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# Risk perception in small island developing states: a case study in the Commonwealth of Dominica

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## Abstract

Small island developing states (SIDS) face high vulnerability to natural hazards; thus, understanding risk perception in SIDS is an essential step toward reducing vulnerability. A case study in the eastern Caribbean's Commonwealth of Dominica, which has a notable volcanic risk, was selected to explore local risk perception, using a mixed-methods approach. Focus groups were conducted in 18 villages throughout Dominica. During the focus groups, participants produced hand-colored maps to show where they believed volcanic risk existed on the island and shared their reasoning behind their maps. Additionally, all focus group participants completed surveys collecting sociodemographic information. Participant's hand-drawn maps were scanned into a geographic information system, converted to raster images, and aggregated into various configurations based on demographic variables. The verbal explanations of their maps were transcribed, coded, and analyzed qualitatively using a grounded theory approach to identify key trends in perceived risk. Although gender was the only significant variable when analyzing the entire island, other demographic variables had differences in perception that were significant regionally. Understanding how demographic variables influence risk perception facilitates the development of better-tailored public outreach campaigns that could save lives when the next hazard threatens Dominica.

**Keywords** Risk perception · Small island developing states · Mixed methods · Geographic information systems · Participatory mapping

## 1 Introduction

The impact of risk perception on disaster outcome was demonstrated in 2010 when a 7.0 magnitude earthquake struck the Caribbean nation of Haiti. Immediately following the earthquake, Sri Lankan United Nations soldiers stationed in Haiti self-evacuated to high ground, while the Haitian population did not self-evacuate. Sadly, several Haitians died

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when two minor tsunamis inundated the coast (Fritz et al. 2013). Although Sri Lanka and Haiti are exposed to similar hazards, the Caribbean had not experienced a large earthquake-generated tsunami in 64 years (O'Loughlin and Lander 2010). Conversely, the 2004 Boxing Day tsunami killed approximately 230,000 people in Southeast Asia (Yamada et al. 2006). As a result, the Sri Lankan soldiers had increased awareness of the tsunami risk and took precautionary measures. Seeking to understand the factors that influence risk perception can result in better-tailored public outreach campaigns to build adaptive capacities in small island developing states (SIDS), which have increased risk and vulnerability to natural hazards.

SIDS are coastal territories that face specific social, economic, and environmental vulnerabilities that can enhance, in the short-term, hazard impacts and, in the long-term, lead to development challenges (United Nations 2011). While SIDS are often located in regions prone to natural hazards (Sjöstedt and Povitkina 2017), their vulnerabilities are heightened due to their isolated nature, limited infrastructure and resources, and dependence on sectors that are highly vulnerable to disasters such as tourism and agriculture. Furthermore, many SIDS have vulnerabilities stemming from the lasting effects of colonialism (Barclay et al. 2019). Thus, when disasters occur, it is appropriate to consider them not as individual events, but as processes impacted by decisions made and enforced throughout history (Oliver-Smith 2010).

SIDS have greater challenges responding to disasters than larger countries. Limited road networks often complicate efforts to reach affected populations (Benson et al. 2001). After Hurricane Matthew in 2016, aid workers in Haiti were unable to reach the southwest peninsula of the island due to the La Digue Bridge collapse (Mogul 2016). Since logistical obstacles often delay post-disaster relief in SIDS, people's risk perceptions greatly influence their preparedness and level of resilience.

As of 2014, 57 countries and territories were classified as SIDS (United Nations 2014) with a collective population of nearly 65 million (United Nations 2011). SIDS have a cumulative area of approximately 777,000 $km^2$, roughly the size of Pakistan. SIDS make up two-thirds of the countries facing the highest amount of loss because of geophysical-related disasters (Wilkinson et al. 2016). The likelihood of increasing disaster damages is further amplified by the threat of climate change-related sea-level rise. Therefore, it is crucial to consider carefully the best mechanisms to minimize disaster impacts (Kelman and West 2009).

Given the unique vulnerabilities of SIDS, it is essential to investigate the variables that influence risk perception so disaster managers can address existing concerns, comprehensions, and misconceptions. Although many hazard and risk perception studies have been conducted, the topics have not been studied adequately within a SIDS context. Méheux et al. (2007) argued that SIDS are at risk of having models inappropriately applied because many models fail to take into consideration the specific characteristics of SIDS nations. An island-centered approach, as called for by Barnett and Waters (2016), includes taking into account not only the physical and economic characteristics of an island, but also the historical, cultural, and social contests. Méheux et al. (2007) also recommend more involvement with local communities, while Jeremy Collymore, former director of the Caribbean Disaster Emergency Management Agency, stressed that the public needs to be more active in creating resilience (Collymore 2011).

This study answers this call for community-level research on risk perception in a SIDS context. An exploratory, sequential, mixed-methods approach is used to understand the factors affecting risk perception related to volcanic risk in the Commonwealth of Dominica. Combined focus group discussions, surveys, and participatory mapping exercises were employed to examine how modeled volcanic risk compared to perceptions of volcanic risk. The variables that were examined include gender, education levels, age, and distance from a volcano.

Volcanic risk was selected to study risk perception in Dominica because it poses a substantial threat to the population. Furthermore, the volcanoes threaten larger geographical areas relative to other hazards. We sampled participants from across the country with varying degrees of familiarity with hazards, thus it was important to select a hazard that laypeople would have a reasonable ability to map. For example, tsunami risk would not have been suitable for a national-level analysis since the risk is confined tightly to the coast given the island's steep topography. Earthquake risk would not have been suitable because the danger to life and property has a greater dependency on infrastructure, and, is thus difficult to map. Although other hazards differ from volcanic risk regarding the anticipated extent of damage, the suddenness of onset, or the frequency, etc., the results of this study can be useful, in a limited sense, as a proxy for understanding risk perception more broadly in SIDS. A follow-up study could be conducted at a different scale with a different hazard to assess whether the results are similar for the various social–demographic groups.

## 2 Background

### 2.1 Defining hazards and risk

Although terms such as hazard, risk, and disaster are often used interchangeably, the words have nuanced differences (Kelman 2018). Hazards are described by Smith (2013, p. 11) as potential events that threaten people, goods, or the environment. Hazards are commonly confused with disasters. However, the difference can be understood by thinking of them sequentially; every disaster develops out of a hazard (Paul 2011; Thywissen 2006). Risk is the exposure of something of human value to a hazard (Smith 2013, p. 11). While most definitions include probability as a component of risk, many also combine variables such as consequence, vulnerability, and magnitude (Paul 2011, p. 94). Vulnerability is the susceptibility of humans or systems to damage from a hazard (Morss et al. 2011). Another important component of understanding risk perception is resilience, which is the ability to respond and recover from disasters (Cutter et al. 2008).

### 2.2 SIDS vulnerability

SIDS are highly vulnerable from a geological and geographical standpoint. Volcanic islands, such as those in the Caribbean archipelago, tend to exist along or near tectonic plate boundaries, which can produce a variety of volcanic and earthquake-related hazards (Wilkinson et al. 2016; Nunn 1998). The physical risk to SIDS is compounded by their economic, social, political, environmental, geographical, and global change vulnerabilities. (Pelling and Uitto 2001; Encontre 1999; MacDonald 2005; DesRoches et al. 2011; Smith 2013; Munji et al. 2013; Wilkinson et al. 2016; Barclay et al. 2019). Although SIDS share many characteristics that increase their general vulnerability, the exact context can be great between individual SIDS. Therefore, it is important to consider each nation's specific vulnerabilities and geological/graphical hazards when developing tools/methods to evaluate or improve resilience (Boruff and Cutter 2007).

### 2.3 Risk perception

Given the high vulnerability of SIDS, it is important to understand risk perception adequately so emergency managers can proactively address existing beliefs and concerns. Without understanding how people think about risk, strategies devised to reduce risk may be ineffective (Slovic 1987). For instance, when Hurricane Matthew was approaching Haiti, many refused to evacuate out of fear their homes would be burglarized. Sadly, some who did not evacuate lost their lives (Mogul 2016). Decision-making related to natural hazards depends on both physical and behavioral factors. The instance in Haiti demonstrates how the ability to access information and to protect one's self is often not uniform within a society and leads to disparities during disasters (Eiser et al. 2012).

