Risk Perception in Small Island Developing States: A Case Study in The Commonwealth of Dominica

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ABSTRACT

RISK PERCEPTION IN SMALL ISLAND DEVELOPING STATES: A CASE STUDY IN THE COMMONWEALTH OF DOMINICA

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Northern Illinois University, 2018
Walker Ashley, Co-Director
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Small island developing states (SIDS) face high vulnerability to natural hazards. Understanding risk perception in SIDS is an essential step towards reducing vulnerability on these at-risk island states. A case study in the eastern Caribbean's Commonwealth of Dominica, which has a notable volcanic risk, is used to explore risk perception. Specifically, focus groups were conducted in 18 villages throughout Dominica where participants produced hand-colored maps to show where they believed volcanic risk existed on the island and shared their reasoning behind their maps.

Surveys were administered to all focus group participants to collect necessary sociodemographic information. Subsequently, participants’ hand-drawn maps were converted to raster images and aggregated to various configurations using a raster calculator. The explanations of their maps were transcribed, coded, and analyzed qualitatively using a grounded theory approach to identify trends in thought processes among demographic groups. Analyses conducted included modeled vs. perceived risk, gender, distance from volcanic hazards, education level, and age. Statistical analyses were applied to determine if the difference in risk perception between groups was significant.
When composite risk maps of the entire island were analyzed to examine differences in risk perceptions among demographic groups, the gender of the participants was the only statistically significant factor. However, different demographic groups perceived portions of the island to have significantly higher volcanic risk, for instance, the far north of the island for participants who had been to college, portions of the western coast for participants living more than 6km from a volcanic peak, and a section of the southeast for participants aged between 40 and 50. Understanding the demographic variables that have the most considerable influence on risk perception facilitates the development of better, more tailored public outreach campaigns that could save lives when the next hazard threatens Dominica.
RISK PERCEPTION IN SMALL ISLAND DEVELOPING STATES: A CASE STUDY IN THE COMMONWEALTH OF DOMINICA

BY

HANNAH EBOH
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A THESIS SUBMITTED TO THE GRADUATE SCHOOL
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Thesis Co-Directors:
Walker Ashley
Courtney Gallaher
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my vision and brainstorming to identify the tools (and code) needed to make it a reality. I thank Dr. James Wilson for providing support and feedback over the course of this project.

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Hannah Eboh, 2018
DEDICATION

To the nation and people of the Commonwealth of Dominica as they continue to recover from Hurricane Maria
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES</th>
<th>vii</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF FIGURES</td>
<td>viii</td>
</tr>
<tr>
<td>LIST OF APPENDICES</td>
<td>viix</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2. MANUSCRIPT</td>
<td>5</td>
</tr>
<tr>
<td>Introduction</td>
<td>5</td>
</tr>
<tr>
<td>Background</td>
<td>8</td>
</tr>
<tr>
<td>Methods</td>
<td>15</td>
</tr>
<tr>
<td>Results and Discussion</td>
<td>23</td>
</tr>
<tr>
<td>Conclusion</td>
<td>48</td>
</tr>
<tr>
<td>3. WHITE PAPER</td>
<td>52</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>58</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>63</td>
</tr>
<tr>
<td>Table</td>
<td>Description</td>
</tr>
<tr>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>1:</td>
<td>Common challenges faced by SIDS.</td>
</tr>
<tr>
<td>2:</td>
<td>Analyses conducted and the statistical tests applied.</td>
</tr>
<tr>
<td>3:</td>
<td>Summary statistics for each analysis and percentages that met the parameters for mild and moderate effect sizes.</td>
</tr>
<tr>
<td>4:</td>
<td>Percentages of demographic groups that spoke about the various factors influencing volcanic risk perception.</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Reference map of the Commonwealth of Dominica</td>
<td>14</td>
</tr>
<tr>
<td>2: Example of individual maps</td>
<td>20</td>
</tr>
<tr>
<td>3: Results of the modeled versus perceived risk analysis</td>
<td>24</td>
</tr>
<tr>
<td>4: Results of the gender analysis</td>
<td>28</td>
</tr>
<tr>
<td>5: Results of the distance analysis</td>
<td>30</td>
</tr>
<tr>
<td>6: Results of the education analysis</td>
<td>32</td>
</tr>
<tr>
<td>7: Results of the age analysis</td>
<td>34</td>
</tr>
</tbody>
</table>
# LIST OF APPENDICES

