

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

## International Journal of Disaster Risk Reduction

journal homepage: [www.elsevier.com/locate/ijdr](http://www.elsevier.com/locate/ijdr)

# Volcanic disaster risk reduction in indigenous communities on Tanna Island, Vanuatu

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## ARTICLE INFO

### Keywords:

Indigenous disaster risk reduction  
Volcano  
Traditional belief  
Mt. Yasur  
Vanuatu

## ABSTRACT

This research addresses how an Indigenous disaster risk reduction framework, which calls for the integration of cultural aspects in order to assess the risk of people and communities and their abilities to cope with the impact of a disaster, can apply to volcano hazards in the context of rural communities where villagers strongly maintain a spiritual connection to an active volcano. In the area called Sulphur Bay, Tanna Island, Vanuatu, although deemed vulnerable to Mt Yasur eruptions, no evacuation or any sort of science-based volcano risk reduction plans have ever been implemented. This is because the villages are governed according to traditional belief systems, which see Mt Yasur as their ancestor and have rejected the introduction of external ontologies. Our interviews with the chiefs, custom leaders and general villagers find that for the majority of the villagers, the risk is to internalize any external ontologies, not the volcano, and they understand a volcano eruption as the expression of anger by their ancestor because of a wrong action of community members. Although their ontology has been constantly influenced by external agents and a few see such an ontology becoming out-of-date, under the hierarchal chiefly governing system, they are still certain to perform rituals to calm down Mt Yasur's angry spirit if it erupts. While existing research on volcano risk reduction has called the combination of indigenous belief systems and science-based approaches to improve volcano risk reduction, this research spots challenges to do so in some particular contexts.

## 1. Introduction

The Sendai Framework of Action 2015–2030 called for the capacity enhancement for disaster risk reduction (DRR) in developing countries, paying particular attention to small island developing countries [1]. In remote communities of small island countries, the less established infrastructure and communication network, together with the difficulty to deliver material aid, may be a particular issue after a disaster. As a response to this call, the DRR literature has shown an increased interest in the integration of social, cultural, and historical aspects into disaster management and the utilization of domestic resources and knowledge as a more holistic and systematic approach [2–4]. Indigenous DRR, which requires a paradigm shift from “positivistic, reductionistic, anthropocentric and secular worldviews” to “exploring how family, community, tribal, social-environmental, historical, spiritual, livelihood, and governance processes can be regenerated” in order to assess the risk of people and communities and their abilities to cope with the impact of disasters, is one of such approaches [3]; p2). This holistic approach is important to assess the risks because some people understand a disaster based on their religious belief, rather than western-based scientific interpretations, and may not act as expected by the

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<https://doi.org/10.1016/j.ijdr.2022.102937>

Received 27 September 2021; Received in revised form 30 January 2022; Accepted 30 March 2022

Available online 1 April 2022

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authority during a disaster. Hence ignoring such people's ontology and imposing disaster management plans from a top-down approach will rather endanger the people and/or communities. The top-down approach also disregards indigenous/local people's capacity to generate culturally specific methods to respond to a disaster. Indeed, indigenous peoples have demonstrated their culturally specific methods to cope with the impact of disasters across the world, including cyclones, tsunamis, and earthquakes [3, 5–10].

Vanuatu, located in the Pacific Ring of Fire with six active volcanoes, has attracted volcanologists [11–14]. Like many rural communities in PICs, most villages located outside the capital city of Port Vila still maintain customs that have been practiced over generations. Hence the previous research on DRR in Vanuatu has stressed the development of locally-led adaptation and coping mechanisms generated from community resources (e.g., Refs. [8,10,15]; however, it only looks at climatic hazards and DRR has not been discussed regarding volcanic hazards. Anthropological research also did not look at indigenous beliefs on volcanos (e.g. Ref. [16]). In 2017, when the Lombenben volcano on Ambae Island erupted, the Ambaens acted under their ontology. That is, the Ambaens understood the Lombenben eruption as the result of misbehaviors of themselves, who broke taboos and acted disrespectfully against their customs. For them, performing rituals to calm down the angry spirit of the Lombenben was the only means to stop the eruption. Lahars, water, food contaminations, destructions of gardens and homes, and ashfall threatened the lives of the Ambaens [17,18] and the government of Vanuatu declared a state of emergency on Ambae, ordering the Islanders to evacuate. However, the Ambaens (especially village chiefs and leaders) ignored the government's order, which risked lives. Later the government sent law enforcement officers to vacate the Island. This event highlighted a very crucial issue that needs to be addressed regarding a volcano eruption. That is, how can DRR regarding volcanic hazards be more efficient in some specific cultural contexts like Vanuatu and what can be done for protecting the lives of people who are under the strong influence of traditional and cultural beliefs associated with volcanoes and tend to prioritize such values over governments' instructions to evacuate? With six active volcanoes, in Vanuatu, a scenario like this may repeat on other islands, including the Sulphur Bay area on Tanna Island, the case study of this research. As our results below show, the four case study villages in Sulphur Bay also maintain a strong spiritual connection to Mt Yasur, an active volcano, and villagers often act and interpret Mt Yasur eruptions under their cultural belief, rather than a western science-based approach. As such, it is crucial to investigate the cultural beliefs on volcanoes of people and how one's cognition of volcanoes determines the reaction to a volcanic eruption. Hence this article addresses how an indigenous DRR framework may (or may not) apply to communities like Sulphur Bay, and if DRR can be formulated solely based on indigenous beliefs for volcanic risk reduction in the case of Mt. Yasur. It also considers how this case can be extrapolated to other volcanoes in Vanuatu.