The study of risk perception gained popularity around the nuclear proliferation debates in the 1960s (Sjöberg et al. 2004). Since then, numerous theories have been developed to explain how people perceive risk. Theories orient around either the characteristics of the hazards, such as the psychometric model (Fischoff et al. 1978; Sjöberg 2000; Rippl 2002), or the characteristics of the people exposed to the hazard (e.g., Chauvin et al. 2007). Wildavsky and Dake (1990) identified five theories that influence individual risk perception; the political risk theory, the knowledge risk theory, the personality risk theory, the economic risk theory, and the cultural risk theory. This research draws primarily on the political and knowledge risk theories.

*The political risk theory* positions itself around variables such as gender, age, class, race, and political alignment. Regarding gender, women tend to perceive threats to pose a higher risk than men (Flynn et al. 1994). However, understanding precisely why perception differs between the genders is challenging (Gustafson 1998). Cutter et al. (1992) found women were only slightly more concerned about risk than men with the most dramatic differences in perception occurring when the hazard had the potential for death or the hazard political in nature, such as war. Regarding age, one theory is that adolescents are more impulsive and sensation-seeking than adults, which increases their tendencies to engage in risky activities (Reniers et al. 2016). However, few differences have been observed between middle-aged and senior populations (Bouyer et al. 2001).

*The knowledge risk theory* assumes people perceive risk depending on the extent of their knowledge of a hazard (Wildavsky and Dake 1990). Knowledge can be gained through multiple avenues such as education, ancestral knowledge, or experience (Johnston et al. 1999). Furthermore, knowledge of one hazard can influence a person's perception of other hazards. Thus, the awareness of real risk is a significant factor influencing perceived risk. However, the relationship between real risk and perceived risk is often underemphasized in the literature (Sjöberg 2000).

Effective risk communication depends on having quality relationships and collaborations between at-risk communities and civic agencies. This is especially important when people are exposed to hazards that occur infrequently and thus may not have firsthand experience to draw from to inform their perception of the risk (Paton et al. 2008), as is the case with volcanic risk in Dominica. When developing risk communication methods and outreach campaigns, it is important to consider whether the hazard is chronic or acute (Tobin et al. 2011). While no one has experienced a volcanic disaster in Dominica's recorded history, residents who live in the southern portion of the island are chronically exposed to evidence of the island's volcanic nature through their proximity to many of the island's geothermal features. This could influence their perception compared to others who do not have geothermal features in their communities.

### 2.4 The Commonwealth of Dominica

Dominica is a highly vulnerable SIDS located in the eastern Caribbean (Wilkinson et al. 2016). The island gained notoriety in September 2017 after it was directly hit and devastated by Hurricane Maria, a category five hurricane. The first author was in Dominica at the time of the storm, and as a result, data collection for this research was shortened.

Across Dominica's 750 km2 of area, roughly 72,000 citizens commonly live in disaster-prone structures and locations. Many homes are built on slopes prone to landslides and are constructed with concrete that can become deadly during an earthquake. Furthermore, the majority of the population lives near the island's coast and/or in low-lying river valleys, at risk of experiencing tsunamis, storm surges, and rain-induced flooding (Andereck 2007). Dominica's densely populated coast is a direct result of its colonial and emancipation history. In the 1700s "the Kings Three Chains," a 66-yard-wide coastal strip reserved for government purposes, was established. Following emancipation in 1838, landless former slaves often cultivated unoccupied land within in the King's Three Chains, ultimately resulting in an overcrowded coastal zone exposed to storm surge and flooding (Barclay et al. 2019).

The island has one of the highest concentrations of potentially active volcanoes in the world with nine volcanoes above an active magma reservoir system (Lindsay et al. 2005). It also has a collection of geothermal features, such as the world's second-largest boiling lake, multiple warm sulfur pools, and bubbling coral reefs. Dominica has a high risk of having an eruption in the next 100 years (Lindsay et al. 2005). Furthermore, most of the island's existing infrastructure, including its capital Roseau, is built on a historical pyroclastic flow (USAID 2006). Having key infrastructure built on historic flows is not uncommon among volcanic islands where most of the topography is steep (Wilkinson et al. 2016). With such a diverse set of hazards, as is typical with SIDS, it is important to understand the population's risk perception, working ultimately to mitigate future disaster outcomes.

### 2.5 Existing data models and maps

The volcanic risk model found in The Volcanic Atlas of the Lesser Antilles (Lindsay et al. 2005) served as a control for this study (Fig. 1). The data and information about the island of Dominica came from a volcanic hazard assessment conducted by Dominica's Office of Disaster Management in partnership with the Seismic Research Unit (2001).

To develop the volcanic hazard model, the six most likely volcanic scenarios were identified, decreasing in likelihood from 1 to 6:

1. Phreatic eruption in the Valley of Desolation
2. Dome-forming eruption in the Plat Pays complex
3. Explosive eruption at Morne Anglais/John
4. Dome-forming eruption from Wotten Waven/Micotrin
5. Explosive Plinian eruption from Wotten Waven/Micotrin
6. Dome-forming eruption from Morne Aux Diables.

The risk levels of each scenario were calculated based on likelihood and modeled extents of volcanic hazards such as ballistics, ashfall, and lahars. The volcanic risk extends from the eruption vent in various ways depending on the type of eruption; symmetrically/radially for ballistics, oblong/radially for ash, and through the valleys for

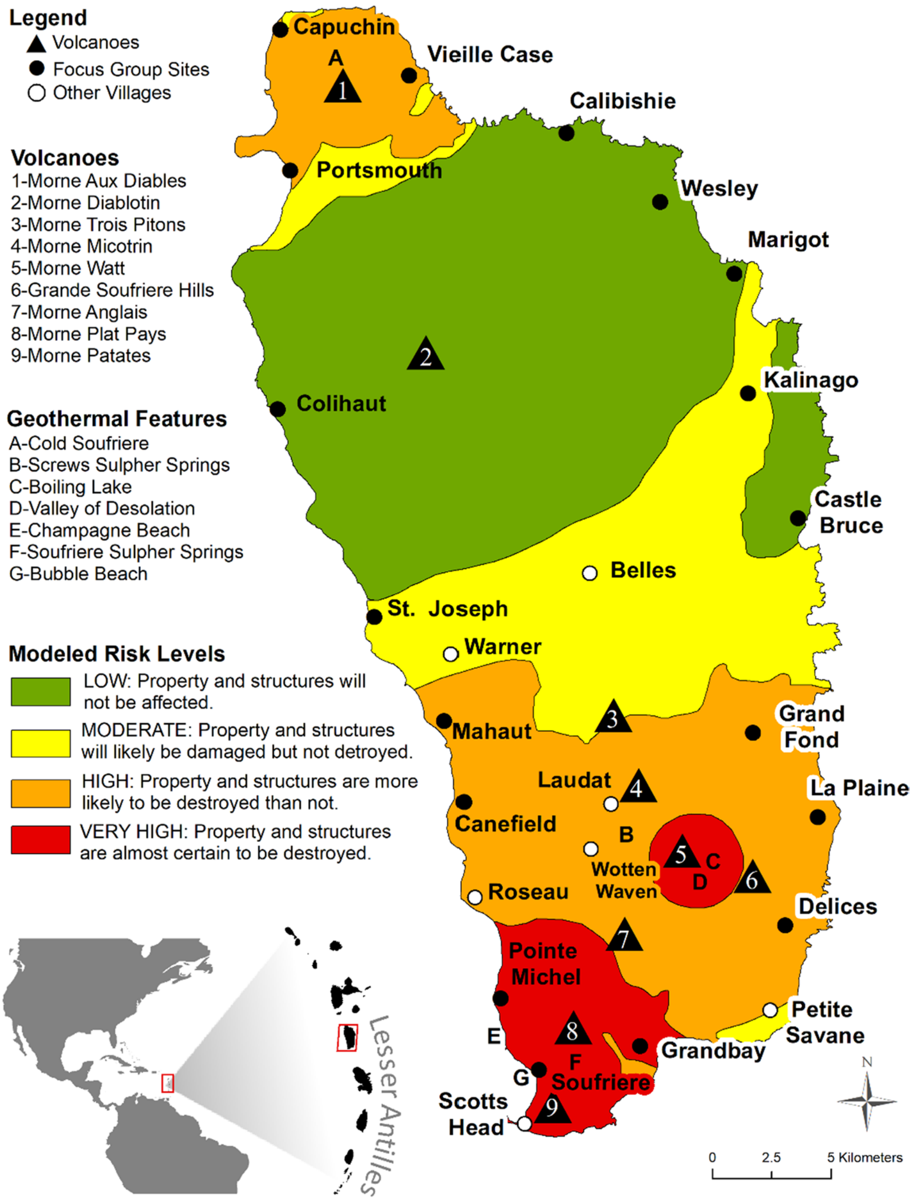


**Fig. 1** Reference map of the Commonwealth of Dominica depicting the location of the island and its volcanos, geothermal features, eighteen focus group sites, and additional villages for reference. The risk level data comes from The Volcanic Hazard Atlas (Lindsay et al. 2005). The risk data were used to create the modeled risk map, and the legend was provided for participants to use while completing their individual maps

