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Traditional warning signs of cyclones on remote islands in Fiji and Tonga

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Traditional knowledge of disasters has been found to save lives. On remote islands where telecommunications to the mainland are unreliable, unless there are always working batteries in the radio, signs from the environment may be the only warning of an oncoming cyclone. But this knowledge is in danger of being lost, as it is an oral history not well documented, and younger people increasingly rely on technology. This article presents the results of fieldwork on remote islands in Fiji and Tonga in the South Pacific, documenting natural warning signs on islands in two different countries. The results show that there are numerous known signs, with remarkable similarities and consistencies between the two islands. This provides evidence that not only is traditional knowledge of warning signs for cyclones alive and well, the consistency in the signs suggests support for this knowledge as being just as important as western scientific knowledge. The integration of traditional knowledge and western scientific knowledge into a comprehensive warning system may help to overcome some of the limitations of the existing system and the reasons why warnings are sometimes ignored.

Keywords: cyclone; disaster warning; natural signs; traditional knowledge; Pacific; remote islands

1. Introduction

The best chance a person has of being safe during a disaster is to know that it is coming – well positioned and managed evacuation facilities will be empty if no one has time to reach them. The importance of early warning systems for disasters is clear. How to translate that need into efficient and effective systems is not always so clear. An early warning system is:

The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss... A people-centred early warning system necessarily comprises four key elements: knowledge of the risks; monitoring, analysis and forecasting of the hazards; communication or dissemination of alerts and warnings; and local capabilities to respond to the warnings received. (United Nations International Strategy for Disaster Reduction [UNISDR], 2009)

A system will be less effective when one of these elements is weak or absent.

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The socio-psychological steps involved in responding to warnings are hearing, understanding, personalising the risk, and the decision to respond (Paul & Routray, 2013). Some of the reasons why warnings are ineffective or people do not respond in a timely way are economic factors, lack of understanding, experience that official warnings are not always reliable, inconsistencies in the warnings, and warnings coming from a single source only (Howell, 2003; Ronan & Johnston, 2005). Cyclones in particular are unpredictable in their behaviour, and so official warnings are often considered unreliable (Veland, Howitt, & Dominey-Howes, 2010). People need to trust in the warnings and in the need to act upon those warnings. It has been found that communities with good traditional knowledge and oral histories of previous disasters are more likely than others to survive disasters (Arunotai, 2008; Mercer, Dominey-Howes, Kelman, & Lloyd 2007;).

Traditional or Indigenous knowledge is a:

body of information passed down through generations in a given locality and acquired through the accumulation of experiences, relationships with the surrounding environment, and traditional community rituals, practices and institutions. (Kelman, Mercer, & Gaillard, 2012, p. 13)

This type of knowledge is often overlooked and undervalued as not being ‘scientific’, but rather inaccessible and different or difficult to deal with (Mercer et al., 2007). However, natural warning signs are understood locally by people who may feel alienated from the scientific system, and give good lead times for preparation (Howell, 2003). Traditional knowledge has been found to significantly enhance the ability to understand and interpret warning information (Sharma, Patwardhan, & Patt, 2013). The usage of traditional knowledge leads to practical strategies that are accepted by local cultures and are therefore more likely to be sustained (Hodgson, 2010). The incorporation of traditional knowledge into warning systems has been recommended to increase perceptions of reliability and hopefully thus increasing responses (Howell, 2003; Paul & Routray, 2013).

The ways in which this local knowledge combines with external knowledge and improvised responses in the Pacific have been noted (Lauer, 2012). The need for documenting traditional knowledge and integrating it with more scientific understandings has been recognised by both Governments in the South Pacific and researchers in this field (Mercer, Kelman, Taranis & Suchet-Pearson, 2010; Vanuatu, 2006). The documentation and use of traditional knowledge is specifically mentioned relevant regional frameworks including the Pacific Islands Framework for Action on Climate Change (2006–2015) (South Pacific Regional Environment Programme, 2011) and the Hyogo Framework for Action on Disaster Risk Reduction (2005–2015) (UNISDR, 2005). The Pacific Disaster Risk Reduction and Disaster Management Framework for Action 2005–2015 lists as one of the expected outcomes by 2015 having traditional knowledge incorporated into effective disaster warnings, alongside technology (SOPAC, 2005).

