and Tonga are ranked as 1st and 2nd in the world for both the highest overall disaster risk as well as the highest exposure to risk. SI, Fiji and PNG also feature among the top 15 countries with the highest exposure to risk. Kiribati is ranked 18th. The level of exposure to risk for these six countries is classified as very high (17.74 – 86.46), with Samoa again classified under medium risk (11.71–14.50).

However, in comparison, the exposure to risk from damaging hazards accompanying TCs, for example floods and storm surges, and other disasters such as earthquakes and tsunamis, is much greater in Vanuatu [10].

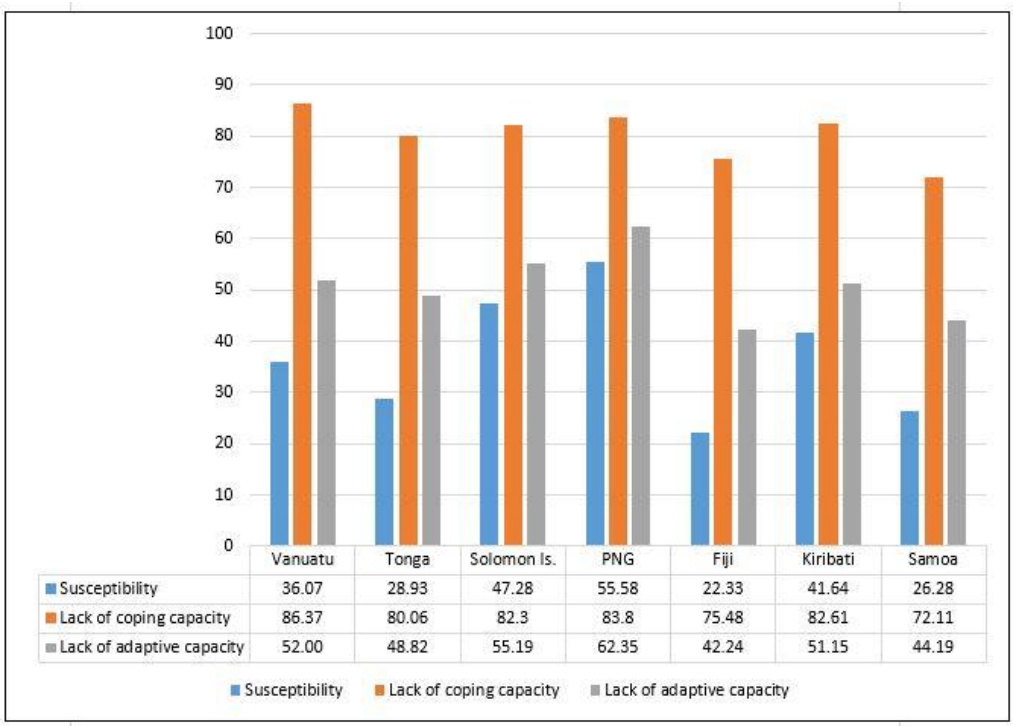
Further, it is not unknown for such disasters to occur in quick succession. In 2017, on the island of Ambae in the Penama province of Vanuatu, the Manaro volcano erupted. In 2018, when category 4 TC Hola caused further damage in the Penama and Malampa provinces, the volcano was still active [11]. A 41-year study between 1970 and 2010 revealed that the frequency of TCs in Vanuatu was approximately 3.9 per season [12].

Among the six countries, only PNG, ranked as 20th in the world, and SI, ranked as 38th, are classified as very high (63.01 – 76.47) in the estimation of the vulnerability of its society. Vulnerability in Vanuatu, Tonga and Kiribati is classified as high (48.61 – 63.00) and in Samoa and Fiji as medium (40.78 – 48.60).

The derivation of the index for vulnerability is based on three aspects of society – susceptibility to harm, a lack of coping capacities and a lack of adaptive capacities [1].

As reflected in Figure 2, the level of vulnerability is most influenced by the lack of coping capacity of these countries, which is classified as very high for all seven countries.