lahars and pyroclastic flows (Lindsay et al. 2005). Risk levels were categorized to range from low to very high (Lindsay et al. 2005). The authors noted it was complicated to analyze the real risk since, unlike on other Caribbean islands, Dominica has multiple volcanoes. Thus, the volcanic scenarios were weighted to avoid exaggerating the risk. The authors carefully noted that the models are subject to change if there are shifts in volcanic activity and as knowledge of the volcanos increases (Lindsay et al. 2005; Lindsay and Robertson 2018).

While not perfect, an aggregated risk map is appropriate to use since the population is exposed to aggregated risk from the volcanoes. During the focus groups, participants almost always mapped in a weighted manner, taking into consideration the likelihood and order in which they perceived the volcanoes would erupt. The goal of this research is to compare the modeled risk with perceived risk using participatory mapping methods.

## 3 Methods

This study used an exploratory, sequential, mixed-methods approach. Primary data on volcanic risk perception were collected in Dominica between March and September 2017 via focus groups, surveys, and participatory mapping. A geographic information system (GIS) and grounded theory were used to examine how risk perception was influenced by gender, age, education level, and distance from a volcanic peak. Approval to conduct this research was obtained through Northern Illinois University's Institutional Review Board.

### 3.1 Village and participant selection

Focus group locations were selected based on four criteria, village type (urban, suburban, rural), village population (ranged from 200 to 3,500 residents), the location on the island (north, south, east, west, interior), and distance from a volcano (<6 km, >6 km) (Fig. 1). Six kilometers was chosen as the threshold for categorizing villages for analysis since it was the median distance that villagers lived from a volcano. Additionally, the 6 km division point also broadly aligns with hazard exposure; following the 1995–1998 volcanic eruption in nearby Montserrat, an exclusion zone of approximately 4 to 6 km (depending on topography) was established to prevent people from getting too close to the volcano (Haynes et al. 2007). Considering elevation as a variable, along with distance, would have strengthened this study as hazardous materials such as lahars and pyroclastic flows do not emit symmetrically and instead travel along valleys. However, it was beyond the scope of this study due to difficulties effectively representing topography to participants (Haynes et al. 2007). Topography and village location, either in a valley or on a ridge, was brought up regularity during discussions and could be analyzed subsequently.

Although 25 focus groups were planned, only 18 were conducted due to the landfall of Hurricane Maria in September 2017. For each focus group, participants were purposively sampled so that 12 people—consisting of four adults under 30, four adults between 30 and 60, and four adults over 60, with two males and two females in each category—had confirmed their intent to attend. Typically, around ten people participated.

Lunch was provided as an incentive. In some locations, lunch was an important draw, while, in other locations, participants were indifferent. Overall, people were interested and eager to participate. However, the young men were notably less interested. In contrast to younger participants, older participants generally saw the research as highly important, including participants well into their 90 s.

### 3.2 Local support

A pilot focus group was conducted with geography students at the Dominica State College. Their feedback was instrumental, permitting improvements to the survey instrument that was administered to all attendees. A handful of the students volunteered to help facilitate future focus groups and administered surveys to participants with difficulty reading.

Village community centers were used as focus group venues and members of the village councils assisted in inviting participants to attend, particularly the older and younger adults since those demographics were challenging to locate independently. Villages were canvased, accompanied by a council member, the morning of the focus group to remind invited participants, and invite any needed replacements. One member of the village council attended each focus group as a participant and to assist should translations be needed. The role of village councils was key to gaining the trust of the community members, particularly when canvassing.

Additionally, Dr. Robert Watts, a volcanologist on the island, volunteered, and attended most focus groups to close with a question and answer session to provide accurate information regarding volcanic hazards in Dominica.

### 3.3 Focus groups

First, participants received a brief explanation of the research objectives, an overview of the activities, and the opportunity to ask questions. After providing their consent to participate, a survey was administered to gather sociodemographic information and inquire about previous disaster experiences and hazard awareness. The survey results were used to classify individual maps into various sociodemographic groups for analysis.

Next, participants received crayons and a map of Dominica containing only town locations and roads for reference. Participants were instructed to map their perceived boundaries of low (green), moderate (yellow), high (orange), and very high (red) volcanic risk, in correspondence with the legend used in the scientific model (Fig. 1) (e.g., Fig. 2). The study took place when there were no signs of volcanic unrest. Participants mapped based on where they believed there was potential for an eruption and the degree of damage they anticipated. The completed individual maps were used to create composite maps during analysis.

Participants worked at their own pace until they finished mapping. This approach was successful as it accommodated individuals arriving at different times, minimized the likelihood of participants working together, and ensured researchers were available to assist participants who had vision or reading limitations.

After a lunch break, participants were gathered into a circle and took turns sharing their maps and the thoughts that guided their mapping process. This portion was video-recorded to be transcribed and coded for data analysis. Participants were welcome to skip this portion of the event if they were uncomfortable sharing and were reassured that there was no shame in saying they guessed.

Following the group discussions, participants collaborated to create a single volcanic risk map of Dominica, which will serve as an area of subsequent study to evaluate how collaboration may impact risk perception compared to individual assessments.

