

“Even if it doesn’t come, you should be prepared”: Natural hazard perception, remoteness, and implications for disaster risk reduction in rural Fiji

Tristan Pearce^{a,b,*}, Renee Currenti^b, Brendan Doran^b, Roy Sidle^c, James Ford^d, Javier Leon^b

^a University of Northern British Columbia, 3333 University Way, Canada

^b Sustainability Research Centre, University of the Sunshine Coast, Australia

^c Mountain Societies Research Institute, University of Central Asia, Tajikistan

^d University of Leeds, UK

1. Introduction

The Fijian islands and similar small island environments are geographically exposed to a suite of natural hazards, including cyclones, floods, droughts, earthquakes, volcanic eruptions, landslides, and tsunamis [1]. These hazards, except droughts, are considered episodic events with rapid onset [2]. Hazards like tropical cyclones and floods have disrupted societal functions and caused widespread human, material, economic, and environmental losses [3]. In recent decades, climate change has exacerbated existing natural hazards resulting in new risks to human livelihoods [4]. These changes are projected to continue, and worsen, in the future [5,6]. Fijians will have to adapt [7], and this is reflected in the Republic of Fiji’s National Adaptation Plan [8], the increasing urgency with which adaptation financing commitments to Fiji and similar small island environments are being considered [9], and the implementation of community-based adaptation projects (e. g. Ref. [10]).

To initiate adaptation actions, decision makers and local peoples need to understand the nature of vulnerability to natural hazards in terms of who and what are vulnerable, to what stresses, in what way, and why, and also what is the capacity to adapt? [11]. This involves working with people in communities to identify the ecosystem attributes that are relevant and important to people, how these attributes are changing and what adaptations are realistic, feasible and desirable. Because most ecosystems are dynamic, disaster risk reduction and adaptation planning needs to be iterative to accommodate change [12]. Community scale disaster risk reduction and climate change adaptation overlap and there is a need to combine efforts to enhance effectiveness and reduce confusion for communities [13]. This article focuses on the human component of disaster, including residents’ perceptions of risk, worldviews and beliefs, and their effectiveness to deal with emerging

risks [14].

Several different communities of people are represented in Fiji’s population structure, one of which are *iTaukei* or Indigenous Fijian villages. *iTaukei* villages are distinct from other non-*iTaukei* rural settlements in many ways including, land ownership, connection to country, familial relationships, village governance, culture, and religion, which influence how people experience and respond to hazards [15,16].

Herein, we examine aspects of disaster risk reduction among *iTaukei* living in Nawairuku village, in the highlands of Ra Province, Fiji. Our examination focuses on how people prepared for, experienced and responded to Tropical Cyclone (TC) Winston in February 2016 and a subsequent major flood event in December 2016. The following sections provide a brief background on Nawairuku village, TC Winston and the extreme flooding event, and the research approach and methods used. We then examine how people prepared for, experienced, and responded to the disasters. The article is distinct from other disasters scholarship in Fiji as it focuses on an inland village, whereas most other research reports on the experiences of peoples living in the coastal zone [3,17,18]. The data presented in this article were collected as part of larger climate change adaptation project in the village [19].

2. Case study

Nawairuku village is in the rural interior of Ra Province, Fiji at an elevation of 51 m (m) and 24 km (km) from the coast (17°38’15.52”S, 178°12’51.66”E) (Fig. 1). Ra Province covers an area of 1340 km² and has one major town, Rakiraki, which is located 43.6 km from the village via Kings Road. The village is situated within a riverine valley between the Tavunikoko and Namolaca mountain ranges surrounded by steep forested and cultivated hills with slopes up to 30° and 230 m in elevation. The village is adjacent to an upper-catchment tributary of the

* Corresponding author. University of Northern British Columbia, 3333 University Way, Canada.

E-mail address: tristan.pearce@unbc.ca (T. Pearce).

Lawaki River which, in turn, is a tributary of the Wainibuka and Rewa Rivers, all within the Rewa Basin. The village population is approximately 320, 100% *iTaukei*, living in 65 households. The population of the village seasonally fluctuates as it is common for men to leave the village for the sugar cane harvest season between June and November. This temporary out-migration affects the demographic of the village and lowers the internal labour force available for routine farm work.

All families rely on farming and small-scale animal husbandry for subsistence and income. Commonly harvested foods include root crops (cassava, *dalo* (taro), *kumala* (sweet potato), *uvi* (yam), *yaqona* (kava plant)), fruits (*niu* (coconut), *jaina* (banana), *meleni* (watermelon), *vudi* (plantain), *uto* (breadfruit), *moli* (mandarin), papaya (pawpaw), and vegetables (*tomata* (tomato), *kiukaba* (cucumber), *baigani* (eggplant), *papukeni* (pumpkin), *bele* (edible greens), *dalo* leaves, *rokete* (chillies) and *kaveti olo* (Chinese cabbage). Cassava, taro, and banana are the main cash crops.

In Nawairuku, traditional *bures* (traditional Fijian homes made of locally sourced natural materials) have been entirely replaced with houses constructed from imported materials like iron roofing and walls, and a mix of raw and treated wood framing timbers. The last bure was built in the village before 2000, it was damaged over time and was not maintained or rebuilt due to lack of knowledge of construction techniques, and the absence of locally sourced materials, which had been replaced by land clearing and cropping. All families in Nawairuku rely on agriculture for subsistence and income.

2.1. Tropical cyclone Winston and extreme flooding

Nawairuku endured two major disasters in 2016. First, TC Winston in February causing damage due to cyclonic winds and flooding; and second, a Tropical Depression (TD04F) causing extensive flood damage.

Both events delivered a high volume of rainfall, but the flood event associated with TD04F resulted in a higher flood peak than during TC Winston.