The 2011 Fiji national report regarding progress against the Hyogo framework underscored difficulties in achieving goals such as this, noting the:

need to document and share traditional knowledge on early warning systems and disaster preparedness, and to look at the relevance and applicability of this to the changing hazard characteristics. Preserving and transferring local knowledge from older to younger generations is a major challenge. (National Disaster Management Office, Fiji [NDMO], 2011, p. 16)

While there have been studies looking at how to integrate traditional and western scientific knowledges (e.g. Cronin et al., 2004; Hodgson, 2010; Kelman et al., 2012; Mercer et al., 2010), there are few studies concentrating on actually documenting the traditional knowledge on weather forecasting and early warning signs of cyclones. Some have been done in Bangladesh

(Howell, 2003; Paul & Routray, 2013), Samoa (although about weather forecasting generally Lefale, 2010), Vanuatu (concentrating on one tsunami event, Walshe & Nunn, 2012), and the Cook Islands (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2011). Fewer still, are studies seeking to validate natural warning signs by looking at the statistical links between them and actual events. One is also currently underway in Vanuatu to validate traditional weather forecasting against scientific forecasting, following a successful pilot in 2012 (<http://www.nab.vu/vanuatu's-traditional-knowledge-use-climate-forecasting-and-adaptation>). More work has been done in this field in relation to earthquakes both in documenting signs and validation (e.g. Grant & Conlan, 2013; Tributsch, 1982; Yong et al., 1988).

This study seeks to add to this growing knowledge base, by documenting traditional warning signs of cyclones on two remote islands in the South Pacific, one in Fiji and one in Tonga. The study will not only provide evidence from two more locations, but also note similarities in traditional warning signs of cyclones in two different countries.

2. The islands in the study

Fiji is an independent country of less than one million people, at 18°00'S latitude and 175°00'E longitude in the Melanesian area of the South Pacific. The more than 320 islands that make up Fiji cover a land mass of over 18,000 km², and are a mixture of mountainous and volcanic terrain. The largest 2 islands, Viti Levu and Vanua Levu, are inhabited, along with about 100 of the smaller islands, leaving a population density of about 46 people per km².

Tonga is a small Kingdom in the Polynesian area of the South Pacific, at 21°12'S latitude and 175°12'W longitude, with a population of just over 100,000 people. There are 172 named islands in Tonga of which 36 are inhabited, making up an area of 649 km². The islands are clustered – Tongatapu and 'Eua in the South, Ha'apai in the middle, Vava'u in the north and Niuafo'ou and Niuva Toputapu in the far north (National Emergency Management Office, Tonga, 2010). About half the population lives on the main island, Tongatapu, and 25% of the population live in urban areas (World Bank, 2011). All the atoll islands, including the main island are flat with an average altitude of 2–5 m, while Vava'u, Ha'api and the Niuaas, which together represent about one quarter of the population, also have some high volcanic islands. Even with the smaller population, the small land mass area of inhabited islands in Tonga results in a far higher population density than in Fiji, at 144 per km².

The South Pacific is one of the most vulnerable regions in the world due to a range of factors including the geographical location and socio-economic factors resulting in a high likelihood of extreme events becoming disasters (e.g. poverty, high dependence on agriculture and traditional subsistence farming, developing nations, population increase, migration within countries to peri-urban areas and places at high risk from extreme weather). There are 3 South Pacific countries among the World Bank's list of the top 12 countries worldwide in terms of vulnerability to storms (Samoa 8th, Tonga 9th and Fiji 12th) (World Bank, 2009). About 11% of the world's total of around 80 cyclones annually form in the South Pacific region (Terry, 2007). The average number of cyclones per year in this region from 1970 to 2006 was 9, with 27% occurring in the month of February (Terry, 2007). It has been estimated that 13,000 people are at risk of being displaced because of disasters in the South Pacific each year, including 1716 in Tonga (from storms/cyclones) and 4604 in Fiji (from storms/cyclones and flooding) (Lavell & Ginnett, 2014).