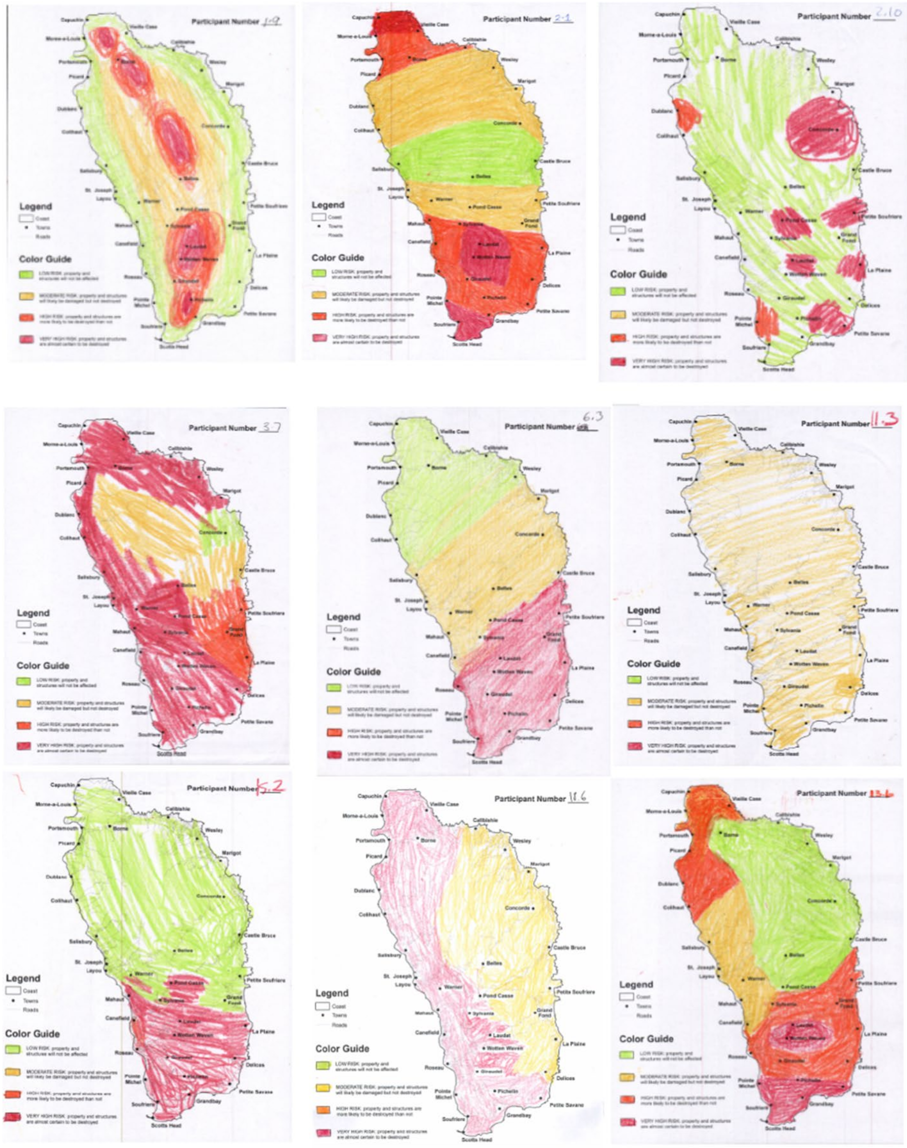


**Fig. 2** Examples of individual maps to show the variety that existed among participant's drawn risk perceptions

## 3.4 Quantitative analysis of risk perception maps

An analysis of individuals' risk maps followed Gould's (1973) analysis of preference maps, updated to accommodate continuous rather than discrete input of ranked data. A series of steps were taken to transform the individual maps drawn by participants into raster images that could be used to construct composites. Upon the completion of each focus group, the individual maps generated by participants were scanned and imported into *ArcMap* where they were georeferenced. Once the image of each participant's map was georeferenced, a coastal outline shapefile of the islands was exported to create a new layer for each participant. The participant's shapefile was then digitized according to the scanned risk map visible below. Each polygon was ascribed a number corresponding to the four risk levels (low = 1, medium = 2, high = 3, very high = 4). Next, each shapefile was rasterized using the Polygon to Raster tool. Rasters generated at this step were aligned to a template, so that each raster's cell size (100 m) and extent precisely matched all others to easily support subsequent overlays and comparison. Finally, Python scripts written as Jupyter Notebooks were used to generate composite maps dependent on the sociodemographic survey results.

To make comparisons between demographic groups, we used several techniques. First, the average composite raster for each group (e.g., "male" and "female") could be compared visually. Second, when only two aggregates were present, the difference between the aggregate rasters of each could also be used to support visual and statistical analysis. To evaluate whether the overall perception of risk was different between groups (e.g., "Does Group A view the island as a whole riskier than Group B?"), we calculated the mean pixel value for each individual and used conventional nonparametric statistical significance testing (Wilcoxon signed-rank and Kruskal–Wallis tests) to determine whether the difference in mean pixel value was significant. Mean rather than median pixel values were used as the basis of comparison, as this enabled the greatest discrimination between pixels given the limited range of responses of four discrete levels of indicated risk.

Finally, to determine *where* perceptions of risk were different, we ran conventional nonparametric statistical tests on the "stacks" of rasters for groups on a per-pixel basis. This was the equivalent of testing whether a given pixel showed a statistical difference in median value between, for example, men and women. For each pixel, we calculated the effect size using Cohen's $d$ (Table 1). The process was repeated for all valid land pixels in the raster set and was automated in Python.

Statistical maps were generated as output to depict the regions of the island where the statistical analyses were significant with a mild effect size, $p < 0.05$, $d > 0.2$ and regions of the island where the statistical analyses were significant with a moderate effect size, $p < 0.05$, $d > 0.5$. We used an alpha level of .05 for all statistical tests.

### 3.5 Qualitative analysis

To understand how demographic factors influenced perceived volcanic risk, audio recordings of the group discussions and researcher memos were transcribed and reviewed to search for emerging themes. Next, transcripts were open-coded iteratively according to grounded theory, and similar codes were grouped to form concepts. By using a grounded theory approach, codes and concepts could emerge from the data, as opposed to being pre-determined by the researchers (Strauss and Corbin 1990; Creswell and Creswell 2009). Themes were then compared by various sociodemographic variables to better understand how different subgroups of participants conceptualized and experienced risk.

**Table 1** Summary statistics for each analysis and the percentages of the maps that were significant with mild and moderate effect sizes

| Analysis | Aggregate group comparisons | | | | Area with mild effect size | Area with moderate effect size |
|---|---|---|---|---|---|---|
| | Test | Statistic | $p$ value | Cohen's $d$ | $.5 > d > .2, p < .05$ (%) | $d > .5, p < .05$ (%) |
| Expertise | Wilcoxon | 3.554 | < 0.001 | 1.13 | 5.1 | 78.5 |
| Gender | Kruskal–Wallis | 4.28 | 0.04 | 0.28 | 17.6 | 1.3 |
| Distance | Kruskal–Wallis | 2.59 | 0.11 | 0.20 | 17.4 | 0.1 |
| Education | Kruskal–Wallis | 2.59 | 0.27 | 0.12 | 8.7 | < 0.1 |
| Age | Kruskal–Wallis | 5.83 | 0.32 | 0.15 | 7.5 | 1.85 |

# 4 Results and discussion

## 4.1 Participant versus expert assessment of volcanic risk

A visual comparison of participants' maps revealed commonalities and differences (Fig. 2). To understand better how Dominicans as a whole perceived risk, all 167 individual maps were aggregated on a per-pixel basis using a GIS to create a composite map (Fig. 3c). The composite map was compared to the modeled volcanic risk map from the Volcanic Hazard Atlas (Lindsay et al. 2005) (cf. Figs. 1, 3a).

As an aggregate, participants rated the island as more risky ($M=2.28$) than experts ($M=2.02$; Wilcoxon signed-rank $T=3{,}554$, $p<0.001$). Broadly speaking, the aggregate participant risk map was similar to the modeled map (Fig. 3). As with the model, participants perceived two distinct zones of very high risk in the southern region with a zone of high-risk surrounding them, as well as a high-risk region in the far north. They perceived moderate risk predominantly in the middle of the island, and a low-risk region in the northeast that extends faintly through the interior, brushing a small portion of the west coast. Per-pixel statistical significance tests (Wilcoxon Signed-Rank test, Fig. 3f) found most of these differences to be statistically significant, with 78.5% of pixels showing a moderate effect size ($0.5 \geq d > 0.2$, $p<0.05$) and an additional 5.1% of pixels showing a mild effect size ($d>0.5$, $p<0.05$).

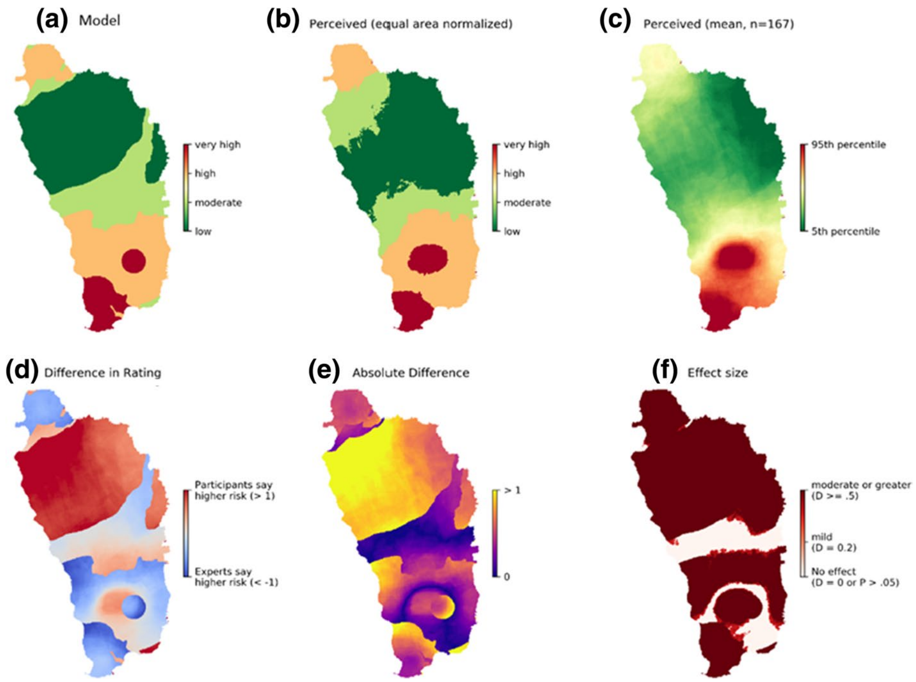


**Fig. 3** Results of the expert modeled versus participant perceived risk analysis including the expert map (**a**), normalized aggregate participant map (**b**), aggregate participant map (**c**), difference map (**d**), absolute difference map (**e**), and map of per-pixel effect sizes. The data shown in panel a come from The Volcanic Risk Atlas (Lindsay et al. 2005)

Because participants' sense of risk may have been uncalibrated relative to the experts, a follow-up representation of perceived risk was constructed in which the relative percentages of land area for the modeled map were used to establish percentile-based thresholds from the participant data (Fig. 3b). In this way, both representations had the same areal extent for each category of risk (very-high, high, moderate, low). Although statistical testing could not be conducted on these adjusted values, it visually distinguishes how participants allocated risk differently in a spatial sense.