TC Winston is the first-ever recorded Category 5 cyclone to make landfall in Fiji and the most intense tropical cyclone in the Southern Hemisphere on record [20]. TC Winston crossed the northeast coast of Viti Levu and tracked westward leaving a trail of destruction across the nation, including 44 lives lost, some 131,000 people left homeless and an estimated USD \$1.326b worth of damage and losses [21]. The Fiji Government estimates that 62% of the population (about 540,000 people) were directly affected by TC Winston [22]. TC Winston passed directly over Nawairuku at approximately 2100 on February 20, 2016, severely affecting local agriculture, physical infrastructure, and human health and well-being with ongoing effects some two years later.

Nawairuku also endured a major flood associated with a slow-moving tropical depression approximately 10 months after TC Winston, (Tropical Depression 04F, or TD04F) [23]. Floodwaters rose rapidly on December 17, 2016 at a time when the village was still recovering from TC Winston (i.e. rebuilding homes and re-establishing farmlands), causing widespread damage to infrastructure and cultivated land. People in Nawairuku reported the flooding to be larger and more severe than anyone could remember. While discharge in the upper tributary of the Lawaki River that flows through Nawairuku was not monitored, rainfall data from Nausori (54.6 km away) provide a crude proxy to compare flood conditions between TC Winston and TD04F. Nausori received 147 mm of rain in the 24-h period on 20–21 February 2016 [24], and 226 mm in the 24-h period of 15–16 December 2016 [23]. Both 24-h intervals coincided with the major rainfall periods of the two events; thus, assuming these temporal trends were similar in Nawairuku, these data support the observations that rainfall and consequent flood flows were greater in the December 2016. Floodwaters

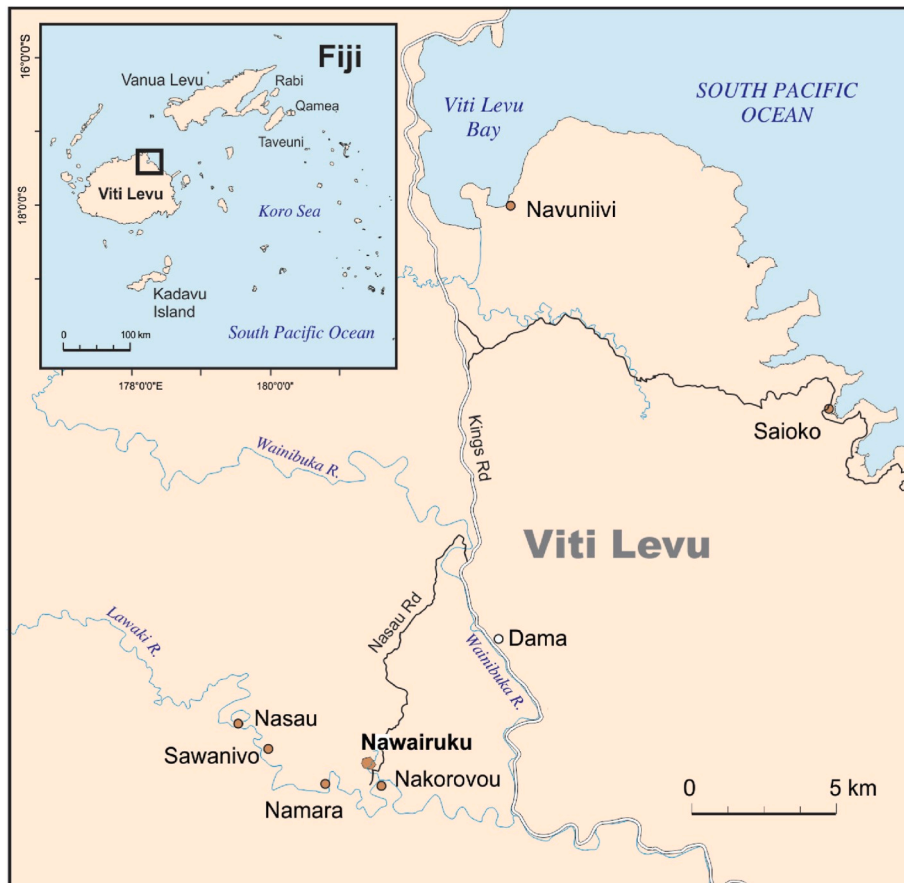


Fig. 1. Location of Nawairuku village in Ra Province, Viti Levu, Fiji [19].

forced businesses in Rakiraki town to close, and the area downstream of Nausori town was threatened by flood waters from the Rewa River, which peaked at more than 4 m [25].

3. Research approach and methods

The research took a grassroots, bottom up approach to data collection that enabled participants to share their knowledge, experience and perspectives on disasters in their own ways without presupposing what conditions were relevant and important to them. This approach is consistent with others working on climate adaptation in the Pacific Islands Region [17,26,48]. Here, vulnerability is conceptualized as a function of *exposure* to biophysical changes, *sensitivity* to these exposures and *adaptive capacity* to deal with exposure-sensitivities [11]. It is thus important to understand the biophysical nature of the disaster as well as the societal conditions that influence how people prepare for, experience and respond to disasters [12].

Data were collected over a 10-week period between June and August 2017 through semi-structured interviews using open-ended questions with 30 participants from 27 households in Nawairuku, participatory observation, and analysis of secondary sources. Participants were recruited using purposive (key informant) and snowball sampling techniques to include: i) male and female participants from different age groups (18+ years); ii) participants from each of the five *matagalis*; iii) participants from households located in different geographic locations within the village (e.g. close to the river, refusing to relocate, recently relocated away from the river); and iv) participants from families with different land tenure - i.e. farmland near the village (approximately 500 m from the village) and those with farmland approximately 5 km away from the village and accessible by foot or horseback. (Table 1).