## 2. Indigenous disaster risk reduction and response to volcano eruptions

Volcano eruptions are regarded as one of the most destructive hazards, which involve lava expulsions, ashfall, earthquakes, pyroclastic flows, and lahars. A large amount of ash, gas and smoke ejected from a volcano could change the surrounding physical environment, which substantially impacts all kinds of creatures [19]. A challenge is that with the most updated monitoring systems and research findings, a volcanic eruption can hardly be predicted [20]. Indigenous DRR may be relevant to volcanic risk mitigation strategies – preparation, evacuation and communication plans. The literature has recognized the necessity to incorporate cultural aspects into “physical assessments, to reduce the risk associated with disasters” [21]; p. 1210). Like some people interpret climate events such as droughts and cyclones based on their religious beliefs [22–25], those who have long lived on slopes or at the base of a volcano have formed an anthropomorphic belief that they are spiritually connected to a volcano. As a result, volcanic eruptions are interpreted based on an anthropomorphic belief, and every time they survive from volcanic events, they accumulate knowledge and experiences on how and why they survived, which have been passed down from generation to generation as guidance to their livelihood [26–28]. In this sense, DRR is already part of their livelihood and such examples can be found across the globe. For instance, the Kilauea volcano in Hawai'i is seen by locals as Pele, Goddess of the fire [29]. In the Philippines, when Mt Pinatubo erupted, it was believed that an evil spirit called Bacobaco was building his house on the top of Mt Pinatubo throwing rocks, ashes down and creating earthquakes [26]. In Java, Indonesia, people believe that Mt Merapi is a holy manifestation of spiritual power and volcano eruptions have been believed to be sources of change. For instance, in the community of Turgo, eruptions have been said to increase dairy and agricultural products in the region [30]. The Javanese also interpret that Mt Merapi is most active during the period of *Suro*, the first month of the Javanese year. It is believed that during the *Suro* spirits are building, cleaning, and cleansing themselves and their homes and disposing of their waste from the volcano vent as lava flows. *Suro* was also the time for male spirits to visit female spirits and get married. People believed that the expulsion of lava resembles the ejaculation of sperm of the male spirit. Although eruptions killed some people, they were assumed that spirits needed help assisting the wedding in the spiritual world. They also believe that an eruption can be stopped if they resolve “wrongness” in their society, or closely communicate with the spirit of the volcano through rituals. This is why they choose not to evacuate during eruptions and do not seek assistance, even though those who do not share the same ontology regard such people and communities as vulnerable.

For the people with those ontologies, volcanic eruptions are not necessarily geological events but actions by God [31,32], or caused by the “wrong” behaviours of human beings; as such, volcanic eruptions will cease if human beings correct the “wrongness” and strive to calm down an “angry spirit”. As Donovan [27] states, with past experiences and these beliefs, those communities have developed effective mitigation techniques; hence they believe that they can survive from the impact of volcano eruptions and do not see the necessity to evacuate. Livestock and farming are other factors that hesitate them to evacuate during an eruption. Because livestock is a substantial asset, villagers often cannot leave their behind and volcano ash helps enrich the soil which in turn poses an advantage for agriculture in communities adjacent to a volcano [33]. As a result, when an eruption occurs, the thought of staying in their motherland and having access to their products outweighs the destruction caused by the eruption, and the thought of being relocated and losing all

they have worked for becomes a difficult decision [26,34,35].

Regarding volcano eruptions and DRR, what need to be paid attention to are the concepts of risk and hazard (eg. Ref. [34]). That is, for some, a volcano is an entity that may cause a hazard; hence living near a volcano is a risk. However, for others, as seen above, a volcano provides a source of livelihood and because of their living experiences with a volcano, it is not necessarily seen as a risk. For those people, a “hazard” and “risk” is caused by DRRs implemented by a top-down approach, that do not incorporate “traditional worldviews, knowledge, and practices to facilitate the (re)building of the individual and collective adaptive capacities” [3]; p2; see also [34,36,37].