From this perspective, there were two key differences in how experts and laypeople understood risk. First, the area of risk indicated by participants surrounding the Morne Watts Complex was substantially larger and shifted westward relative to experts. Second, while the modeled map indicated a low-risk interior, participants indicated larger zones of moderate risk. This is hypothesized to be because of Morne Diablotin and the population's general over-overestimation of the risk it poses. Although Morne Diablotin is the largest volcano in Dominica, it is also the oldest and lowest risk according to experts and thus was not used as a scenario in the weighted model (Lindsay et al. 2005). 78.5% of the island had significant differences with a moderate effect size ($0.5 \geq d > 0.2$, $p < 0.05$), located primarily in the far north, interior, and in three bands in the south. Additionally, 5.5% of the island had significant differences with moderate effect sizes ($p < 0.05$, $d > 0.5$) located in four clusters surrounding the interior with two smaller clusters in the far south (Table 1) (Fig. 3d).

To understand spatial variations in how demographics groups perceive risk, composite risk perception maps were created based on gender, distance from volcanic peaks, level of education, and age. Because of our relatively small sample size, we did not take an intersectional approach to look at the relationship between identity and risk perception.

### 4.2 Gender

Overall, men perceived the volcanic risk slightly more pronounced ($Mdn = 2.44$) than women ($Mdn = 2.22$; $H = 4.28$, $p = 0.04$, $d = 0.28$) (Fig. 4). Relative to women, men tended to indicate higher risk throughout most of the island, particularly the southern region surrounding the Morne Plat Pays Complex and Morne Anglais. Per-pixel effect size analysis indicated that these differences were statistically significant. In contrast, women tended to identify the far northern region surrounding Morne Au Diables as riskier, although with a very weak effect size. Women's risk maps tended to match more closely to the model, more clearly featuring two distinct regions of very high risk in the south and a larger area of high risk in the north. Women indicating lower overall risk than men were unexpected since the literature suggests that men underestimate risk compared to women (Finucane et al. 2000). However, the trend of women being more sensitive to risk has been hypothesized to be dependent on the context of the risk (Eckel and Grossman 2008) and socioeconomic status of the women (Finucane et al. 2000). Cutter et al. (1992) found the most dramatic differences in perception—where women perceive risk higher than men—occur when the hazard had a potential for death or was political. Thus, given the context, it was expected that women would have been more sensitive to the risk.

Since women mapped the island to be generally safer, the women were anticipated to have a more extensive dialogue about the safe areas. However, twice as many men spoke about safe areas than women (Table 2). Thus, there is a disconnect between how men and women mapped the risk and how they spoke about it.

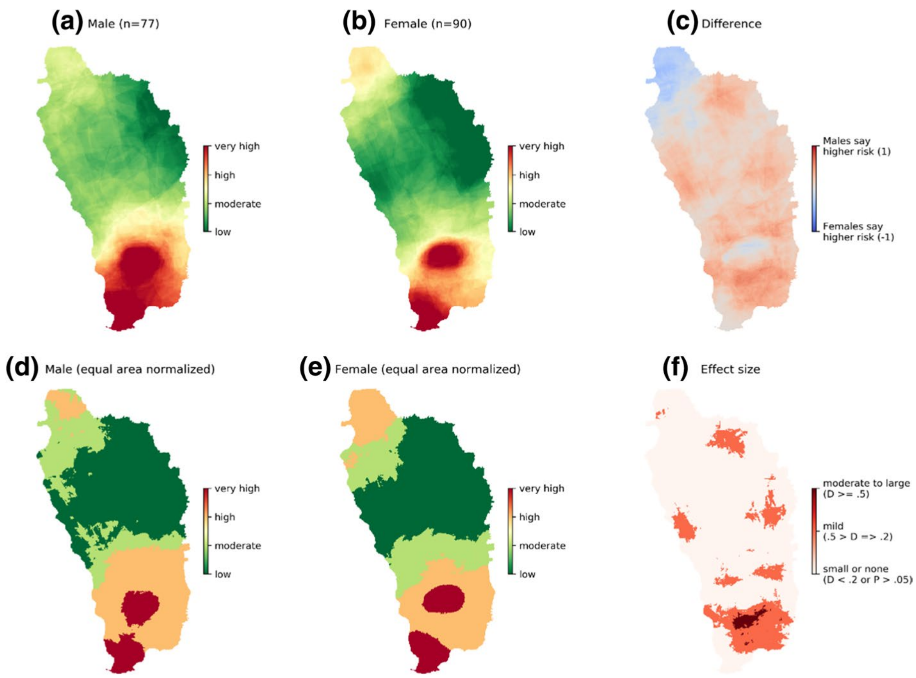


**Fig. 4** Results of the gender analysis including the male composite map (**a**), female composite map (**b**), difference map (**c**), equal-area normalizations (**d** and **e**), and a map of per-pixel effect sizes

## 4.3 Proximity to the hazard

The distance analysis examined the difference in perception between participants who lived within 6 km of a volcanic peak (Fig. 5a) and those who lived further than 6 km from a volcanic peak (Fig. 5b). Those further from volcanoes rated the risk as modestly higher ($Mdn = 2.37$) compared to those living nearer ($Mdn = 2.28$), although this difference was not statistically significant ($H = 2.59$, $p = 0.11$, $d = 0.2$). The per-pixel analysis showed that those living further perceive the risk to be higher along the western edge of the island (Fig. 5c). The northwest and three smaller portions in the southwest were significant with a mild effect size ($p < 0.05$, $d > 0.2$), which accounts for 17.4% of the island. The significant area with a moderate effect size ($p < 0.05$, $d > 0.5$) was only 0.1% of the island, located in the Roseau Valley area (Fig. 5f). Conversely, the eastern interior was perceived as a higher risk by the near group, though not in a significant way (Fig. 5c). Participants living beyond 6 km from a volcano regularly spoke of their villages as being safe, a place where others would come to in the event of an evacuation (Table 2).

> If we remembered in years gone by when they are talking about the volcanoes were active, people were packing their suitcase and their boxes to come to Marigot because they say there was a safe place. (Far, Participant 14.2)

On the other hand, participants within 6 km from a volcano would at times downplay the level of risk in their villages.