Interviews were usually held in or outside the participant's house, and conducted as a *talanoa*-style² conversation in the chosen language of the participant (English or Fijian (Ra dialect)). *Talanoa* is a process in which two or more people talk together, or where one person tells a story while the others listen [27]. The interviews conducted in Fijian were translated during the interview and transcripts were later verified by the local research partner, who is university educated and lives in Nawairuku. Interview questions concentrated on participant's experiences with TC Winston and the December flood. We were particularly interested in preparations made before the onset of the events, impacts on lives and livelihoods, and immediate responses and longer-term recovery. Data were analysed following the principles of latent content analysis, which involved identifying recurring or common themes related to the broad categories of interview guide listed above [28]. Complementary data gathered from participant observation and secondary sources of information (e.g. meteorological data, village data) were used to contextualize the information shared in interviews.

4. Results

4.1. Preparing for TC Winston and flooding

There was no central village hazard management plan at the time of TC Winston or flooding in Nawairuku and no one had crop insurance as

Table 1
Demographic characteristics of interview participants.

Age	Male	Female	Total
18–24	1	0	1
25–34	2	4	6
35–44	2	3	5
45–54	2	2	4
55–64	5	2	7
65–74	3	2	5
75+	1	1	2
Total	16	14	30

it was not available at the time of the research. For the most part, households worked individually and made *ad hoc* preparations drawing upon personal experiences with previous tropical cyclones and floods. General methods of preparation for natural hazards described by participants in Nawairuku are documented in Table 3, but very few people implemented these preparations before TC Winston or the flood because of the miscommunication about the tracking of TC Winston and the unanticipated intensity of both hazards. Participants' perception of the approaching TC Winston and TD04F was that these events would be no different to cyclones and heavy rain events experienced in the past. Older participants (>50 years) expected TC Winston to be like past cyclones, such as TC Bebe and Kina (Table 2) and prepared accordingly. Previous radio warnings of cyclones and other extreme weather events, which resulted in no direct impacts, dissuaded people from over-preparing due to a false sense of security. Some participants shared a fatalistic perspective when asked how they prepared for TC Winston and flooding. They downplayed their role in influencing disaster outcomes and shared that they had to accept what was going to happen as being God's plan.

Confusion of how to interpret warnings and the unexpected track of TC Winston also influenced how the village prepared for the cyclone. An initial warning was issued by the Fiji Meteorological Service on February 14, but as TC Winston tracked away from Fiji the warning was cancelled two days later [32,33]. When the cyclone doubled back towards Fiji, warnings were again issued on February 18 and continued until the system passed [34]. When the cyclone warning was cancelled people relaxed and then when the new warning came, people were more complacent and opted to stay put rather than move to safer buildings like the school. General unfamiliarity with meteorological terminology such as 'Category 5', meant that many people were unaware of the intensity of the approaching cyclone and did not prepare for it.

Similar circumstances resulted in minimal preparations being made ahead of the major flood in December 2016. The Fiji Meteorological Service issued a flood alert and a press release relaying information about Tropical Depression 04F (TD04F) on December 14, 2016 [35] but all participants said that no flood warnings were received in Nawairuku. Consequently, people were ill-prepared and caught off guard. Some people moved their belongings to higher ground ahead of time, but many waited until it was too late. As the water levels in the river rose, many people resorted to hope and prayer to try to stop floodwaters from inundating their houses. One participant waited until the water reached a critical level, he thrust a metal rod into the ground in front of the water line and told the water to stop. Coincidentally, the water did not move past the metal rod, leaving him to believe that his actions stopped the flood water from rising.

4.2. Experiencing TC Winston and flooding

No human lives were directly lost in the village due to TC Winston or the flooding, but the disasters had severe impacts on agricultural lands, built infrastructure and human health and well-being. Some of these impacts were inter-linked and severely disrupted peoples' lives and livelihoods. In terms of overall impact, TC Winston caused a lot more damage to infrastructure and agricultural lands than the flood. The flood happened at a time when the village was still recovering from TC Winston and subsequently exacerbated existing stresses.

4.2.1. Impacts on agriculture

Winds up to 300 km h⁻¹, heavy rainfall, and flash flooding associated with TC Winston caused physical damage to agricultural land, including landslides and waterlogging, which destroyed most crops. Participants reported losing entire harvests of *dalo* (taro), cassava, *vudi* (plantain), and the expected income they would have earned by selling the produce.

"Yes, many crops damaged in Winston. One year I didn't get anything from the crops, one year no income. Just stay and try to rebuild

Table 2
Characteristics of notable cyclones identified by participants [29–31].

Cyclone	Date	Category	10-min sustained wind speed (kmh ⁻¹)	1-min sustained wind speed (km h ⁻¹)	No. of fatalities in Fiji	Estimated damages in Fiji (USD)
Bebe	Oct 1972	3	155	205	24	\$10 m
Kina	Dec 1992	3	150	220	26	\$110 m
Winston	Feb 2016	5	280	285	44	\$1.4b

Table 3
Different methods of preparation for natural hazards described by participants in Nawairuku.

Purpose	Method
Protect physical infrastructure	<ul style="list-style-type: none"> • Dismantle <i>bolabolas</i> (temporary structures) • Cover windows with iron sheets • Secure roofs with iron rods or heavy stones • Hang gallon water containers from eaves to secure roof bracing • Trim fruit trees nearby houses
Protect personal belongings	<ul style="list-style-type: none"> • Move household belongings to higher ground
Secure livestock	<ul style="list-style-type: none"> • Untether livestock so they can instinctively seek shelter
Increase food security	<ul style="list-style-type: none"> • Cut cassava stems short to avoid wind damage • Keep an emergency stockpile of non-perishable foods • Plant <i>kumala</i> (sweet potato) in October/November so yield is ready for harvest in cyclone season
Human well-being	<ul style="list-style-type: none"> • Have phone with you to keep updated by warnings • Share warning updates with others • Plan evacuation route and emergency shelter

to restart to earn the living. Replant everything and start planting again because Winston take it away.” (Male participant, Penisimani Rabenawa no. 2, 25 years, July 2017)

Some slopes near the village that had been recently cleared for agriculture failed¹ triggering landslides, something that villagers were not accustomed to seeing.