An issue is that such local “culture of hazard” is not always shared by the government. For instance, with regards to Merapi, the Indonesian government has worked together with international scientific bodies to produce effective mitigations and countermeasures regarding volcanic eruptions [38]. However, the government’s community resettlement attempts failed several times because the residents saw them as “hazard” brought by the government, who was seen to be attempting to destroy their communal values and livelihood. Such residents’ attitudes may increase a population’s vulnerability. In fact, during the 1994 eruption locals refused to evacuate because of this anthropomorphic belief, which resulted in 63 deaths and the destruction of everything in the six-mile range. As Dove [38]; p. 330) states, what we see here is “the difference in the way that natural hazards and disasters are perceived by the proximate communities versus central governments. The state technologizes and thereby exoticizes this threat. Whereas the villagers see eruptions as routinized catalysts for productive change; the state sees them as episodic threats to well-being”. Such a statement is echoed by Bankoff et al. [39]; based on the case study of Mount Mayon in the Philippines. While the volcano forms part of the livelihood of local people, some local elders “feel” that government agencies merely attempts to classify volcanoes based on their eruptive history and assess their risk without integrating people’s perceptions on the “risk” of the volcano. In actuality, DRR based on an inflexible assessment of risk will not function well in a country like the Philippines, where more than 80% of the population is living near active volcanoes [33]. Thus, Bankoff et al. [39] argue that DRR must integrate local historical and cultural memory on a volcano; otherwise, it will have very little effectiveness.

As a response to these calls, collaborations between the community (particularly leaders) and scientists or government officials to mobilize communities to enhance the community’s resilience have taken place regarding volcano risk reduction [27,40]. For instance, Andreastuti et al. [5] stated that in some communities near Sinabung or Kelud volcanoes, Indonesia, community members actively participated in the formulation of a disaster mitigation plan, when community leaders utilized knowledge of local culture and resources to educate members. Andreastuti et al. [5]; p. 300) also stress the importance to share information among “the source of information (scientists), decision-makers (disaster management institutions) and the groups of potentially threatened people (communities)” during a volcano crisis.

An attempt to incorporate local knowledge into volcanic risk management plans and enhance community awareness was also made on Ambae Island, Vanuatu. Cronin et al. [6]; p. 653) adopted Participatory Rural Appraisal (PRA) methods - an “approach in building partnerships of respect between ‘outsiders’ and ‘insiders’” - so that community members do not reject outside scientific views while scientists understand local customs and world views that may hinder volcanic emergency management. After a series of participatory exercises and the follow-up visits to the communities of Lolovange and Lolowai, Cronin et al. [6]; p. 666) claimed that they “established a common ground for communication about hazards that also demystified the science”. Nevertheless, the long-term effect of this project is in question, given that in 2017, the Ambaens refused to listen to the government’s order to evacuate and insisted to rely on their traditional methods to deal with the eruption, as already seen. Also, it is unclear to what extent Cronin et al.’s project considered the spiritual connection of the residents with Mt. Lombenben.

In the Pacific Island Countries (PICs), people often interpret natural hazards based on their religious beliefs [23,41,42]. For instance, severe flooding that occurred in Nadi (Fiji) in 2012 was viewed by indigenous Fijian Christians as an act of God to punish permissive sexual behaviours allowed by the tourist industry [23]. Cox et al. [41] further observed how Methodist informants spoke about the moral assessment of those affected by Tropical Cyclone Winston on Koro Island, Fiji, in 2016 to be a result of overindulgence



Fig. 1. Sulphur Bay (Source: Authors).

in the consummation of kava and the non-observance of the Sabbath. If a Pacific Island country attempts to implement a DRR plan regarding volcano eruptions, integrating local cultural views is critical. Without understanding the world view of the members of at-risk communities, any attempt to introduce a science-based disaster mitigation plan may not function well. Such an approach also agrees with the nature of Indigenous DRR.