Fieldwork was conducted for four weeks on Druadrua island in Fiji during 2012, and four weeks on 'Uiha Island in Tonga during 2013. A follow-up visit was conducted to both islands in May–June 2014. These islands are located far from the capital cities of their respective countries. Druadrua is in the Northern Division of Fiji, and has a population of about 200

people. 'Uiha Island is in the Ha'apai region of Tonga, with a population of around 500 people. Each is 2–3 hours by boat from the nearest regional centre, making them remote or outer islands within remote island countries.

Both islands had experienced numerous cyclones of varying strengths. The most recent severe cyclones in Druadrua were Ami in 2003 and Tomas in 2010. For 'Uiha Island, the most recent and most destructive cyclone experienced was Ian in January 2014.

The results presented here form part of a larger study on disaster response and adaptation to climate change on remote islands. In each country, interviews were conducted with community members on the islands, and representatives from aid organisations and government departments responsible for disaster response. For more details on the Fijian aspect of the larger study, see Johnston (2014). This article focuses on responses from community members to some of the preliminary questions from the interviews, regarding how they know if a cyclone is coming, details of any natural warning signs they know of, and which signs they consider to be the most reliable. It was beyond the scope of this study to test the validity and reliability of the signs, and no attempt is made here to do so. Nevertheless, documentation of traditional warning signs is a recognised need (Mercer et al. 2010; NDMO 2011), and the results of this study are intended to provide a baseline of information for future work to build upon.

There were 17 community interviews in Fiji and 16 in Tonga. All interviews were with adults in the community, selected using primarily snowball sampling, while also attempting to ensure good representation across age and gender. The youngest adults interviewed were in their mid-20s, and the oldest in their 80s, with most aged between 40 and 70 years. Although detailed demographic statistical profiles for the islands were not available, this sample is broadly reflective of the observed demographics on the islands, where most young adults have left home for education or work purposes. However, the results from this small sample should be considered representative of that sample, rather than of the entire populations.

In Fiji, there was also a focus group conducted with Class 6 students from the local school (12–13 years old). A similar group was not conducted in Tonga as schools were on holiday during most of the fieldwork period.

The research incorporated the talanoa method, which is culturally appropriate in Pacific Islands (Johnston, 2013). In this approach, interviews are flexible and unstructured, as a relationship is established between the researcher and participants. Using a culturally appropriate technique such as this has advantages because the participants are more likely to engage with the research, and share their stories and perspectives. However, interviews tend to be more fluid and informal than in Western countries, with multiple participants coming and going throughout interviews. Some interviews that begin with an individual end up as group interviews or even similar to a focus group. This means that it is difficult and potentially misleading to precisely enumerate results.

A scoping trip was made to both countries prior to the fieldwork, and discussions with government and aid organisation representatives during this scoping trip assisted in the development of the interview guide.

Face-to-face interviews were conducted in English where participants were comfortable using this language, and or in the local dialect with a local volunteer interpreter. Audio recordings were made, and the interviews were later transcribed and then analysed using HyperRESEARCH software. The data were analysed using a framework approach as a structured inductive method of thematic content analysis. Codes were applied to the data, with themes emerging from the data. These themes and codes were then refined, with associations between themes leading to the development of more abstract concepts, and patterns in the concepts and themes then used to interpret the data.

3. Results

Community members on both islands talked often about the importance of having some warning before a cyclone arrives. Those with the most experience of cyclones considered warning to be more important than the strength of the winds:

Never mind it's a strong hurricane, the warning is the best thing to come ... the warning is more important so you can get people to be prepared. (Fiji, male villager, aged 60+)

There were a variety of warning signs and methods discussed, including a mix of traditional signs and radio warnings. Some signs were mentioned in only one or two interviews; others in almost every interview.

The warning signs described incorporated 16 different types of changes in flora, fauna, the ocean, and local environment (Table 1). Many people nominated traditional signs as their first and most reliable way of knowing that a cyclone was approaching. These signs cover a broad temporal spectrum of warnings, from months to hours. There was remarkable consistency between the Fijian and Tongan communities in terms of the traditional warning signs described. Most of the signs described in Fiji were also described either closely or exactly by community members in Tonga.