“I just see how forefathers do things. Before they didn’t plough the land, they only use fork and spade. That’s one thing that is different this time. This time, many places doing the farming have landslides because of spraying the land, because there’s no trees. Big trees were taken away. (Male participant, Epeli Raisevu, 58 years, July 2017)

Some agricultural plots, mostly those located on the slopes near the village, were completely lost in landslides and fertile soil was stripped from the hillside within the landslide scars and runout zone. Loss of agricultural produce resulted in financial hardships for some people. Similarly, during the December 2016 flood, some villagers lost whole plots of agricultural land that were washed away by floodwaters. The fertile, moist soils near the river are an attractive location to plant short-term crops and *dalo*, but plots located within the riparian corridor and near the village drainage systems were particularly exposed to flooding.

4.2.2. Impacts on built infrastructure

Participants described the impact of TC Winston on village infrastructure, including houses, community dwellings, water and power distribution systems, and roads and bridges. One participant shared how his “iron roof was torn away like paper” (Male participant, 58 years, July 2017). Sixty-two of the sixty-five houses in the village sustained damage significant enough to qualify for government funds for rebuilding. The Fiji Government offered vouchers of different values to purchase construction materials. Funds were allocated based on self-assessments of damage to individual houses. Government assessors visited the village to

¹ A slope failure is a phenomenon that a slope collapses abruptly due to weakened self-retainability of the earth under the influence of a rainfall or an earthquake.

confirm the validity of self-assessments and compensation was issued based on the extent of damage. Table 4 gives the breakdown of the three categories of damage and the respective amount of funding received. This dataset was obtained from records kept by the *turaga-ni-koro* (village headman) who recorded the damage to submit claims to authorities for recovery compensation. Many villagers were in the final stages of rebuilding their houses when the floodwaters associated with TD04F arrived further complicating re-building efforts. Layers of mud up to 0.6 m thick in some places carpeted the inside of houses, smothering woven mats, bedding, clothes, and other household belongings.

There is one unsealed road (Nasau Road, 11.7 km) that connects the village to Fiji’s “Ring Road” (Kings Road). The bridge (Savusavu crossing) on Nasau Road was destroyed by flood waters disrupting peoples’ ability to access markets to buy and sell produce. The alternative route to Rakiraki town (markets, services) takes three additional hours and additional transport costs like time and fuel, limiting who can travel. It is notable that after TC Winston, a temporary bridge was constructed at the Savusavu crossing by the Fiji Roads Authority, which was again destroyed by floodwaters associated with Cyclone Josie and Keni both in early April 2018. At the time of writing, construction is underway on a permanent causeway to the value of about USD \$1.3 million [36].

4.3. Effects on human health and well-being

TC Winston and flooding had indirect effects on human health and well-being. Following TC Winston, one participant fell sick and was bedridden for a week with boils rising on her skin due to unsanitary conditions, constantly being wet while cleaning, poor nutritional intake, and lack of clean drinking water. She believed the main reason that she, and other people, got sick was because of the damaged pipes and lack of access to clean drinking water. She further noted that the clean water from the school borehole and the hundreds of fallen coconuts were a blessing for Nawairuku, as sources of some hydration and nutrition.

There was a food shortage following TC Winston due to crop damage. A schoolteacher recalled children from Nawairuku and two other nearby villages bringing no lunch for school or not attending school due to having nothing to eat. Government-supplied rations were delivered by helicopter a month after TC Winston supplying flour, rice, sugar, cooking oil, canned food, and in the meantime, households depended on each other to share whatever food supplies they had on hand.

The disasters affected people’s mental health. A female participant recalled her psychological struggle to comprehend and deal with the onset of another disaster, flooding, threatening to damage her house

Table 4
House damage by TC Winston and “Help for Homes” recovery funds received.

Category of damage	Number of households	Recovery funds per house (FJD\$)	Total (FJD\$)
“Fully destroyed”	42	7000 (USD\$3256)	294,000 (USD \$136,744)
“Full roof damage”	9	3000 (USD\$1395)	27,000 (USD \$12,558)
“Partial roof damage”	11	1500 (USD\$698)	16,500 (USD \$7674)
Total	62		337,500 (USD \$156,977)

Note: FJD\$2.15 = USD\$1.00 (August 01, 2019).

after recovering from TC Winston.

“Kini just got all the boys to take all the stuff up. The clothes, like that, Jo’s suitcase. Some other things. I don’t want to go and take anything up. Like I’m growling or what? I was thinking of the cleaning up, it’s very hard. Only Kini and the boys take the things, I don’t want to, I just sit here and look at them. Big job, big job.” (Female participant, Viniana Salabogi, 52 years, July 2017)

An elderly man suffered a stroke the day after the flood when visiting his house and seeing the intense damage throughout. He sadly passed away in April 2017, two months after his first stroke.

4.4. Responding to TC Winston and flooding

The post-disaster response and recovery effort involved months of rebuilding houses and re-establishing farmland. Immediate responses to TC Winston included clearing and burning vegetation and salvaging damaged construction materials to rebuild temporary housing (*bolabolas*). Villagers cleared mud and debris from Nasau Road to improve access for when help would eventually arrive, undertook repairs on the water reservoir and distribution pipes to restore access to drinking water, and cleaned household goods such as floor mats and bedding that were wet during the storm. Activity commenced the morning after the disaster and was continuing at the time of this research, 18 months after the event. TC Winston struck on a Saturday night and the following day, Sunday, was a religious day of rest, but villagers continued to work and instead sought God’s forgiveness.