> My area, which is south Soufrière, I didn't want to put it completely red. I know we

**Table 2** Percentages of demographic groups that spoke about various factors influencing volcanic risk perception. Villages were coded as dangerous or safe based on the descriptions provided by the participants

| All participants | Villages | | Physical features | | Self-confidence | |
|---|---|---|---|---|---|---|
| | Dangerous (%) | Safe (%) | Topography (%) | Geothermal (%) | Confident (%) | Diffident (%) |
| All participants | 74 | 42 | 52 | 35 | 20 | 26 |
| *Gender* | | | | | | |
| Male | 98 | 78 | 74 | 43 | 30 | 24 |
| Female | 63 | 33 | 37 | 32 | 16 | 32 |
| *Distance* | | | | | | |
| Within 6 km | 85 | 56 | 64 | 43 | 20 | 33 |
| Beyond 6 km | 72 | 31 | 48 | 27 | 21 | 22 |
| Education | | | | | | |
| < High school | 79 | 38 | 40 | 25 | 24 | 24 |
| High school | 86 | 50 | 75 | 34 | 30 | 27 |
| College | 84 | 45 | 55 | 51 | 16 | 38 |
| *Age* | | | | | | |
| < 30 | 94 | 37 | 83 | 34 | 9 | 51 |
| 30 s | 77 | 50 | 78 | 50 | 22 | 44 |
| 40 s | 77 | 65 | 69 | 38 | 23 | 26 |
| 50 s | 81 | 63 | 74 | 37 | 44 | 26 |
| 60 s | 95 | 70 | 85 | 45 | 25 | 35 |
| > 70 | 82 | 32 | 68 | 25 | 25 | 39 |

> are threatened by our volcano. We don't know when it could happen, anytime, but I still feel that it is not so much of a high risk. (Near, Participant 13.3)
> I have colored that section of Dominica as low risk; purely because I am biased you know, I live there (group laughs). (Near, Participant 16.5)

Generally, participants in the south of the island, along with those in the extreme north, reside within 6 km of a volcano, while participants who live in the interior and northeast tend to live further than 6 km away from volcanos. Their patterns of risk perception suggest that people who live near the volcanos have accepted the risk around them and see it as less of a threat, perhaps underestimating the risk as a coping mechanism, a phenomenon Sjöberg (2000) refers to as risk denial. Conversely, the people who live further from the hazard could be overestimating the risk because it is less familiar to them, which is a common tendency (Slovic 1990).

### 4.4 Educational attainment

Participants' maps were aggregated into three groups to examine the differences in volcanic risk perception according to educational attainment: less than high school (Fig. 6a), high school (Fig. 6b), or college/university (Fig. 6c). When comparing their composite maps, the southern region is similar for all three groups (Fig. 6). However, participants with some level of college education identified higher risk in the far north

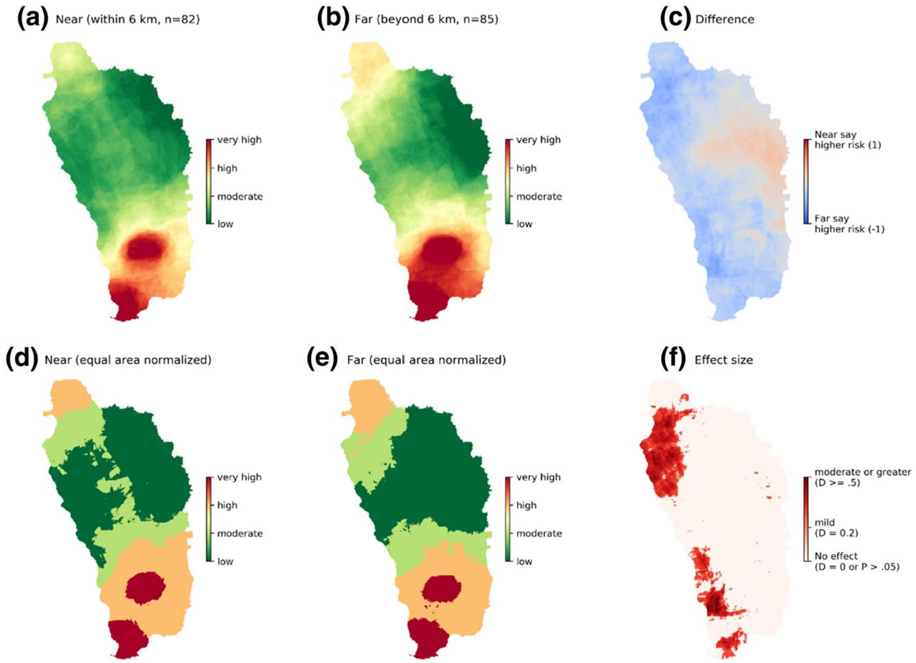


**Fig. 5** Results of the distance analysis including the composite map for participants who live within 6 km from a volcanic peak (**a**), the composite map for those living beyond 6 km (**b**), the difference map (**c**), equal are normalizations for both groups (**d**, **e**) and a per-pixel map of effect sizes (**f**)

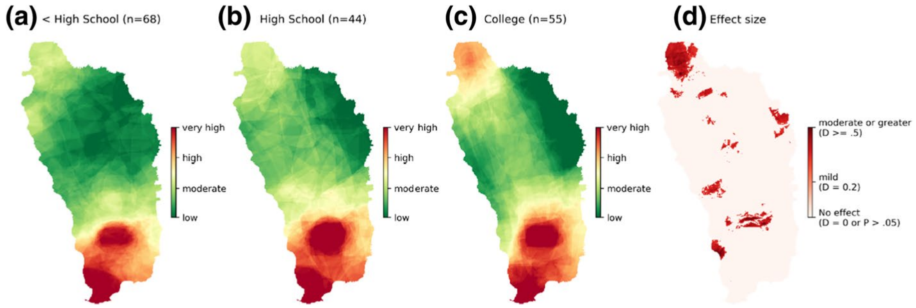


**Fig. 6** Results of the education analysis including the composite map for participants who did not complete high school (**a**), the composite map for participants who did complete high school (**b**), the composite map for participants who have some level of college education (**c**), the per-pixel effect size map (**d**)

than the other two groups. In this respect, the college-educated composite was more reflective of the scientific model. Statistically, the overall differences between the educational group's risk perceptions were not significant ($H = 2.59$, $p = 0.27$, $d = 0.12$), with those having less than a high school education viewing the aggregate risk level as slightly lower ($Mdn = 2.28$) than the other two groups (high school $Mdn = 2.37$, college $Mdn = 2.35$) (Table 1). However, the region in the far north, along with eight or so scattered patches were significant with a mild effect size ($p < 0.05$, $d > 0.2$) covering 8.7%

of the island. The significant areas with a moderate effect size ($p < 0.05$, $d > 0.5$) only account for 0.1% of the island (Fig. 6d).

The composite of those who went to college resembles the female composite and could be a result of the college group being comprised of 64% women. When canvassing, individuals were not asked about their educational attainment. The college group having 14% more women supports the findings of Bailey (2009) that the tertiary education gender imbalance generally favors women in the region.

## 4.5 Age

To analyze the difference in volcanic risk perception among age groups, participants' maps were aggregated according to their age by decade (Fig. 7). The under 30 demographic (Fig. 7a) viewed the island the most moderately with two distinct very-high-risk zones in the south. Those in their 30s (Fig. 7b) had greater low risk in the interior with their southern very-high-risk areas less clearly defined. Of all the demographics, they identified the far north as having the highest risk. Those in their 40s (Fig. 7c) and 50s (Fig. 7d) perceived the southern portion of the island the most dangerous with extensive very high risk, even higher than the scientific model suggests. Those in their 60s (Fig. 7e) and those 70 and older (Fig. 7f) depicted relatively small very-high-risk areas in the south. Those in their 60s captured high risk in the far north, while the 70 and older group considered the far north as moderate and the safest of all the age groups.

Although age was not a significant factor overall ($p = 0.32$) (Table 1), there were scattered portions of the age map that were significantly different ($p < 0.05$). 7.5% of the map was significant with a mild effect size ($d > 0.2$), and 1.8% of the map was significant with a moderate effect size ($d > 0.5$) (Fig. 7g). Most of the significant regions were on the southeast side of the island, likely the result of the very high risk perceived by the participants in their 40s and 50s. The increased sensitivity to the risk in the south by those in their 40s and 50s could be related to a massive swarm of approximately 1,500 earthquakes, between 1998 and 2000. The quakes resulted in the Seismic Research Center in Trinidad sending a scientific team to Dominica to conduct aerial surveys, ground reconnaissance missions, and install a 19-station GPS monitoring network across the south (Cakafete 1999; University of the West Indies-Seismic Research Centre 2009). The participants in their 40s and 50s would have been aged between 20 and 40 at the time of these seismic swarms and may have a stronger memory of these events.