### 3. Study sites and methods

The four case study sites – the villages of Imale, Ipikil, Lamakara, and Port Resolution – are located in Sulphur Bay, the eastern side of Tanna Island, Tafea province, Vanuatu. Sulphur Bay is known to the Tannese as “white sands” (Fig. 1). The physical attributes of each village are similar, where the soil and vegetation are covered with ash and traditional cane huts being the dominant houses around. The distances between each village and Mt Yasur are: Ipikil situated approximately 1.9 km from Mt Yasur; Imale situated approximately 1.8 km from Mt Yasur; Lamakara being the closest, 1.4 km from the base of Mt Yasur; and Port Resolution being the most distant, 3.6 km from the base of the volcano (Fig. 2). The eastern side of Tanna, unlike the western side, has observed little infrastructural development, only with a few schools, churches, and locally owned resorts that employ a few locals. *Kastom* – a Pijin (Bislama) word to refer to a traditional Melanesian way of life – is widely practiced to govern each village by a chief and *Tubunis*, a spiritual man who is believed to have the power to communicate with the spiritual realm. With regards to religion, the Sulphur Bay area has believed in its religions according to *kastom*, although Christian churches have been constructed over the years and some Christian interpretations have become part of the revived *kastom* [16]. Of particular note in Sulphur Bay is the strong influence of John Frum, a classic example of what anthropologists call a “cargo cult” that sprang up in villages during World War Two when thousands of American troops entered Tanna [43]. The John Frum movement aimed to revive *kastom* among the Tannanese, including kava consumptions, dancing, and beliefs. According to the John Frum doctrine, any external religions, knowledge systems, capitalism, and infrastructural/material development do not need to be accepted [44]. The Tanna *kastom* believers have rejected tourism development as the symbol of capitalism and did not accept the idea of ‘a nation-state managed from an island other than their own’ [16]; 310). Among the four case study sites, Lamakara is strictly following the John Frum doctrine, while the other three villages observe Presbyterian, Seventh-day Adventist, and Mormon as well. Port Resolution has observed infrastructural development including the internet connection. The village also has the Port Resolution primary and secondary schools to accommodate children from across Sulphur Bay; thus the belief of the Port Resolution villagers has somewhat been influenced by external knowledge systems. They are more open to different thinking and the village once allowed external groups such as the Vanuatu National Disaster Management Office (VNDMO) to hold disaster risk awareness sessions. Such sessions have hardly taken place in the other three villages. A few volcano hazard risk assessments have been conducted by overseas researchers without involving any local community members, for the safety of tourists (e.g. Ref. [12]).

Regarding the risk of volcanic hazards from a scientific perspective, the entire Sulphur Bay is classified as the “red zone” – exposed



Fig. 2. Vanuatu, Tanna Island, and four case study villages and Mt Yasur (1: Imale; 2: Ipikil; 3: Lamakara; 4: Port Resolution) (Source: Authors based on Google Map).

to flying rocks and gas from eruptive vents during an eruption – by the Vanuatu Meteorology and Geo-Hazards Department [45]. Because the three communities – Imale, Ipikil, and Lamakara – are located on the right foot of Mt Yasur, a slight intensification of volcanic activities increases sulphur eruption as well as health risks. Located behind Mt Yasur, Port Resolution does not experience much ashfall and sulphur gas exposure unlike the other villages; hence it is located outside of the “thick ash zone” on the Tanna Communities Safety Map. The other three villages are in the thick ash zone, where volcanic bombs can land at any time and the only way to avoid the risk is to stay off from Yasur [45]. However, for the Tannanese, Mt Yasur has often been interpreted as “a volcano which presents no real danger” [16]; 108). This is because Mt Yasur is a Strombolian volcano – constant minor explosions without going dormant are its normal state [13,14] – and the hazard maps only show the potential maximum travel distance of ash or rocks [12].

The four sites were visited in June and July 2019, and interviews were conducted with 13 individuals in each village, 52 in total. Among 13 participants from each village, 3 were in a leadership position, including chiefs and custom leaders, while the other 10 were general villagers. We first sought approval and assistance from chiefs, who informed villagers of our project; thereafter participants were conveniently recruited. The gender and age groups of the participants are shown in Tables 1 and 2. The participants were dominated by men. This is because men take social responsibilities in these villages. Although some women agreed to participate in our interview, they insisted on the presence of their husbands, which influenced the quality of data, because the women were hesitant to fully express their opinions. For the same reason, we requested chiefs and custom leaders not to be present while interviewing general villagers, which was agreed upon. All interviews except one were conducted in Bislama (Vanuatu pidgin) by one of the authors, who is originally from Ipikil, and later translated into English. One interview was conducted in the Tanna language with the help of a local translator.

As traditional conservative community members, the Sulphur Bay villagers are not always open to outsiders. However, as stated, being from Ipikil, villagers saw us as family members and were not hesitant to share information. Nevertheless, some interviewees, particularly elders insisted that some detailed information should never be exposed to outsiders as it has long been kept secret; hence all data presented in this article are the ones that can be shared with outsiders.

Interview questions asked on their spiritual connection to Mt Yasur, legends and beliefs on Mt Yasur passed down over generations; the reasons for Mt Yasur eruptions; actions previously taken when Mt Yasur erupted; villagers’ opinions on science-based volcano risk reduction plans; and their prospective actions when Mt Yasur erupts in the future. The participants were also asked how they acted when Category 5 Tropical Cyclone Pam hit the country in 2015. The nature of this question was to investigate their view on the natural hazard. Narrative analysis was used as the data analysis method. In addition, we interviewed VNDMO and VMGD officials in April 2021 to investigate if these government sections have any plan to implement volcano risk reduction plans around the Sulphur Bay area and how such a plan can be implemented. In the next section, we quote interviewees’ statements; however, only the participant’s age range is revealed. This is to avoid potential attacks against those who have expressed an opinion that may reject the power of rituals, given that the number of the participants is not quite large.