Recovery efforts involved internal village labour and external financial and material support. External assistance was provided, including by CARE Australia (water, sanitation and hygiene (WASH) kits and shelter kits), Australian Defence Force (food rations dropped by helicopters), Habitat for Humanity Fiji (‘Build Back Safer’ awareness session), and the People’s Republic of China (temporary housing tents). As part of the Fiji Government’s coordinated plan to rebuild from TC Winston, the *Help for Homes* initiative was designed to assist people rebuild damaged homes and make them more resilient to future cyclones through improved design and building materials. Sixty-two households applied for and were issued electronic cards that could be used at selected hardware retailers to purchase materials to rebuild. The amount of funding was based on the extent of damage (Table 4). However, in some instances, households waited up to 18 months to receive building materials and reconstruction was further delayed by the fact that there were only two skilled carpenters available to work in the village. For some households, the amount of funding received was not enough to rebuild their house or use newly learned skills to improve structural integrity. As a result, these people had to rebuild their house the same way it had been built previously, and some opted to purchase roofing iron and a chainsaw with the funds and venture into nearby forests to collect fallen logs and mill their own lumber instead of buying lumber. Participants acknowledged, however, that self-milled lumber would not match the longevity of purchased treated pine timber, potentially rotting and needing replacement sooner. The use of more robust building materials such as concrete in housing designs was ruled out by high prices and transportation costs.

Despite financial challenges, some participants acknowledged the need to increase the resilience of their houses to disasters. Several people rebuilt their houses on higher ground, positioned them to avoid wind tunnels, and constructed houses with the narrow side of the house facing windward to reduce wind resistance. Having seen the ability of strong winds to peel iron roofing away from rafters, carpenters purchased and installed as many tie-downs and bracing rods as possible to reduce lift in future events.

Some participants chose not to relocate their houses to lower risk areas, even though they acknowledged the risk of doing so, for personal reasons. One participant explained that although he knew that his house

was in a high-risk area and was significantly damaged by TC Winston and the flood, he did not want to relocate because his house had access to running water. If he were to relocate to a lower risk area, he would have to travel to a communal water tap, something he was not willing to do. Other participants were resistant to relocating their houses to lower risk areas because of familial ties and wanting to remain co-located with family.

5. Discussion

We noted earlier that other disaster risks reduction scholarship in Fiji has mostly focused on the experiences of peoples living in the coastal zone. We cannot directly compare the experiences of people living in the coastal zone with those in Nawairuku, but our data suggest some important conditions in interior villages that are relevant for disaster risk reduction. The findings are specific to Nawairuku. Every village is different and this underlines the importance of conducting disaster risk reduction and climate change adaptation at the village scale.

The finding that there were limited preparations made in response to disaster warnings shows that there is room for improvement on the disaster communication front. It is vital that accurate weather information is communicated in locally relevant ways, including terminology and modes of communication, to ensure that people take warnings seriously and act accordingly. Preparation is key to surviving a disaster and minimising damage, and adequate and accurate information is essential to cue preparation. “*Even if it doesn’t come, you should be prepared*” was the attitude adopted by some Nawairuku villagers after learning from the mistake of being underprepared for TC Winston (Male participant, Epeli Raisevu, 58 years, July 2017). This finding supports Ellis et al. [37] and the notion that “experience is a central factor in motivation, and the more recent the experience the better” (2004, p. 42). Becker et al. [38] note that people who have directly experienced a disaster can recall information better, which they can in turn use to inform future decisions for disaster preparedness. Given that prior to TC Winston the most relatable experience was Cyclone Kina in 1992, few people would have had vivid recollection of the associated impacts. The fresh memory of the extensive damage inflicted by TC Winston and the flood has encouraged people, for the time being, to think proactively and implement some disaster risk reduction measures with government support. The question remains as to how long this ‘fresh memory’ of disaster will remain? In social-ecological systems where shocks like cyclones or floods are not frequently experienced, and even in some cases where they are, the benefits of building resilience into the system, like climate proofing houses, may be undervalued [39]. Learning and local knowledge can also be lost over time [40].

However, Mills et al. [41] and Martin et al. [42] found that in addition to previous experience with disasters, other personal factors such as worldviews, beliefs and government policies were also highly influential in disaster preparedness and recovery. Most people in Nawairuku shared a fatalistic viewpoint on TC Winston and flooding and resigned themselves to God’s will. In taking this perspective, people neglected to consider the episodic nature of natural events and failed to proactively plan for TC Winston or flooding because they felt that they had no control over them. Participants interpreted TC Winston as a fluke event indicative of bad luck, no other tropical cyclone has been that strong, and participants were wary to suggest that a tropical cyclone of that magnitude could happen again as it was up to God to determine what the future holds. Here, a strong belief in God’s role in natural disasters could hamper future efforts for disaster risk reduction. On the other hand, in Nawairuku, religion aided disaster recovery by bringing people together to rebuild. People’s faith fostered a communal spirit of helping each other and leaving no one behind [3].

The finding that people in Nawairuku initiated disaster recovery actions immediately after the events is noteworthy. Villagers did not wait for external assistance to start recovery work, which reflects their do-it-yourself mentality and the role of strong leaders in the village. Due

to their remote location, villagers are accustomed to doing things themselves as external assistance is often slow to reach them, if at all [19]. That said, the research shows that people in Nawairuku are not short of initiative but they often lack the necessary financial and material resources to construct houses that are more resilient to cyclones and floods.