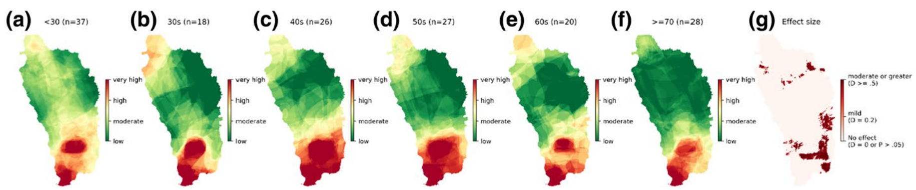


**Fig. 7** Results of the age analysis including the composite map of participants aged between 18 and 29 (**a**), the composite map of participants in their 30s (**b**), the composite map of participants in their 40s (**c**), the composite map of participants in their 50s (**d**), the composite map of participants in their 60s (**e**), the composite map of participants aged 70 and above (**f**), the per-pixel effect size map (**g**)

### 4.6 Factors influencing risk perception

While there are similarities between the overall perceived risk and the modeled risk, only a handful of participants mentioned having previously seen a volcanic risk map of the island. Data from the focus group discussions suggest that the similarity between the maps is largely the result of a combination of personal experiences and the recollection of claims heard over the years. Aside from the variables, three factors that influenced how participants spoke about volcanic risk were identified: (1) the geography of the island's villages, (2) the island's physical features, and (3) participants' confidence in their knowledge. Furthermore, how these factors intersected with gender, distance from volcanic peaks, education levels, and age were examined (Table 2).

### 4.7 The geography of the island's villages

When discussing the island's volcanic risk, participants categorized specific villages as either dangerous, safe, or moderately safe. In doing so, the participants expressed mental maps, which captured their opinions on the physical landscape. Perception is influenced by how an individual understands the structuring of their environment (James 2018). Lynch (1960) first used a freehand participatory mapping method to understand differences in how people perceive the same city environment.

In our study on volcanic risk, most participants (74%) (Table 2) described villages as dangerous, especially villages in the island's south. Conversely, less than half (42%) of participants referred to specific villages as safe (Table 2).

Villages considered safe were most commonly those in the northeast, such as Marigot and Wesley. On multiple occasions, it was expressed that the northeast villages would serve as evacuation locations in the case of a volcanic eruption. Also, in that vicinity is the Kalinago territory, where the indigenous people of Dominica still live (Honeychurch 1995). The Kalinago territory was frequently associated with low volcanic risk. When a focus group was conducted with the Kalinago, their territory was the only place on the island they considered low risk.

Historically, the Kalinago fiercely resisted colonial control of Dominica for over two centuries. However, by the time the British gained full control of the island in 1763, the Kalinago were restricted to several isolated hamlets in the northeast. In 1776, Britain officially set aside 232 acres of land for the Kalinago. Their territory was expanded in 1903 and now spans 3,700 acres, roughly 2% of Dominica (Carib Territory in Dominica n.d.; Kalinago Territory n.d.). Other indigenous groups have long hazard-related oral histories that have survived within the communities until the modern day (Fritz and Kalligeris 2008; King and Goff 2010). Thus, it is possible the Kalinago occupied the northeast because of ancestral knowledge of risk. However, there were no mentions of passed down oral histories about risk that were recorded during focus group discussions. We intended to conduct follow-up interviews related to this matter. However, Hurricane Maria struck Dominica three days after the Kalinago focus group, tragically devastating the community. Thus the topic remains an area for subsequent research.

The propensity for participants to talk about dangerous villages more than the safe villages could be related to participants' seemingly increased exposure to information regarding the dangerous areas of the island compared to the safe areas. 82% of what participants cited as having learned from peers, the media, etc., explicitly referred to dangerous regions of the country as opposed to safe regions. Furthermore, the additional emphasis on dangerous locations corresponds with findings that animals are conditioned to understand safety as the learned absence of danger (Rogan et al. 2005). In this context, perhaps participants in our study discussed dangerous places more than safe places since only one volcano must be perceived as threatening an area for the area to be considered dangerous. Conversely, for an area to be considered safe, participants would need to perceive an absence of risk from all nine volcanoes. More information is needed for a location to be perceived as safe as opposed to dangerous. Furthermore, a small number of participants admitted that, although they colored safe areas on their maps, they did not believe those areas were actually safe. Thus, some participants' maps do not fully reflect their perception.

> I wanted to do the entire country in red but didn't want to seem crazy (group laughs). Just for us not to be scared, I put some green parts (group laughs), but that is not what I think is reality (Man, Participant 3.1)

Participants commonly classified villages as dangerous or safe relative to a village's proximity to various physical features. Thus, villages were serving as mental shortcuts for describing the locations of the various physical features.

### 4.8 The Island's physical features

The second factor influencing risk perception was the island's physical features, which were categorized as topographic (mountains or valleys) or geothermal (sulfur springs, bubbling reefs, etc.). Across all participants, 52% of physical feature references were topographic, while 35% were geothermal (Table 2).

Study participants perceived very-high-risk zones to exist primarily in the southern region. Focus group discussions revealed that these regions are perceived as risky due to their proximity to geothermal features. Most participants cited the Boiling Lake and Valley of Desolation as the reasons they perceived the Roseau Valley environs to have high risk. In far southern areas perceived as high risk, most participants emphasized the Champagne Beach and the Soufrière sulfur springs.

Six of Dominica's nine volcanoes are located in the southern third of the island. Thus, it is unsurprising that participants perceived this area to be high risk. The southern volcanoes were generally referred to collectively or with phrases such as "the volcano above Roseau," while the central and northern volcanoes tended to be referred to by name. This may be because the southern volcanoes are smaller and younger compared to the volcanoes in the north, which are more physically prominent and seemingly better known. The participants increased familiarity with the northern volcanoes is potentially related to the island's tourism industry. Although Dominica has a less robust tourism sector than other Caribbean islands (Boxill and Severin 2004), many ecotourists are attracted to the island to hike. Hiking trips to the peak of Morne Diablotin in the north and Morne Trois Pitons in the interior are popular and bring tourism dollars into the surrounding areas. Conversely, tourism in the south is more closely linked to geothermal features such as going for a soak in the sulfur springs or snorkeling at Champagne Beach.

Most of the risk identified in the interior was related to Morne Diablotin, Dominica's largest and highest volcano. Due to its age, it is the least likely to erupt and is represented as low risk on the scientific model (Fig. 1). Regardless, participants focused extensively on risk related to Morne Diablotin during the group discussions. Only one individual alluded to its unlikelihood of erupting.

> Morne Diablotin has been dormant for more than 400 years and from what volcanologists say 400 years and more is considered extinct, right? It is considered extinct. (Participant 14.1)

The area in the far north was perceived as high risk primarily due to earthquake swarms. In April 2003, there was a swarm consisting of as many as 1,000 shallow earthquakes, which were likely due to magma settling beneath Morne Aux Diables (Abraham 2003). In 2004, a 6.0 magnitude earthquake occurred 10 km to the north of Dominica, which caused a church to collapse (DaVibes 2013). This event was cited on multiple occasions during the focus group discussions.

While the physical features were almost always considered an indicator of high risk, there were instances when villages near mountains or geothermal features were considered safe. This was due to the expectation that wind patterns would blow the ash away or that a nearby valley would redirect lava around specific villages or remain beneath villages located on top of a valley.

> While some agree it is in high-risk, I would put Grand Fond [as] low-risk. It is true we have the volcano, or we are close to Laudat, but because of our topography in Grand Fond, we have these mountains, these valleys on either side and mountains. (Participant 4.8)

When references to physical features were analyzed by gender, a greater number of men spoke about the topography of the island (74%) than geothermal features (35%) (Table 2). The men referred to specific volcanoes more consistently and expressed heightened concern for the byproducts of a potential volcanic eruption including lava and ash, as well as the impacts an eruption would have on the island's infrastructure and people's health. Conversely, women spoke with almost equal likelihood about the topography (37%) and the geothermal features (32%). Women seemed to associate the volcanic risk more closely with personal experiences, such as visiting the sulfur pools for a swim, or recollecting when a volcano-related earthquake damaged the church in the north.

> There is no reason that the water in Soufrière should be as hot as it is…sometimes you can cook an egg or hardly put your toes in there because of the heat. (Woman, Participant 13.7)

Women in our study demonstrated an embodied environmental knowledge, linking their understanding of volcanic risk to how they have physically used and experienced the affected spaces, consistent with other literature on the gendered environmental knowledge production (e.g., Rocheleau et al. 1996; Bee 2016). Conversely, the more abstract focus of men's emphasis on the byproducts of the volcanic eruptions, and impact on the infrastructure and people's health, is consistent with other literature on environmental risk perception that has found that men tend to frame risks in more scientific or technical terms, while women frame risks in environmental or community terms (Gustafson 1998).