#### 4. Results

##### 4.1. The spiritual connection to Mt Yasur

First, we investigated the interview participants’ spiritual connection to Mt Yasur. As stated, over the years, some Christian interpretations have been incorporated into *kastom*, a source of the intimate link between Mt Yasur and the people living in the surrounding area. The Sulphur Bay area has also been exposed to the external knowledge systems, including school, the government, and knowledge brought by village immigrants or available on the internet and media. Hence their ontological worldviews are “fluid, contested, and ever changing” [42]; 10) and so should be their spiritual connection to Mt Yasur. Nevertheless, we found two major views from our interviews: those who prioritize the belief in the spirit of their ancestors residing in Mt Yasur and confirm their spiritual connection to Mt Yasur over generations; and those who see such spiritual connection as a belief of the past. The former view was widely observed among village chiefs, leaders, elders, and some villagers and indeed, 77% (40 out of 52) participants claimed their spiritual connection being alive. They claimed that Mt Yasur has long been referred to as *Apu* (ancestor), also the source of life, on which their ancestors relied for protection, guidance, and provision. According to the chiefs of the four villages, their ancestors believed that Mt Yasur was not an ordinary volcano but part of them that was reincarnated into a volcano. Mt Yasur was also referred to as God simply because of its name, Yasur or Yahweh, meaning God in Hebrew:

*Yes we are still connected to him (Mt Yasur), he speaks to us and we also talk to him. We understand his language, when he erupts he is talking to us. He tells us when things are about to happen, for instance, if someone is going to die he lets us know. When he is not happy he*

**Table 1**  
Participants by gender.

Gender	Male	Female	Total
Imale	8	5	13
Ipikil	10	3	13
Lamakara	10	3	13
Port Resolution	11	2	13
Total	39	13	52

Source: Authors

**Table 2**  
Participants by age group.

Age	18–28	29–39	40–50	60>	Total
Imale	2	2	6	3	13
Ipikil	5	2	3	3	13
Lamakara	3	5	2	3	13
Port resolution	1	3	6	3	13
Total	11	12	17	12	52

Source: Authors

*lets us know. He provides for us and protects us. Similarly, when we want something we ask him for it, like good weather or good harvests and he will give us what we ask for. This only happens when there is peace between the people and Mt Yasur, if there is no peace he will not answer our prayers.* (Participant in the fifties)

Those who are skeptical about such a spiritual connection were mostly pastors, those who migrated to one of the case study villages by marriage, or a few young villagers of Port Resolution, although they were a minority:

*Kastom and traditional beliefs that our ancestors lived by in the past are no more. Schools and churches have increasingly led to the demise of our kastom and beliefs. Today we serve the powerful God [of Christianity], stronger than kastom principles, we have moved away from our ancestors' lifestyle and have begun a new journey with God. Yes, we still respect how our ancestors lived and survived in the past, but that is the past. I believe we are more connected to God than to Mt Yasur.* (Participant in the twenties)

Those who believe in the spiritual connection to Mt Yasur also explained the cause of its eruptions based on such a belief - Mt Yasur only erupts when people have broken taboos:

*We are the only ones who will cause Mt Yasur to erupt because of our actions. When we break kastom laws or do things that are not pleasing to him (Mt Yasur), he will erupt. When he erupts we immediately know that it is for a reason, so we start asking around to find out the issue that led to the eruption. He will never erupt on his own. There is always a reason behind an eruption.* (Participant in the seventieth).

Then chiefs listed the reasons for Mt Yasur eruptions and the actions taken to stop eruptions, based on memories (Table 3). They further listed some means to calm down Mt Yasur's "angry spirit" (Table 4). According to the chiefs, the rituals shown in Table 4 have been performed in all the four case study villages when Mt Yasur erupted, and they claimed that in any village these rituals must have been the only way to calm down Mt Yasur's spirit. The most commonly performed ritual was to sacrifice a white chicken and drink kava at the top of the crater.

However, those who were skeptical about the spiritual connection did not also believe the power of the rituals:

*Today, unlike in the past, we have technology and volcano equipment that can be of very good use during a volcanic eruption. These things have been given to us by God and we should use them.* (Participant in the twentieth)

The participants were then asked whether or not these rituals will be held to calm down Mt Yasur's spirit if it erupts in the future. All 12 chiefs and leaders, as well as 35 other participants out of 52 (90%), believed in the power of rituals and stated that the rituals would still be held as the only way to calm down Mt Yasur:

*Yes, the rituals will be performed when Mt Yasur erupts in the future. It is what our ancestors have done and it is also what we will do to deal with the Mt Yasur eruption. There are no other methods or plans that can be done to calm down Mt Yasur, only through our kastom rituals will stop Mt Yasur from erupting. Even with the introduction of new knowledge, we will still rely on kastom beliefs to guide us through, it is what our ancestors have done and it is also what we will do.* (Participant in the seventieth)

They were firmly confident with the means adopted for survival by their ancestors, and argued that the same beliefs and knowledge must function today:

**Table 3**  
Reasons for Mt Yasur eruptions and villagers' reactions.

Reasons for Mt Yasur eruptions and associated phenomena	Actions taken by ancestors
Collisions of wind direction and intensity from the four main nakamals found around Tanna Island	Through communication between the four main Nakamals, wind intensities must be set back to normal by the <i>tubunis</i> . Only then can it bring balance to the four corners of the Island and prevent Mt Yasur from erupting
When custom laws or protocols and peace within the village is broken Yasur volcano will erupt	Chiefs gather people responsible and figure out how to solve the issue. Locals have to ask for forgiveness from one another and also from Mt Yasur. Only when there is peace then Mt Yasur will stop erupting.
When a new season starts Mt Yasur will show signs of activity to let people know it is the start of a new season	He (Mt Yasur) talks to us and we understand what he is saying. We know when it is time to go and start cleaning our gardens to start a new season
Locals sometimes in anger or jealousy go and upset him (Mt Yasur) through dark magic rituals.	To undo this, either the chiefs ask people in charge of this behavior to go stop what they have done or people search and remove the items used for the rituals. This is normally located around the crater area. Once removed eruptions will stop.
Disputes between tribes also upset Mt Yasur	Similarly, disputes have to be solved and reconciled In order for Mt Yasur to stop erupting

(Source: Authors)

**Table 4**

Means to calm down Mt Yasur spirit.

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It is believed that the descendants of Yasur are the only ones who can talk directly to Yasur.

Therefore in the past during an eruption, descendants of Yasur go up to him and ask him to calm down and he will listen.

Just talk to him, we believe that he listens to all of us

A ritual is carried out by special people (custom man). A white chicken is sacrificed at the crater of Mt Yasur followed by Kava drinking that is believed to open the gateway to Yasur's home/realm. Then people communicate with him

Custom leaves are chewed and this allows locals to communicate with Mt Yasur.

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(Source: Authors)

*It would be shameful if we do not follow our traditions that have been passed down from generation to generation. Not only will it be shameful but it will also show the lack of respect towards our elders, chiefs and ancestors. Our traditions are our identity, it is who we are. If we choose to follow other things then that will make us backstabbers to our identity. Our ancestors have survived because of our traditions. If they did it I believe we can do it also. (Participant in the thirtieth)*

A few pastors and young villagers did not believe in the power of such rituals. Nevertheless, they shared the view that the traditional rituals would be held when Mt Yasur has erupted. According to them, this is because the chiefs have the absolute power and make a decision:

*In the end, it all comes down to our leaders [chiefs] and what they think is the best for our village. Because we have chiefs who still boldly abide by traditional beliefs and also the presence of our Tubunis there is no doubt that rituals and traditional beliefs will be performed if Mt Yasur erupts in the future. (Participant in the twentieth)*

#### 4.2. Science-based volcano risk reduction plans

As discussed, the literature on Indigenous DRR has suggested the incorporation of traditional local knowledge into science-based volcano hazard mitigation systems to enhance community resilience. The participants were asked for their view on the integration of the external knowledge systems into their ontology, as well as the development and implementation of science-based mitigation/evacuation plans. Fifteen participants – pastors, village immigrants, and a few young villagers – agreed that these external knowledge systems or help may be useful to some extent, but the degree of their acceptance was limited within “material aid” right after a disaster. In Lamakara, where villagers strictly follow the John Frum doctrines, all participants rejected any external knowledge systems and disagreed with the idea to integrate external knowledge systems into their ontology. With regards to science-based mitigation/evacuation plans, the majority of participants were not so eager to implement: 32 participants preferred the traditional knowledge systems as the only means to be employed to cope with Mt Yasur eruptions:

*Because our ancestors relied only on our beliefs and kastom to guide them through during an eruption, they considered evacuation and implementing [science-based] mitigation measures as a waste of time. Our ancestors ignored the evacuation routes and preparation methods introduced by government agencies. (Participant in the sixtieth)*

*It is a waste of time to integrate the external knowledge systems, they should never be put together. What we have is enough and we trust that our kastom will always protect us. Everything we need is around us, food, firewood, and water. Everything is provided by nature, so why should we try and adapt to things that are not part of our ontology? (Participant in the fortieth)*

Indeed, there have been no escape routes or volcano risk reduction measures established by the VNDMO or non-governmental organizations in Sulphur Bay. The chiefs and leaders firmly believe that the villages have all the necessary resources to deal with Mt Yasur eruptions. Villagers also trusted their chief and *Tubunis*:

*The chief and Tubunis know what to do when Mt Yasur erupts, therefore what we as villagers have to do is simply follow their instructions. There is nothing to worry about because they are spiritually connected to Mt Yasur and can communicate with him. That is why we do not have to set up evacuation routes because we trust in our kastom and leaders. (Participant in the sixtieth)*

#### 4.3. Reactions to Tropical Cyclone Pam in 2015

Vanuatu was exposed to a category 5 Tropical Cyclone Pam in 2015 and the entire Tanna Island was devastated. The participants were asked how they responded to the cyclone. For them, listening to the *Tubunis* was the most important as a preparation means and 86% of the participants (45 out of 52) stated that they continued their daily routines, believing the *Tubunis*' power to deal with Pam. Since the *Tubunis* “failed” to do so, the *Tubunis* was blamed:

*Our Tubunis always redirect cyclones; therefore when Pam came, we trusted the Tubunis to redirect the wind to push Pam away from us; however, that was not the case. Pam hit us because our Tubunis was late. He was unpunctual and for that reason, his power was weak. (Participant in the fortieth)*

According to the participants, the Sulphur Bay villages have never proposed establishing evacuation shelters or accepting assistance from the VNDMO to enhance community resilience for upcoming cyclones.