The finding that rebuilding efforts included the reconstruction of houses like those that were destroyed, suggests that some village infrastructure remains susceptible to harm from future natural hazards, especially those houses rebuilt in high-risk locations such as near the river. While some people are incorporating more bracing in the design of new houses, the typical iron-walled, iron-roofed structures with pine bracing are still vulnerable to cyclonic winds. Lack of essential resources like building supplies, knowledge, expertise, building codes (enforced) and financial capital confine people to building what they know [43]. In Nawairuku, there being only two skilled carpenters, and one less active than the other, limited the pace of housing reconstruction. The demand on these individuals constrained their abilities to re-establish their farms and tend to their own household reconstruction needs. Lack of financial support has also prevented people from rebuilding their houses to disaster-resilient standards [44]. If another high category cyclone hits Nawairuku, the chances of which will be increased with climate change [5,45], the village will be faced with the same structural inadequacies. Building designs must be climate-proofed for longevity and constraints overcome to promote resilient housing standards [22].

Climate-proofing infrastructure could involve returning to some traditional construction methods, which has not happened to date in Nawairuku. The traditional one-roomed, thatched roof, earth floor *bure* proved its ability to withstand the elements of extreme weather events, such as high velocity winds and heavy rainfall [46]. Traditional *bures* were entirely replaced with contemporary houses constructed from newly introduced materials (iron roofing and walls, treated pine framing timbers) in the latter half of the 20th century [46]. This transition saw the loss of *bures* and with it, the comfortable and climate-resilient designs. While it may not be feasible or desirable for all buildings to be constructed as *bures*, because of access to building materials, changing motivations, preference, and absence of knowledgeable *bure*-building teachers, some traditional building techniques could be used in modern construction. Furthermore, construction of storm water drains in the village could help alleviate uncontrolled runoff and erosion.

In Nawairuku, generations of exposure to natural hazards should provide the population with a knowledge platform for effective decision-making. However, in the wake of TC Winston and subsequent flooding, it is apparent that previous knowledge is not always useful when a larger event strikes if people are accustomed to smaller events [2]. Similarly, existing knowledge of climate risks may be insufficient to deal with the types and scales of risks that are yet to be experienced [47]. Participants explained that because of their lack of preparation for TC Winston and the consequential damage sustained, the village is more likely to prepare better for future cyclones. It was noted that several weeks after TC Winston, a warning was issued for another cyclone and villagers were far more responsive than before, indicating that some degree of social learning had taken place.

6. Conclusions

We examined how people living in Nawairuku village prepared for, experienced, and responded to TC Winston and a major flood event. The findings of this research provide insights into how natural hazards are experienced and responded to by people living in an interior village in Fiji and raise questions about the ability of current disaster risk reduction efforts to cope with expected future hazards. First, level of preparation affects the amount of damage sustained by disasters. Early and ongoing preparations are vital to ensure the best chances for survival and reduced harm. Accurate and timely information about natural hazards is needed and must be communicated in accessible ways to cue

preparation. Second, the speed of onset and intensity of natural hazards like TC Winston and flooding, challenge local knowledge of weather forecasting. Local knowledge systems will have to adapt to accommodate changing conditions. Third, local perceptions of risk, worldviews and beliefs influence the ways in which people respond to warnings and prepare for disaster impacts. People's understated perception of risk from TC Winston and fatalistic perspective contributed to inadequate preparation for its impact. Fourth, while experience with past disasters can contribute to resilience, people's historic knowledge of, and familiarity with, less-severe events can contribute to some degree of complacency in the face of new hazards. Finally, re-building homes in safer areas (i.e. away from flood plains) and climate-proofing housing drawing upon modern and traditional construction methods, and supported by local initiative and external finance is needed to lessen the impact of future disasters. Our findings reinforce the importance of scale in disaster risk reduction and the need to understand the local governance structure, belief system and priorities of villagers to design interventions that are relevant and effective. Efforts that do not account for these important local characteristics tend to be less effective and could be maladaptive in the longer term. Taken together, these findings provide the basis for a renewed conversation on disaster risk reduction in Fiji and similar island environments under changing climatic conditions.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Acknowledgements

Vinaka vakalevu to the people of Nawairuku for their generous hospitality and to those who shared their knowledge and experiences that are the heart of this paper. Due acknowledgement is given to Kiniviliame Salabogi, Teresia Salabogi, Luke Vuli and Roger Kitson for research assistance and intellectual contributions. Thank you, Lui Manuel, Nadroga-Navosa Provincial Council, Jeremy Hills, University of South Pacific, Suva campus, and Teresa Rietberg for your partnership and in-country support. Thank you, Marie Puddister, University of Guelph for Fig. 1. The research was made possible through financial support from: Research Fellowship Grant, University of the Sunshine Coast, Australia; Graduate Research Scholarship, Australian Government Research Training Program, Australia; and Canada Research Chairs Program, University of Northern British Columbia, Canada.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2020.101591>.

References

- [1] J. Campbell, An overview of natural hazard planning in the Pacific island region, *Australas. J. Disaster Trauma Stud.* 1 (2010) 1–9.
- [2] R.C. Sidle, J. Gallina, T. Gomi, The continuum of chronic to episodic natural hazards: implications and strategies for community and landscape planning, *Landsc. Urban Plann.* 167 (2017) 189–197.
- [3] E. Nolet, "Are you prepared?" Representations and management of floods in Lomanikoro, Rewa' (Fiji), *Disasters* 40 (2016) 720–739.
- [4] J. Gallina, R.C. Sidle, Natural hazards and cumulative climate change: likely impacts on coastal environments on the Sunshine Coast, Queensland, Aust. *J. Emerg. Manag.* 33 (3) (2018) 30–37.
- [5] L.A. Nurse, R.F. McLean, J. Agard, L.P. Briguglio, V. Duvat-Magnan, N. Pelesikoti, E. Tompkins, A. Webb, Small islands in, in: C. Field, V. Barros, D. Dokken, K. Mach, M. Mastrandrea, T. Bilir, M. Chatterjee, K. Ebi, Y. Estrada, R. Genova, B. Girma, E. Kissel, A. Levy, S. MacCracken, P. Mastrandrea, L. White (Eds.), *Small Islands in: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, USA, 2014, pp. 1613–1654.
- [6] Pacific Climate Change Science Program (PCCSP), Current and future climate of the Fiji Islands, in: *International Climate Change Adaptation Initiative*. Fiji