As a result, when a severe TC strikes, these countries are highly dependent on Australia, New Zealand and France (FRANZ Agreement), who stand ready to assist under an agreement signed with the PIF [13], its Pacific neighbors, international organizations and various non-governmental organizations. (NGOs).



	Vanuatu	Tonga	Solomon Is.	PNG	Fiji	Kiribati	Samoa
Susceptibility	36.07	28.93	47.28	55.58	22.33	41.64	26.28
Lack of coping capacity	86.37	80.06	82.3	83.8	75.48	82.61	72.11
Lack of adaptive capacity	52.00	48.82	55.19	62.35	42.24	51.15	44.19

Figure 2. Susceptibility, lack of coping capacity and lack of adaptive capacity [1]

3. A SCRUTINY OF THE PAST

3.1 Traditional coping methods

The ethnic origins of the indigenous populations of these countries are either Melanesian, Polynesian or Micronesian, with the Micronesian people being the most culturally diverse [14]. All three cultures have a strong sense of family with extended kinship networks of the same ethnic origin across nations. In addition, the customary land tenure system emphasizes the socio-cultural identity of these kinship groups. Traditionally, in the SWP region, these two characteristics, in tandem, have acted as the support system for communities in crisis. It was common practice for family residing in low-lying areas to migrate temporarily as a preventive strategy during cyclone season or to relocate permanently to join family following an environmental disaster and loss of security [15].

After the missionaries arrived, Faith-Based Institutions (FBI) became an important association within the communities in building resilience. According to Robbins [16], 75 per cent of the Pacific population reside in the Melanesian sub-region and 90 per cent are Christian. In the Polynesian and Micronesian sub-regions, the Christian population is approximately 99 per cent. FBIs introduced the provision of health care and education, especially in remote rural areas. They are considered by the indigenous populations in these Pacific communities as an essential part of their traditional support system and welcomed by the governments of these

peoples as partners in development.

In these Pacific nations, the majority live in rural areas (e.g., PNG, Tonga, Samoa, Vanuatu) where there are many isolated communities. In current times, the support provided by the FBIs to build resilience in times of a crisis, e.g., a tsunami, has been invaluable. Governance and leadership within these nations are also best understood in the context of the prevailing cultures of these nations. Structures of power and wealth distribution still strongly reflect traditional practices tied to principles underlying the kinship networks, despite colonization and the introduction of Western systems of governance [14, 17].

Traditional coping strategies still survive in these nations in times of crisis. Mercer et al. [18] refer to SI, where the indigenous people of Tikopia Island would seek shelter on higher ground beneath overhanging rocks to survive a cyclone accompanied by strong gusts of wind. Traditional Polynesian and Melanesian architecture was designed to minimize damage from the collapse of homes. They were constructed of light material and were unlikely to cause death if they collapsed [19]. The Fijian bures built on mounds were able to withstand flooding accompanying storm surges [18, 20]. In addition, these low-budget constructions were within the capacity of the residents to rebuild with the assistance of their kinship network.

Food security, based on traditional diets, included the practice of producing surpluses for transfer from unaffected areas to cyclone-affected areas. The surplus food had special means of storage to protect it from damage from flood or rain. The practice of agricultural diversity, including famine foods, ensured the continuity of their livelihoods in the aftermath of a cyclone or flood damage [20].

3.2 Tropical cyclone activity and fatalities

Although, damage to the built and natural environments from a severe TC can cause economic hardship and psychologically affect the community, a TC's most devastating impact is a high death toll.

Figure 3, with highlighted cells indicating the countries affected, illustrates the incidence of category 4 and category 5 cyclones in the SWP between 2001 and 2018, and the resulting death toll.

Fatalities from a category 3 cyclone, though not considered, could be just as severe or worse as in the case of cyclone Ami referred to previously [8].

Since the new millennium, the highest death toll resulting from a TC was experienced in Fiji. Cyclone Winston in 2016 was psychologically and physically the most traumatic with 44 fatalities [21]. Diamond et al. have reported that Vanuatu, Fiji and New Caledonia have experienced the greatest number of TCs in any season [12].