#### 4.4. Government officials' views

Our interviews with the VMGD and VNDMO officers show that the government is aware of the potential impacts of ashfall, flying rocks, gas, and lavas caused by Mt Yasur eruptions on the Sulphur Bay area:

*The area is vulnerable in terms of volcanic hazards and exit routes, e.g. the only exit route is through the sea which is not safe and might be too dangerous for the vulnerable people in the community.* (VNDMO officer)

Hence the VMGD has prepared some resources, including hazard maps and survival guides [45], and set up three seismic stations with cameras sending pictures every 15 min and ozone monitoring instruments to detect sulphur dioxide (SO<sub>2</sub>); however, the VNDMO clarified that they have never conducted risk awareness sessions in Sulphur Bay and would not directly implement any DRR framework onto the Sulphur Bay communities (interview with a VNDMO officer). The VNDMO claims that they respect decisions made by chiefs, and when evacuation is required, a displacement order shall come from the provincial government.

## 5. Discussion and conclusion

Our findings show that the spirit of Mt Yasur is deeply rooted in the people of the Sulphur Bay villages, and it is part of their livelihood. They firmly believe that they know how to communicate with Mt Yasur spirit and how to cope with the impact of an eruption. With this ontology, they have rejected externally formulated science-based disaster risk reduction plans. From a science-based DRR viewpoint, these communities may be at risk, because they lack structural and survival preparedness measures, such as defensible spaces, storing food, water, and cooking resources, or measures to reduce the risk of injury and death [1,46,47]. Also, the fact that there is only one main entrance to the Sulphur Bay area is a risk, in terms of securing multiple evacuation routes. However, for the Sulphur Bay community members, internalizing any external ontologies is the “risk” (e.g. Refs. [34,38,42]). Meanwhile, our findings also spot multiple views on Mt Yasur and multiple interpretations of its eruptions and the power of rituals (e.g. Ref. [34]). For instance, while Lamakara strictly follows protocols and believes in the power of the rituals, Port Resolution is somewhat open to accepting external ontologies. Even on the individual level, some (pastors, migrants, and a few young members) are skeptical about the tradition. Nevertheless, regardless of their belief in the power of the rituals or the degree of their spiritual connection, the villagers are quite certain with the traditional rituals being the only option employed by the villages when Mt Yasur erupts in the future, under the chiefly hierarchical social structure. Hence the voices of those who may want to integrate science-based volcanic risk reduction plans are currently not reflected in decision-making. Their ontology is built on their traditional belief and has been their foundation of governance. A major part of their belief is anthropomorphic, considering Mt Yasur to be their ancestor. This belief has given ancestors and people today a sense of hope and security in the villages. The fact that villagers now are exposed to external ontologies makes them aware of the “risks” of a volcano event and for some, it stirs up fear, which was absent in the past as community members lived with *kastom* as a means for survival. Hence one could say that multiple interpretations of Mt Yasur eruptions and the power of rituals destroy the community bond and increase the vulnerability against volcanic hazards.

Cronin et al. [6]; pp. 652–653) stated that major challenges to implementing disaster risk reduction plans in Vanuatu are: 1) utilizing “scientific information within practical risk reduction policies and programs”; and 2) having “villagers accept the scientific information from the outside alongside local or traditional knowledge”. Our findings do confirm these challenges and these are particularly so on Tanna Island, where their power from *kastom* and ancestor is strongly beloved to be held, under the influence of the John Frum doctrine [16]. Their standpoint that they do not want to be led by those from another island also affects the approach of the government. Currently the resources available from the two government sections, VGMD and VNDMO are very basic to-do lists during an eruption based on scientific information, and very little is on *kastom* and beliefs on Mt Yasur and its eruption. By saying that “respect the decision made by chiefs” and “[evacuation orders] are given from a higher level”, the relevant government sections appear to be avoiding addressing these challenges.