When evaluating how distance from a volcanic peak influenced participants' understanding of the island's physical features in relation to the volcanic risk, both topographic and geothermal features were spoken about more by participants living within 6 km of a volcanic peak (64% and 43%, respectively) than those living beyond 6 km from a volcanic peak (48% and 27%, respectively) (Table 2).

As mentioned, participants living closer to volcanoes mapped the high-risk areas (according to the model) as safer than those living further from volcanoes. This is in line with the findings of Sjöberg (2000) that people who are familiar with a hazard tend to underestimate risks.

When physical features were analyzed in relation to educational attainment, the results mirrored the general analysis that groups focused more extensively on topography than geothermal features. Participants with college educations repeatedly distinguished between the north being safe and the far north being dangerous by referring to Morne Au Diables in the far north and its earthquake swarms over the recent decades. The distinction between the risk levels in the north and far north was made less frequently by the other two education demographics.

### 4.9 Participants' confidence in their knowledge

The third major factor influencing how participants drew their risk maps and spoke about their assessment was their confidence in their understanding of volcanic risk. According to Slovic et al. (1980), confidence does not ensure accuracy since people often hold misconceptions with great confidence. During focus group discussions 20% of participants made statements expressing confidence in their understanding of volcanic risk, while 26% of participants expressed a lack of confidence in their understanding (Table 2).

The level of confidence varied by gender; men spoke more frequently and on a broader variety of topics. Thirty percent (30%) of men express confidence, while 24% of men expressed diffidence (Table 2). They cited a combination of travel, what they had heard from others and their occupations as reasons for their confidence.

> I know for a fact that we have about 9 active volcanoes in Dominica, and I know for a fact that they are in these regions, and the reason I know it is because I am employed at the Forestry Division. (Male, Participant 15.8)

On the other hand, twice as many women expressed diffidence (32%) than expressed confidence (16%). Many of the women who expressed confidence attributed their knowledge to what they had heard said by others.

> I don't know much about volcanic hmm eruptions…. but I believe Laudat, Wotten Waven, and the surrounding areas will be greatly affected. Ok. The majority of my map was guesswork (laughs) (Woman, Participant 7.2)

Considering that the women's composite map is more reflective of the scientific model than the men's, there is no identifiable reason to believe they are less knowledgeable about the risk. These results support the findings of Hill et al. (2010) that women are less confident than men in matters related to the sciences.

Participants who lived in closer proximity to the volcanoes were less confident in their understanding of risk than those who lived further. This is different from other cases, such as in Vanuatu, a SIDS located in the Pacific, where local knowledge has played an important role in recognizing indicators of increased volcanic risk, such as unusual bubbling or gas smells surrounding geothermally active regions (Cronin et al. 2004).

An inverse relationship exists between participants' level of education and how confident they felt in their understanding of volcanic risk. The college-educated participants expressed uncertainty (38%) more frequently than confidence (16%), often citing that they did not study a relevant field (Table 2). College-educated participants typically qualified their ability to assess volcanic risk in the context of their educational experiences, occupations, or travel.

> Recently, I was in Soufrière doing Scuba diving research; even under the water, we have bubbles coming on, so that is evidence of volcanic activities. (College, Participant 14.5)

Less-educated participants were more confident in their abilities to assess volcanic risk, expressing equal levels of confidence and lack of confidence. Participants with college educations expressing less confidence than the other two demographics can be likened to the Dunning–Kruger effect, which proposes that there is a negative relationship between competence and confidence until a certain point of expertise is reached (Dunning 2011).

Participants' confidence in how well they understood the volcanic risk was also related to age. Participants at both the younger and older ends of the spectrum expressed more diffidence (Table 2). The younger participants, like the college group, often referred to not studying geography. The middle-aged participants referenced a wider variety of sources for their knowledge such as media, workshops, and travel for work and leisure.

> We have learned through history, the news, the broadcast, the radio, and experts coming from Trinidad to Dominica, they usually let us know that Laudat and the boiling lake is the most active volcanic area (50 s, Participant 11.8)

For the older participants, lack of confidence was attributed to age or poor memory. One participant also referenced having lived abroad as the reason they were not confident in their assessment. It is not uncommon for Dominicans to go abroad for large portions of their lives, returning home to retire (Fontaine 2006). Therefore, this sentiment is likely not unique.

## 5 Conclusion

This study employed a mixed-methods approach to understanding the risk perception of a natural hazard using focus groups, surveys, participatory mapping, and GIS. Multiple key findings can be used to understand how Dominicans perceive volcanic risk and inform best practices for outreach campaigns.

When composite risk maps of the entire island were analyzed, gender was the only statistically significant variable. However, there were statistically significant regional differences in the maps, related to the participant's level of education, age, and how far they lived from a volcano. Focus group discussions revealed three primary factors that influenced thought processes of how participants perceived risk on the island: (1) the island's physical geography, predominantly its topography and geothermal features, (2) the participant's confidence in their assessment of the risk, and (3) the perceived safety levels of villages.

Based on the findings of this study, a series of recommendations are proposed. Dominicans are generally aware of the island's volcanic nature, yet unsure how a volcanic eruption would unfold. The first recommended is that more information is shared regarding the types of eruptions and warning times that are expected. For instance, the most likely volcanic scenario is from the Valley of Desolation and that while unlikely to emit magma, such an eruption would be capable of sending ballistics up to 5 km (Lindsay et al. 2005). Additionally, clarifying information about Morne Diablotin's unlikelihood of erupting should be shared along with the reassurance that signs of unrest are expected to precede an eruption from any of the volcanoes, allowing people to evacuate (Lindsay et al. 2005). People's understanding of volcanic hazard maps could be enhanced by incorporating 3D maps and aerial photographs, as was done by Haynes et al. (2007) when studying the effectiveness of communicating volcanic risk in Montserrat. Doing so could be crucial to raising resilience, since lowering the risk via developmental planning is particularly difficult in volcanic SIDS. For instance, the data put forth in the Volcanic Hazard Atlas has yet to be used widely within the region to redirect development away from the very-high-risk areas, likely due to a lack of realistic options in lower-risk zones (Lindsay and Robertson 2018).

The second recommendation is for increased community-level outreach and dialogues regarding the natural hazards that threaten Dominica. Those knowledgeable about local hazards could facilitate community discussions, similar to what was accomplished by Dr. Watts, the volcanologist who attended focus group sessions to answer questions. If done, it is anticipated that confidence would rise among citizens as they gained familiarity with the risks around them.

Third, the results of this study could be used to develop more targeted public outreach campaigns via media outlets to address the currently held beliefs within communities and demographic groups. By doing so, emergency managers would be better situated to respond to the concerns of the communities to increase resiliencies.

Fourth, while this study sought to understand perceptions of volcanic risk in Dominica, it is anticipated that many of the findings may apply to other hazards or contexts within the island. The population's risk perception is likely influenced by being exposed to such a wide variety of hazards (multiple volcanos, tsunami, earthquake, hurricane, etc.) compared to populations with less overall risk. As was mentioned above, this study was cut short by Hurricane Maria, a category 5 storm. That experience alone could have affected the population's sensitivity to risk. Further research could be conducted to investigate.

The fifth recommendation is that the participatory mixed-methods approach used in this study should be replicated and applied to understand risk perception in a variety of contexts beyond Dominica, including both SIDS and non-SIDS regions. Hypothetically, if a similar study were applied to SIDS outside of the Caribbean—such as in the Pacific—the analyses may produce different results due to higher percentages of indigenous groups. The methods could also be applied to other types of hazards such as crime in urban centers. The methods could be used to understand hazards at varying scales ranging from local to global. It is encouraged that others utilize these methods to understand differences in perception among other sub-fields of hazard research.

Sixth, we believe the mixed-method participatory GIS approach used in this project has applications outside of hazards and risk perception research and could potentially be used for other forms of environmental management.

Seeking to understand how and why demographic variables influence risk perception further allows emergency managers and organizations to understand existing concerns and beliefs and enables them to provide clarifying information about hazards and how to respond in the event of a disaster. By following these recommendations, at-risk nations like Dominica could become more prepared and resilient.

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