Countries-->		Melanesia				Polynesia				Micronesia
Year	Name (Category)	Fiji	Vanuatu	SI	PNG	Tonga	Samoa	Tuvalu	NCL	Kiribati
2018	Gita (4)					2				
2018	Hola (4)		1							
2016	Winston (5)	44								
2015	Ula (4)									
2015	Pam (5)		11							
2014	Ian (5)					1				
2012	Evan (4)						12			
2011	Yasi (5)									
2010	Ului (4)			1*						
2010	Tomas (4)	2								
2007	Daman (4)									
2004	Ivy(4)		1							
2003	Erica (5)									
2003	Beni (4)			1*						
2002	Zoe (5)									
2002	Waka (4)									
2001	Paula (4)	1	1							
* Fatalities not confirmed										

Figure 3. SWP region: Severe TCs - 2001 to 2018 [9]

Winston was the first category 5 cyclone experienced by Fijians and the most destructive in approximately 20 years. Systems were in place to issue warnings and instructions despite damage to some stations, however, the path of Winston was erratic and the extent of destruction was a new experience. As a result, the public were not only caught unawares, but also their capacity to comprehend and act was inadequate [21].

In 2015, fatalities from category 5 cyclone Pam in Vanuatu were contained to 11 and considered as remarkable due to various reasons. Fortuitously, the slow pace of the cyclone and the time of day it struck the populous areas of Eromango and Tanna allowed adequate time for preparation and monitoring the path of the cyclone [22].

Early warnings were issued effectively via radio broadcasts and text messages, by the Vanuatu Meteorological and Geo-hazard Department, until the mobile communication infrastructure sustained damage. With no modern shelters built to withstand cyclones of this intensity, warnings in urban areas contained detailed instructions on seeking appropriate shelter in public buildings. Traditionally a 'Nakamal' (or community shelter) was critical in providing refuge during cyclones in villages and is still in use as an emergency shelter and for other community gatherings [23].

Fatalities during a severe TC also depend on the resilience of the community. An example is the experience of Tikopia and Anuta, two small remote islands of SI. Warnings of the approach of Zoe, which developed into a category 5 TC, were received and transmitted in three-hourly time intervals by the

SI Broadcasting Corporation on the 26th of December, with no confirmation received from either Tikopia or Anuta. On the 28th of December, Tikopia was 'under the eye wall cloud' and Anuta was on the edge of the eye wall, judging from satellite images. Outside assistance reached Tikopia on the 5th of January and Anuta on the 7th. Although there was extensive damage on both islands, there were no fatalities, largely attributed to the Islanders' dependence on traditional survival tactics [24].

4. RECENT SUCCESSFUL STRATEGIES

4.1 Strengthening community resilience

In 2012, when category 4 TC Evan made landfall in Samoa, disaster response plans were already in place as the country had experienced a tsunami in 2009. There was a general sense of confidence based on knowledge and understanding of TCs from previous experience.

Despite this, preparedness was generally perceived to be low at community level. It was reported that procedural delays in naming the cyclone and the accuracy of monitoring the cyclone being dependent on the United States, both due to human resource constraints, caused delays in issuing timely warnings [25].

Fourteen fatalities were reported but were mostly unconfirmed due to 10 sailors reported as missing rather than dead. The source for this study, for consistency purposes, is the most recent UNOCHA bulletin on Samoa, which confirmed 12 deaths as a result of cyclone Evan [26].

In Tonga, even though alerts were issued early and continuously when cyclone Ian struck, many residents delayed accessing the evacuation shelters. The Tonga Meteorological Service expressed the need for a traditional approach to connect with communities in a manner readily understood [27].

It is well understood that in building community resilience, preparedness to prevent this seasonal natural hazard progressing to disastrous levels is important. NGOs, which are also an integral part of SWP communities, play a crucial role in building resilience. For example, since 2010, Act for Peace (AFP) has been working together with the Tonga National Council of Churches towards this very goal. Together, they had implemented the Tonga Community Disaster Risk Management program (TCDRM). Through TCDRM, AFP has been able to train communities in Tonga to improve disaster preparedness. When cyclone Gita struck in 2018, although damage was significant in Tonga, there were only two deaths confirmed. It was reported that being involved in TCDRM empowered people to act [28].