According to the United Nations International Strategy for Disaster Risk Reduction, preparedness is an important component of a comprehensive Disaster Risk Reduction [46,47] and it stresses the knowledge and capacities to *anticipate*, respond to and recover from the impact of disasters [46,47]. Indigenous DRR also emphasizes the role of local Indigenous knowledge and practices to reduce the “risks” posed by natural hazards. As Ali et al. [2]; p1) state, “deep reciprocal relationships with country and ecological knowledge, strong kinship relations, Elder’s wisdom and authority, women and men sharing power, and faith in a supreme power/God and Indigenous-led community organizations enable DRR”. Indigenous DRR also calls “to conduct genuinely collaborative research partnerships involving Indigenous peoples and their Western counterparts in ways that facilitate Indigenous peoples reviving and strengthening their Indigenous worldviews, knowledge, and practices and applying them to DRR” [2]; p2). To what extent do such DRR frameworks, focused on preparedness, the “revival” of Indigenous worldviews, or collaborative partnerships with Western counterparts, apply to a few particular communities like Sulphur Bay, or volcano risk reduction in general? From one perspective, for instance, government sections or other external agents that would like to implement a DRR framework, the existence of a volcano is surely a risk, and communities without a DRR framework need to be taken care of. Hence such means as collaborative partnerships sound feasible. However, for those who believe that they know what to do, the risk is to be influenced by an external ontology, not the volcano. In this sense, they already have their own “indigenous DRR framework” and there is no need for “revival” of local Indigenous knowledge and practices, or the re-implementation of Indigenous DRR by external agents. Still, should the government or other external agents intervene and attempt to implement another DRR plan to reduce the “risk”? If so, what is the justification to do so? Or can they merely be left alone? Will the scenario of the 2017 Ambae Island be repeated, if Sulphur Bay has been exposed to a massive eruption of Mt Yasur? Or do they start willing to listen to external actors to address the root causes of disasters (cf. [42])?

In Vanuatu, research on cultural aspects of volcanoes has rarely been conducted except a few and past attempts to introduce volcanic hazard awareness and education programs did not fully succeed [6,48]. In addition, DRR has mostly looked at climatic hazards by overseas researchers, with the dominant discourse of the development of locally-led adaptation and coping mechanisms generated from community resources (e.g., Refs. [8,10,15]). Hence our research attempted to fill this gap and to examine to what extent such dominant discourse, which may be a good fit in Indigenous DRR, is relevant to volcano risk reduction in the context of

communities like Sulphur Bay. Regarding volcano risk reduction, an Indigenous DRR framework can explore the possibility of DRR formulated solely based on indigenous beliefs, rather than seeking partnerships with external agents or suggestions by overseas researchers.

Bird and Gísladóttir [49] find that after the 2010 Eyjafjallajökull eruptions, Iceland, residents' attitudes changed. For instance, some residents close to Eyjafjallajökull became to stay alert to any signs of volcanic activity and are ready to move out. Bird and Gísladóttir [49] hence state that a massive eruption may be an opportunity to re-assess residents' attitudes and behavior concerning volcanic risk management. Our research was focused on Tanna Island. This is because at the time of our data collection in 2019, the Ambaens were still scattered across the country, mostly in evacuation centres in nearby islands and still recovering from the shock. We did not believe it was appropriate to visit evacuation centres and interview them. However, if one investigates how their views have changed before and after the Lombenben eruption of 2017, we may have some clues to address whether or not a formal volcano risk reduction plan should be implemented into Sulphur Bay and if so, what the feasible means are. Although in 2018 the VNDMO and government teams released assessment reports and action plans for the recovery from the impact of the Lombenben eruption on Ambae, the focus was more on material aids and the relocation of destroyed communities, and it did not much address the preparedness of the Ambaean communities and their ontologies [18,50]. The recommendations were also limited within the development of scientific techniques to collect data and monitor volcano activities [17]. Hence when the time comes, it is crucial to conduct similar research with the Ambaens focusing on their ontology and its change before and after the island evacuation. Of course, we must note the differences in the context of the two islands and volcanoes: Mt Yasur is a Strombolian volcano while the Lombenben volcano is not, hence the people's understanding of volcano eruptions may be different. Nevertheless, such research may identify means to work with these communities to enhance the level of preparedness and may open up a way to strengthen an Indigenous DRR framework regarding volcano hazards. And for such research, it is very crucial to include the voices of the most vulnerable – perhaps women and children. As the Sendai framework [47]; 7) has stated, “A gender, age, disability and cultural perspective should be integrated into all policies and practices, and women and youth leadership should be promoted”. Specifically, it calls for “adequate capacity-building measures ... to empower women for preparedness” [47]; 19) and identifies children and youth as agents of change. As stated, in Sulphur Bay, we were not successful in collecting the voices of those populations because of the hierarchical structure and the lack of women's empowerment. Targeting those populations may provide further keys to address whether or not these communities need an alternative framework of volcanic disaster risk reduction and how they can be implemented.

## Funding

The Government of Vanuatu and The University of the South Pacific.

## Availability of data and material

None.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Acknowledgement

We thank the villagers of the four case study sites to participate in our interviews and the VNDMO office for providing relevant information. The Vanuatu Government Scholarships and The University of the South Pacific funded this research.

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