3.1. Nesting behaviour of bees and hornets

In the months prior to the November–April cyclone season, honey bees, and hornets build their nests closer to the ground. In Tonga, this was noted during 1–2 months prior to a cyclone:

It's telling by the insect named bee. If they were coming with their home and live under the tree like this (points down low), tell them there will be a cyclone. And if they are hiding up the tree, there will be no cyclone. They are telling it by how they live. (Tonga, male villager, aged 35–45 years)

Table 1. Traditional warning signs described.

Type	Timeframe	Location
<i>Fauna</i>		
Nesting behaviour of bees and hornets	Months	Fiji, Tonga
Appearance and behaviour of particular birds	Days	Fiji, Tonga
Changes in spiders' webs	Months/weeks	Tonga
Nesting behaviour of chickens	Hours	Tonga
<i>Flora</i>		
Fruit growing in bunches	Months	Fiji, Tonga
New growth on banana plants	Months	Fiji, Tonga
Reflection of sunlight on coconut leaves	Not stated	Fiji
<i>Ocean</i>		
Stronger current and higher tides	Weeks	Fiji, Tonga
Appearance of the reef	Days/hours	Tonga
Sound of the reef	Hours	Fiji
<i>Environment</i>		
Rainbows change shape	Not stated	Fiji, Tonga
Strength of winds	Days/Hours	Fiji
Frequency of strong winds	Years	Tonga
Wind direction	Months and hours	Tonga
Cloud shapes	Not stated	Tonga
Dull stars	Days/hours	Tonga

In Fiji, the nesting of the honey bee was noted to change earlier than in Tonga, during the July–September prior to the November–April cyclone season.

3.2. *Fruit growth*

Fruit, especially breadfruit, grows in bunches rather than just one or two together:

Here on the island, when there is plenty of breadfruit, they say that next year there will be a cyclone here. (Fiji, male villager, aged 45–59 years)

In Tonga, this was explained as being related to a lack of rain during the early part of the cyclone season. Less of the heavy summer rains means that the baby fruit are not damaged, so they are more likely to grow in bunches. This sign, of fruit growing in bunches, was described consistently in Fiji and Tonga.

The new growth on banana plants changes shape, curling over instead of growing straight up. Almost identical descriptions of this sign were provided in the two countries:

Some signs that our older generation used to talk about, he has experienced that as well. The vudi plant, like a banana but short and fatter, the shoot right on top, when it's 3 or 4 months before a hurricane, it comes down like this. It used to point up, the younger leaves. (Fiji, male villager, aged 60+, through an interpreter)

He is talking about the old people. They can understand there must be a cyclone for about months or weeks before cyclone hitting our village or Tonga. They are looking for, you know the banana trees, and the tree like this, you know the young one. The straight one is going like this, show us nothing bad, the forecast must be good. If bend down, you know, the trees understand there must be a cyclone. (Tonga, male villager, aged 45–59 years, through an interpreter)

3.3. *Ocean currents and tides*

In Fiji, the community members described changes in the currents of the ocean, about one month before a cyclone:

Current, because when the waves come on the barrier reefs, sometimes it's coming with a lot of current, and then we can experience that when the tide comes in, it goes right to the beach. Sometimes we can see the big waves coming when it's high tide like that, from the open sea. (Fiji, male villager, aged 45–59 years)

The Tongan villagers also described the behaviour of the ocean currents and waves as being a warning sign of a coming cyclone or bad weather. The tide rises, with waves coming in towards the houses, before the cyclone comes. There was also a description of changes in the shape of waves:

From the waves, also the wave of the sea. When the waves are too strong, sometime you can see there is like a flag on top of the wave. If there is another small one like a flag over the wave. There's nature tell us to get ready, something will happen in the future. (Tonga, male villager, aged 60+)

3.4. *Rainbows*

The villagers in both countries noted changes in the shape of rainbows. In Fiji, the change is in the appearance and timing of the rainbow:

Another sign is like a rainbow, but rainbow is longer, this one is a little bit shorter. Sometimes when it's a good day like this, you can see this rainbow. So then they know that there are some changes coming in the weather, especially the strong wind or hurricane. (Fiji, male villager, aged 60+)

In Tonga, an incomplete rainbow is a warning sign:

They said they can tell when they see the rainbow, half rainbow. Then it might be bad weather or cyclone. Half rainbow. (Tonga, female villager, aged 35–45 years, through an interpreter)