Further, Caritas and other well-established NGOs operating in Tonga were able to quickly mobilize emergency supplies to meet water, sanitation and hygiene needs, tarpaulins and other essentials to affected communities from prepositioned storage facilities [29].

4.2 Dealing with poverty and inequality

Although the communal ownership of land provides for food security in Pacific nations [30] and prevents extreme poverty, there are many still engaged in subsistence living, especially in rural areas.

Among the Pacific countries reviewed (excluding New Caledonia, a French Territory), Fiji has the highest GDP per capita and is the most developed, yet poverty and inequality is prevalent in both urban and rural areas [31]. In 2013, the Government introduced the Poverty Benefit Scheme, a social safety net program targeting very poor households [32], to its already existing social protection schemes.

When cyclone Winston struck in 2016, Fiji became the first country in the SWP to utilise its safety net programs to transfer top-up funds targeting the most vulnerable [31]. It was found that such an action assisted recipients of the top-up cash to recover from injury, damage to dwellings, agricultural land, and community infrastructure, far faster than those who did not benefit from this scheme [33]. Tonga, where GDP per capita is second to Fiji, followed suit in the aftermath of cyclone Gita, targeting the elderly and the disabled, two of their most vulnerable groups [34].

Traditionally, Polynesians, especially from Tonga and Samoa, Micronesians from Kiribati and Melanesians from Fiji depend on their extended kinship network for social protection, which includes transfers of cash (international remittances) in times of crisis. However, informal social protection is increasingly being viewed as stretched to the limit, considering the number of problems related to climate change that are faced by these countries in the SWP.

Formal protection is minimal in these countries despite recent efforts by some governments. The scores from a social protection index developed for the Pacific shows that formal social protection is highest for Tuvalu, followed by Fiji and then Tonga and Vanuatu at 0.09. Social protection is almost non-existent in PNG. Samoa, SI and Kiribati were not included in the estimations, however, the general view is that it would be no better in these countries [35]. Thus, cash transfers to the vulnerable as post-disaster relief, by the Fijian and Tongan Governments, is a new and remarkable development [34].

4.3 Identifying resilient infrastructure

In 2016, Caritas, in cooperation with Habitat for Humanity, embarked on a program to build cyclone-resistant housing, where the future owners, together with volunteers, engaged in the construction of their homes. These houses survived cyclone Gita, though much damage to houses was caused elsewhere [29].

In Tongatapu, the mainland, approximately 2000 homes were either destroyed or severely damaged. Almost 80 per cent of homes lost power and the Australian Government provided sufficient electricity generators to supply power to approximately 1000 homes [36].

Another rare occurrence was the support received from the private sector in New Zealand and Australia to repair and rebuild damage to business infrastructure [37].

In Kiribati, a simulation study of future tropical cyclones by the World Bank [38] revealed that although some years will experience no tropical storms, others will reflect the historical pattern of one or more storms, resulting in tremendous damage to important infrastructure caused by storm surges and flooding.

Kiribati is a remote country and has one important road in its densely populated capital, Tarawa. The South Tarawa road connects approximately 50,000 people living near its seaport in the west and its international airport located in the east. This road, given its importance to the population and Kiribati being a resource-poor remote collection of atolls, was in poor condition and was rehabilitated in a 2016 project funded by the World Bank [39] and the ADB. The project has also provided

for its maintenance in the future.

4.4 Coastal relocation

Sea level rise and other climate change related problems are threatening many communities located on low-lying atolls (e.g., Kiribati and Tuvalu) or coastal areas. It appears that the inevitable choice in the long run for some communities is relocation [40].

In Samoa, many communities from the coastal areas of Upolu chose to relocate inland after the tsunami of 2009.

The Samoan Government, with the assistance of international agencies, supported this decision by increasing road access to inland areas of Upolu and strengthening the sea wall infrastructure. This initiative was undertaken after months of consultation within the communities [41].