- Meteorological Service, Australian Bureau of Meteorology and Commonwealth Scientific and Industrial Research Organisation (CSIRO), 2011, pp. 1–8.
- [7] H. de Coninck, A. Revi, M. Babiker, P. Bertoldi, M. Buckeridge, A. Cartwright, W. Dong, J. Ford, et al., Chapter 4: strengthening and implementing the global response, 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*, Intergovernmental Panel on Climate Change, 2018.
- [8] Government of the Republic of Fiji, Republic of Fiji National Adaptation Plan: a Pathway towards Climate Resilience, Government of Fiji, Suva, Fiji, 2018, p. 124.
- [9] S.A. Robinson, M. Dornan, International financing for climate change adaptation in small island developing states, *Reg. Environ. Change* 17 (4) (2017) 1103–1115.
- [10] Patrina Dumarua, Community-based adaptation: enhancing community adaptive capacity in Druadrua Island, Fiji, *Wiley Interdiscipl. Rev.: Clim. Change* 1 (5) (2010) 751–763.
- [11] B. Smit, J. Wandel, Adaptation, adaptive capacity and vulnerability, *Global Environ. Change* 16 (2006) 282–292.
- [12] R.C. Sidle, W.H. Benson, J.F. Carriger, T. Kamai, Broader perspective on ecosystem sustainability: consequences for decision making, *Proc. Natl. Acad. Sci. U.S.A.* 110 (23) (2013) 9201–9208, <https://doi.org/10.1073/pnas.1302328110>.
- [13] A. Gero, K. Méheux, D. Dominey-Howes, Integrating disaster risk reduction and climate change adaptation in the Pacific, *Clim. Dev.* 3 (4) (2011) 310–327.
- [14] S.M. Fletcher, J. Thiessen, A. Gero, M. Rumsey, N. Kuruppu, J. Willetts, Traditional coping strategies and disaster response: examples from the South Pacific region, *J. Environ. Public Health* 2013 (2013), <https://doi.org/10.1155/2013/264503>.
- [15] P. Brown, A. Daigneault, D. Gawith, Climate change and the economic impacts of flooding on Fiji, *Clim. Dev.* 9 (6) (2017) 493–504.
- [16] J. Cox, G. Finau, R. Kant, J. Tarai, J. Titifanue, Disaster, divine judgement, and original sin: christian interpretations of tropical cyclone Winston and climate change in Fiji, *Contemp. Pac.* 30 (2) (2018) 380–411.
- [17] S. McCubbin, B. Smit, T. Pearce, Where does climate fit? Vulnerability to climate change in the context of multiple stressors in Funafuti, Tuvalu, *Global Environ. Change* 30 (2015) 43–55.
- [18] R.A. Walshe, P.D. Nunn, Integration of indigenous knowledge and disaster risk reduction: a case study from Baie Martelli, Pentecost Island, Vanuatu, *Int. J. Disaster Risk Sci.* 3 (4) (2012) 185–194.
- [19] R. Currenti, T. Pearce, T. Salabogi, L. Vuli, K. Salabogi, B. Doran, R. Kitson, J. Ford, Adaptation to climate change in an interior pacific island village: a case study of Nawairuku, Ra, Fiji, *Hum. Ecol.* 47 (2019) 65–80.
- [20] T. Di Liberto, Tropical Cyclone Winston Causes Devastation in Fiji, a Tropical Paradise, National Oceanic and Atmospheric Administration, Washington D.C., USA, 2016. <https://www.climate.gov/news-features/event-tracker/tropical-cyclone-winston-causes-devastation-fiji-tropical-paradise>.
- [21] Government of Fiji, Fiji Post-Disaster Needs Assessment, Tropical Cyclone Winston, Suva, Fiji, 2016. February 20, 2016. Government of Fiji.
- [22] M. Miyaji, A. Fujieda, S. Waqalevu, H. Kobayashi, Challenges for self-recovery from cyclone disasters in a traditional Fijian village: the case of Navala village after Tropical Cyclone Winston, *Disaster Manag. Hum. Health Risk V: Red. Risk, Improv. Outcomes* 173 (2017) 161–172.
- [23] ReliefWeb, *Tropical Depression TD04F - Dec 2016*, ReliefWeb, 2016. <https://reliefweb.int/disaster/tc-2016-000132-fji>. (Accessed 10 August 2019).
- [24] R. Davies, Fiji – Tropical Cyclone Winston Causes Destruction and Floods – 21 Reported Dead, Floodlist, Neutrebbin, Germany, 2016. <http://floodlist.com/australia/fiji-floods-winds-tropical-cyclone-winston>. (Accessed 10 August 2019).
- [25] Pacific Beat, Fiji Floods: Days of Torrential Rain Cause Severe Flooding and Landslides, with More Rain Forecast, ABC News, Suva, Fiji, 2016. <https://www.abc.net.au/news/2016-12-19/days-of-torrential-rain-causes-severe-flooding-in-par-ts-of-fiji/8131844>. (Accessed 10 August 2019).
- [26] T. Pearce, R. Currenti, A. Mateiwai, B. Doran, Adaptation to climate change and freshwater resources in Vusama village, Viti Levu, Fiji, *Reg. Environ. Change* 18 (2) (2018) 501–510.
- [27] U. Nabobo-Baba, *Knowing and Learning: an Indigenous Fijian Approach*, Institute of Pacific Studies, University of the South Pacific, Suva, Fiji, 2006.
- [28] H.R. Bernard, *Social Research Methods: Qualitative and Quantitative Approaches*, SAGE Publications, Thousand Oaks, California, 2012.