3.5. *Birds*

The behaviour of a particular type of bird was one of the most common natural warning signs in both countries, especially with detailed descriptions from a variety of people in Fiji:

We see birds like that. There's one big bird that usually knows that the hurricane or bad weather is about to come. A big bird, if it gets down. It flew up there. If it gets down to want to touch the ground, that's a warning that a hurricane or bad weather is about to come. If it's high up, that's OK ... big wings there. We call it manu ni cagi (bird of the wind). (Fiji, female villager, aged 35–45 years)

Another sign that he knows, is a type of bird. A bigger bird. We have a special name for it – bird of the wind. We hardly see them on a day like this, but when we see them coming in numbers, about 20 or more, then it is a sign that a cyclone is coming. When they are coming down, because they normally are at cloud level, but if they are coming down, about 20 or more of them, that is a sign for him. (Fiji, male villager, aged 45–59 years, through an interpreter)

There is the hurricane bird. It's a sign to here that there is a cyclone coming ... it never fails. If she sees the birds, strong winds are definitely coming. So that's the only time that she recalls the hurricanes – if she sees those birds. (Fiji, female villager, aged 60+, through an interpreter)

Similarly in Tonga, there were numerous descriptions of a particular bird, motuku, being a reliable warning sign:

Sometimes they can tell the bird, there is a big bird, flying and they can tell there's going to be a big storm or hurricane ... the black one, big and black. (Tonga, female villager, aged 60+ years, through an interpreter)

It was the black one, and they have something on the back. And if it's open like this, there will be a cyclone, and if it's closed like this, then there will be no cyclone. (Tonga, female villager, aged 35–45 years)

3.6. *Coral reefs*

In Fiji, community members described the sounds coming from the coral reefs near their island when a cyclone is approaching:

And the reef, like in the night, sometimes when it's calm you can hear the reef like roaring, crying. (Fiji, male villager, aged 60+, through an interpreter)

The reef will be roaring. It's a kind of sound that we hear which is different from now. (Fiji, female villager, aged 60+)

She (mother) told us, when you hear the sound of the sea, boom, don't sleep, wake up, it's time to get up. (Fiji, male villager, aged 45–59 years)

In Tonga, it is the appearance of the reef, rather than the sounds coming from it, which signify that a cyclone or bad storm is coming:

And they said they can tell from the reef. The reef was very white from the waves. Because when it's normal, we can tell, like there's no reef on the ocean. So if anyone goes to the beach and they see every reef is white, so they said there's going to be a storm. (Tonga, female villager, aged 35–45 years, through an interpreter)

3.7. *Wind*

Changes were noted in both countries, concerning the behaviour of the wind before a cyclone. In Tonga, the direction of the wind is particularly important and provides both long- and short-term warning:

She said the other sign. Do you know the last day of December? If the wind blow from the south, long ago they said there will be a cyclone on that year. (Tonga, female villager, aged 35–45 years, through an interpreter)

Wind blowing from the northwest is a sign of a cyclone on 'Uiha Island in Tonga, and if the wind comes from the north, there will also be higher waves accompanying the wind.

The regularity of strong winds was another sign described in Tonga:

The one thing I heard from the old people. If you are going to have some wind every year, it's good ... or after 2 years or 3, it's good. If we can't get some wind after 10 years in between, you can ready for the big cyclone coming. (Tonga, male villager, aged 35–45 years)

In Fiji, it was simply the building of wind during the cyclone season that signifies a warning for an impending cyclone:

He knows that in Fiji there's a month for hurricanes from December to April, so he knows during that time that if strong winds keep on coming, there will be a cyclone very soon because it's the season for cyclone. (Fiji, male villager, aged 60+)

3.8. *Clouds*

The community members in Tonga described particular shapes of clouds as being a warning sign:

He said about looking at the cloud in the sky, there is like a horse tail. (Tonga, male villager, aged 45–59 years, through an interpreter)

3.9. *Spiders*

Spiders were described as making more webs before a cyclone comes:

Many different things that the old people learn from. You know the spider, they say the spider when we are going on the road in the bush, trees from trees, the spider make their net between trees and

trees. That is one of the thing that the Tongan people said that the spider try to get good to get ready for the next season. There must be a hurricane or strong wind or something like this. (Tonga, male villager, aged 60+)