In Fiji, following cyclone Winston, 46 vulnerable coastal villages were ordered to relocate. However, Tukuraki was the first inland community to relocate. In 2012, nearly 80 per cent of this village was buried in a landslide.

Neighbours stepped in to help those stranded while some families moved closer to town to find employment in order to survive. Some months later, TC Evan and in 2016 TC Winston caused further damage.

The Tukuraki community relocated nearly five years after the first disaster. A government initiative funded by the European Union assisted the community to rebuild. The land for rebuilding was acquired from another clan through negotiation [42].

5. CONCLUSIONS AND RECOMMENDATIONS

The survival of Tikopia and Anuta with no fatalities, despite the devastation caused by cyclone Zoe [24], the coastal residents' decision in Upolu to relocate inland after the 2009 tsunami [41] and the experience of the Tukuraki community [42] are all examples of the resilience of Pacific rural communities. Traditionally, coastal residents relocated to higher ground temporarily if threatened by disaster, or permanently with kinfolk if they lost their land [15]. Especially in rural areas, it appears that communities still resort to traditional survival tactics when facing a threat [18]. This is not surprising considering TCs and other disasters have affected these communities for centuries. In times of trouble, the kinship networks were the safety net [35]. Initially, with globalization and the introduction of the cash economy, FBIs, the NGOs and remittances filled the gap and communities were able to rebuild in the aftermath of a TC. However, with increasing challenges, decreasing remittances and the means for communities to participate in the cash economy, cash-strapped Pacific Governments have no choice other than to depend on international aid. The FBIs and the NGOs still provide support but they too depend on international assistance. In addition, the majority of the SWP communities are rural and engaged in subsistence living. The lack of coping and adaptive capacities identified is based on the lack of means of governments and communities of these nations to participate effectively in the cash economy. In the past, these traditional communities with their communal lifestyles were more equal. Not surprisingly, maintaining a more expensive lifestyle increases inequality and poverty follows. Take for example the built environment of these countries, no longer made of inexpensive traditional material and now are expensive to maintain. Hence, there is an increased dependence (e.g., the South Tarawa road project in Kiribati) on foreign aid for infrastructure development and maintenance [39, 41]. The traditional 'Nakamals' provided shelter to many during cyclone Pam in Vanuatu. Those that were constructed based on western techniques and materials collapsed, while those constructed based on traditional and cheaper methods and techniques, knowledge of which is now under threat of being lost, withstood the storm [19, 20, 23].

Globalization is irreversible but its detrimental impact of increasing the vulnerability of predominantly rural communities can be reversed with action from international aid agencies and governments, both international and domestic. The impact of climate change on smaller atolls and islands too perhaps cannot be reversed, but may be halted with appropriate action from international and domestic governments. If both vulnerability and inequality in these countries are to improve, villagers need to be empowered by returning to traditional methods and techniques. Real life experiences of the traditional lifestyles of these countries may prove to be more lucrative than just showcasing traditional living as a tourist attraction. It would allow predominantly rural communities to reduce their dependence on subsistence living. Governments need to ensure that such invaluable knowledge is preserved. Communities should ensure that their traditional way of community living is nurtured. Decision making within rural communities should be bottom-up. Aid agencies could transfer control and opportunity to decide on infrastructure needs, in consultation with local communities, to domestic governments in this region by setting up future funds for infrastructure development.

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NOMENCLATURE

ADB	Asian Development Bank
AFP	Act for Peace
FBI	faith based insttutions
FRANZ	France Australia New Zealand agreement
GDP	Gross Domestic Product
NCL	New Caledonia
NGO	non governmental organization between New Caledonia and New Zealand
NZ	New Zealand
PDNA	post disaster needs assessment
PIF	Pacific Islands forum
PNG	Papua New Guinea
SI	Solomon Islands
SWP	Southwest Pacific
TC	tropical cyclones
TCDRM	Tonga Community Disaster Risk Management
UNOCHA	UN office for the Coordination of Humanitatian Affairs
WRI	World Risk Report