- [29] R. Krishna, Publication No. 2: Tropical Cyclones in Fiji: November 1969 – April 1980, Fiji Meteorological Service, Suva, Fiji, 1981.
- [30] R. Prasad, Tropical Cyclone Kina, December 26, 1992 – January 5, 1993 (Tropical Cyclone Report 92/1), Fiji Meteorological Service, Suva, Fiji, 1993.
- [31] Y. Kuleshov, B. Prakash, T. Atalifo, A. Waqaicelua, S. Seuseu, M. Ausetalia Titimaea, Impacts of tropical cyclones on Fiji and Samoa, in: *EGU General Assembly Conference Abstracts*, vol. 15, 2013.
- [32] Fiji Meteorological Service, Special Weather Bulletin Number One for Fiji on Severe Tropical Cyclone Winston, Fiji Meteorological Service, Nadi, Fiji, 2016.
- [33] Fiji Meteorological Service, Special Weather Bulletin Number Fifteen for Fiji on Severe Tropical Cyclone Winston, Fiji Meteorological Service, Nadi, Fiji, 2016.
- [34] Fiji Meteorological Service, Special Weather Bulletin Number Sixteen for Fiji on Severe Tropical Cyclone Winston, Fiji Meteorological Service, Nadi, Fiji, 2016.
- [35] Government of Fiji, Tropical Depression 04F Remains Slow Moving and Gradually Intensifying, in: December 14 2016, Media Centre, Press Releases, Government of Fiji, Suva, Fiji, 2016.
- [36] Fiji Roads Authority, How the 2018-2019 Budget Allocation for Fiji Roads Authority Will Be Spent, 2018. Retrieved from Suva, Fiji: <http://www.fijiroads.org/wp-content/uploads/2018/07/2018-2019-National-Budget-FRA-Leaflet.pdf>.
- [37] S. Ellis, P. Kanowski, R. Whelan, National Inquiry on Bushfire Mitigation and Management, Commonwealth of Australia, Canberra, Australia, 2004. https://www.dfes.wa.gov.au/publications/GeneralReports/FESA_Report_-_NationalInquiryonBushfireMitigationandManagement.pdf. (Accessed 10 August 2018).
- [38] J.S. Becker, D. Paton, D.M. Johnston, K.R. Ronan, J. McClure, The role of prior experience in informing and motivating earthquake preparedness, *Int. J. Disaster Risk Redu.* 22 (2017) 179–193.
- [39] S. Whitfield, E. Beauchamp, D.S. Boyd, D. Burslem, A. Byg, F. Colledge, M.E. J. Cutler, M. Didenia, A. Dougill, G. Foody, J.A. Godbold, M. Hazenbosch, M. Hiron, C.I. Speranza, E. Jew, C. Lacambra, D. Mkwambisi, A. Moges, A. Morel, R. Morris, P. Novo, M. Rueda, H. Smith, M. Solan, T. Spencer, A. Thornton, J. Touza, P.C.L. White, Exploring temporality in socio-ecological resilience through experiences of the 2015–16 El Niño across the Tropics, *Global Environ. Change* 55 (2019) 1–14.
- [40] Reyes-García, M. Guèze, A.C. Luz, J. Paneque-Gálvez, M.J. Macía, M. Orta-Martínez, J. Pino, X. Rubio-Campillo, Evidence of traditional knowledge loss among a contemporary indigenous society, *Evol. Hum. Behav.* 34 (2013) 249–257.
- [41] M. Mills, K. Mutafoglu, V.M. Adams, C. Archibald, J. Bell, J.X. Leon, Perceived and projected flood risk and adaptation in coastal Southeast Queensland, Australia, *Climatic Change* 136 (3–4) (2016) 523–537.
- [42] P.C.M. Martin, P. Nunn, J. Leon, N. Tindale, Responding to multiple climate-linked stressors in a remote island context: the example of Yadua Island, Fiji, *Climate Risk Manag.* 21 (2018) 7–15, <https://doi.org/10.1016/j.crm.2018.04.003>.
- [43] D.H. Aquino, S.J. Wilkinson, G. Raftery, R. Potangaroa, Building back towards storm-resilient housing: lessons from Fiji's Cyclone Winston experience, *Int. J. Disaster Risk Redu.* 3 (2019) 475–480.
- [44] A.D. Magee, D.C. Verdon-Kidd, A.S. Kiem, S.A. Royle, Tropical cyclone perceptions, impacts and adaptation in the Southwest Pacific: an urban perspective from Fiji, Vanuatu and Tonga, *Nat. Hazards Earth Syst. Sci.* 16 (5) (2016) 1091–1105.
- [45] D.L. Hartmann, A.M. Klein Tank, M. Rusticucci, L.V. Alexander, S. Brönnimann, Y. A.R. Charabi, F.J. Dentener, E.J. Dlugokencky, D.R. Easterling, A. Kaplan, B. J. Soden, P.W. Thorne, M. Wild, P. Zhai, Observations: atmosphere and surface, in: J. Hurrell, J. Marengo, F. Tangang, P. Viterbo (Eds.), *Climate Change 2013: the Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, UK and New York, NY, 2013, pp. 159–254.
- [46] A. Fujieda, H. Kobayashi, The potential of Fijian traditional housing to cope with natural disasters in rural Fiji, *J. Disaster Res.* 8 (1) (2013) 1–10.
- [47] J. Mercer, I. Kelman, L. Taranis, S. Suchet-Pearson, Framework for integrating indigenous and scientific knowledge for disaster risk reduction, *Disasters* 34 (1) (2010) 214–239.
- [48] T. Pearce, R. Currenti, A. Mateiwai, B. Doran, Adaptation to climate change and freshwater resources in Vusama Village, Viti Levu, Fiji, *Reg. Environ. Change* 18 (2) (2018) 501–510.