3.10. Chickens

In Tonga, the behaviour of chickens was noted as providing confirmation of whether a cyclone that the radio warning says is approaching will actually hit a particular island:

During the cyclone warning, if the chickens are flying up and sleep in the tree ... if the chicken sleep down, there will be a hurricane ... sometimes you know, the radio says that there will be a hurricane, but because of the direction, the movement of the hurricane, it will not come. So at the first time, come straight. So after 2 hours, 3 hours, change direction so it will not come; the same with the signs. We see the chicken is flying up and sleep there, we know it's okay. We trust that. (Tonga, male villager, aged 46–59 years)

3.11. Stars

One of the signs during 'the calm before the storm' in Tonga is in the appearance of stars in the night sky:

When you looking to the sky, the stars. Plenty stars in the sky, but they not look bright. (Tonga, male villager, aged 46–59 years, through an interpreter)

3.12. Coconut leaves

One villager in Fiji described how elders used to be able to see from the way the sunlight reflected on coconut leaves that a cyclone was coming. This was particularly noted as something younger people do not know how to do.

4. Discussion

4.1. Regional and local signs

It is possible that some of these signs might be closer to folklore than actual traditional knowledge. Certainly, there have been controversies in the past regarding the interpretation of Pacific Island culture from anthropological studies, such as in the case of Margaret Mead's studies in Samoa (Shankman, 1996). The signs documented in this study have not been validated using methods that give them currency in Western scientific knowledge, and it was beyond the scope of this study to attempt such validation. There are, however, initial indicators of validity.

The reliability of these traditional warning signs of cyclones is supported by the strong consistency between Fiji and Tonga in the descriptions. Local variations are to be expected, since the ecological systems on which the signs are based are not identical on the two islands. However, while sometimes the details differed, and there was an overall greater number described in Tonga than in Fiji, for some signs, the consistency was remarkable. This is further supported by a recent documentary made by UNESCO during a project in the Cook Islands looking at traditional warning signs of cyclones in that country (UNESCO, 2011). In that documentary, some signs were broadly similar such as the shapes of clouds, direction of the wind and changes in the tides. There were other signs that were described almost exactly as in both Fiji and Tonga – a

particular bird seen only prior to a cyclone, curled new growth on banana plants, fruit growing in bunches, and chickens cooping at a ground level. This suggests that there may be some signs that are common to South Pacific islands, and others more localized.

4.2. *Limitations of the traditional signs*

It is noteworthy that in the descriptions of the traditional warning signs, people often referred to storms or bad weather, not just cyclones or hurricanes. The signs are of strong winds and rain, but in these descriptions, were not able to differentiate between severe storms and cyclones, or between cyclones of differing strengths.

As the environment and climate changes, so to natural warning signs may change, and traditional knowledge may need updating (Kelman, 2011). In some instances, traditional knowledge may be already outdated and considered ineffective by some within the community itself (Mercer et al., 2007).

In the current study, the signs were considered to be current and reliable by those who held the knowledge. The risk in these communities was more in the limitations of interest in retaining that knowledge.

4.3. *The future of traditional knowledge*

There is a perception among some of the elders in the community that younger people on the island do not know traditional signs and are not interested in learning about them:

Most of the younger generation now, sometimes they don't trust what the elders say about the natural signs, because of what they know now. Because they are more educated than the elders, and you know, technology, it seems like they don't believe in natural signs now. They are not interested in getting it from the elders. (Fiji, male villager, aged 60+)

To a certain extent, the perception of the elders was supported by the interview data, in that in Fiji younger community members (aged 45 years or less) nominated only one type of traditional warning sign – the bird (*manu ni cagi*), and thought the radio was more reliable. However, most of them still nominated the traditional sign first, with the radio viewed as providing confirmation of the traditional sign. In Tonga, again it was elders who provided both the greatest number of signs, and to the finest level of details. There, villagers were equally like to first nominate the radio only or the radio together with a traditional sign. People trust both types of signs and, opposite to Fiji, view the natural signs as confirmation of whether an approaching cyclone will impact their particular island or not – the radio informs a cyclone is in the area, but the natural signs provide a more local confirmation.

A discussion with a Class 6 school group (upper primary) in Fiji yielded a long list of traditional signs. While there was not as much detail provided as by the elders, the sheer number of signs the schoolchildren knew about was both impressive and surprising, given that the elders had said young people were not really interested in traditional knowledge. It is not clear whether this topic may have been recently studied by the school class, as attempts to contact the teacher following fieldwork to determine this were unsuccessful.

The implication here is that younger people are content to rely on the radio to provide cyclone warnings. However, relying on technological warnings can be difficult on remote islands, where communication is unreliable. The Red Cross in Tonga in theory telephone each Town Officer in their area when there is a cyclone approaching, to make sure the warning is received. However, that does not always work:

Sometimes the network isn't good in the outer island, so we can't call through. The only thing they hear is the AM radio. So if the radio doesn't have batteries, they will not hear. That is how difficult the connection through to the outer islands ... sometimes it's no good. And if I don't reach to them to the Town Officer, and that village, that island don't have any radio or their battery is gone, I feel sorry for them. The cyclone hit without any warning. That's how difficult through the connection or warning for the cyclone. (Tonga, aid organisation representative)

Even if there are working radios, people may not be listening to them. This is especially the case with younger people:

But to listen to the radio to get the warning, it's not happening with the youth. They are not listening to any radio, they are listening to music (on their mobile phones). They just respond when their family starts telling them OK, it's a cyclone. (Tonga, aid organisation representative)

This is reflected in the large body of work in the literature exploring the changing nature of youth culture and the way young people use media (Smaill, 2008). As mobile phone technology has spread in developing countries into rural and poor communities, the technology is increasingly being used by development projects and even community radio stations as a way of engaging with youth (Watson, 2012).

In both Fiji and Tonga, aid organisation representatives talked about these changes in the ways young people are using the radio – listening to music on their mobile phones more commonly now, rather than listening to the radio. This means that the radio is at risk of becoming a less effective method of disseminating disaster warnings, particularly to remote communities. In Tonga, the problem is recognised and is being addressed in a very modern way. There are only two mobile phone carriers in Tonga, and the network is used extensively by local businesses for advertising through text messages. This has been taken advantage of with the same system now also being used to send text message warnings of disasters. It was tested successfully for the first time during Cyclone Jasmine (February 2012) to send warnings throughout the main island of Tongatapu.

5. Conclusions

With agreement within this study that preparation is key to surviving a disaster and minimising damage, adequate and accurate warning is essential. Properly acknowledged, preserved, and formalised traditional knowledge has the potential to combine with technological warnings and overcome some of the impediments to warnings being recognised, taken seriously, and acted upon. Locals understand the natural signs, and the understanding may be passed on to those younger people who currently do not have the same knowledge. They are considered to be reliable and consistent, and when combined with the radio and mobile phone warnings, are able to overcome the problem of the mistrust of warnings coming from a single source. In fact given the range of natural signs, both in terms of which part of the ecosystem the sign emanates from, and the temporal scale of it, the traditional knowledge already may provide multiple sources for the warnings. Combining them with the technological warnings formalises that with the advantage that the multiple sources would then include both types of knowledge – traditional and western scientific.

Traditional knowledge is being held mainly by elders, and younger people are relying more on technological warnings such as through the radio, so it is important that those technological warnings keep up with the changes in the ways young people, even on remote islands in developing countries, use that technology.

With mobile phone reception on these remote islands being dependent upon standing under the right tree, or on this particular rock, however, the importance of traditional knowledge is

likely to remain for some time to come. The evidence from this study shows that these signs are not only accessible to the local people, but also consistent, even across countries, which is crucially important for their acceptance.

The integration of traditional and western scientific warnings brings the two worlds together – the wisdom of the elders and the methods of the younger generations. Their integration may also help to reduce the vulnerabilities inherent in each system. Western scientific warnings are able to provide information about the likely severity of an approaching cyclone, but are often unreliable concerning the actual location, given the unpredictable behaviour of cyclones. Traditional knowledge can warn of a cyclone or storm approaching a particular island, but not provide details about the severity of it. People on each of the islands were already informally integrating the two systems, by using one as a validation of the other. People ahead of their time?

The traditional warning signs documented in this article provide a foundation to build upon. Further research validating signs, such as these, and providing signs from other countries is encouraged.

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