<table>
<thead>
<tr>
<th>Appendix</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: INSTITUTIONAL REVIEW BOARD APPROVAL LETTER</td>
<td>64</td>
</tr>
<tr>
<td>B: FOCUS GROUP CONCENT FORM</td>
<td>67</td>
</tr>
<tr>
<td>C: FOCUS GROUP SURVEY</td>
<td>69</td>
</tr>
<tr>
<td>D: FOCUS GROUP BLANK MAP</td>
<td>72</td>
</tr>
<tr>
<td>E: GIS ANALYSIS</td>
<td>74</td>
</tr>
<tr>
<td>F: PYTHON CODE</td>
<td>76</td>
</tr>
<tr>
<td>G: CODING MATRIX</td>
<td>85</td>
</tr>
</tbody>
</table>
CHAPTER 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, a group of Sri Lankan United Nations soldiers stationed in Haiti self-evacuated to high ground. Conversely, the local Haitian population did not self-evacuate. As a result, several Haitians lost their lives when two minor tsunamis inundated the southern coast (Fritz et al. 2013). While Sri Lanka and Haiti are exposed to similar hazards, it had been 64 years since an earthquake last generated a large tsunami in the Caribbean, killing 1,790 in the Dominican Republic (O’Loughlin and Lander 2010). On the other hand, the 2004 Boxing Day tsunami in Southeast Asia killed an estimated 230,000 people, with roughly 31,000 deaths taking place in Sri Lanka (Yamada et al. 2006). Thus, unlike the Haitian population, the Sri Lankan soldiers had increased awareness and perception of the relationship between earthquakes and tsunamis and took additional precautionary measures. Many factors, including past experiences, influence risk perception (Barnett and Breakwell 2001). Seeking to understand those factors can result in better tailored public outreach campaigns to address misconceptions and build adaptive capacities. Doing so is especially crucial in small island developing states (SIDS), which have inherently increased risk and vulnerability to natural hazards and resulting disasters.

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; Table 1). Their vulnerabilities include their isolated nature, limited infrastructure and resources, and dependence on sectors that are highly
vulnerable to disasters, such as tourism and agriculture. Furthermore, SIDS are often located in geographically hazardous areas prone to earthquakes, tsunamis, hurricanes, volcanic eruptions, flooding, drought, storm surge, and landslides (Sjöstedt and Povitkina 2017).

Table 1: Common challenges faced by SIDS. After: United Nations, 2011

- Narrow resources bases
- Small domestic markets with substantial dependence on select outside markets
- High costs of energy, infrastructure, transportation, communication, and services
- Long imports and exports to trade markets
- Low and irregular international travel volumes
- Little resistance to natural disasters
- Small but usually growing populations
- High volatility of economic growth
- Limited private sectors with substantial dependence on the public sector
- Fragile natural environments

SIDS often face more difficulties responding to disasters than larger countries. For instance, in SIDS, limited road networks often complicate efforts to reach affected populations (Benson et al. 2001). In Haiti after the passing of Hurricane Matthew in 2016, aid workers were unable to reach residents who did not evacuate because the La Digue Bridge collapsed and cut off access to the island's southwest peninsula (Mogul 2016). In SIDS, risk perception is commonly more complicated than assessing the initial threats posed by a disaster event. Logistical obstacles often delay post-disaster relief. Thus, people’s risk perception also affects their preparedness for secondary risks such as isolation, theft, violence, and illness in the aftermath of the initial disaster. While community collaboration generally increases following a disaster, so do instances of theft, violent crime, etc. (Frailing 2006). While the vulnerabilities that afflict SIDS have long existed, their formal recognition from the international community has been relatively recent. For instance,
the first official UN recognition of SIDS’ environmental risks was not until 1992 at the UN Conference on Environmental Development (UNCED; United Nations 2011).

As of 2014, 57 countries and territories were classified as SIDS, categorized into three groups: the Caribbean; the Pacific; and the African, Indian Ocean, Mediterranean, and South China Sea (AIMS; United Nations 2014). For perspective, in 2014 there were nearly 65 million inhabitants across all SIDS (United Nations 2011) and SIDS had a cumulative area of approximately 777,000 km², roughly the size of Pakistan. Over time, disaster impacts in SIDS have been increasing. Between 1991 and 2000, the costs of disaster damages rose from 9 billion USD to 22 billion USD and the number of people affected rose from 9 million to 18 million (United Nations 2014). The likelihood of increasing disaster damages is further amplified by the threat of climate-change-related sea level rise. Therefore, it is crucial to carefully consider the best mechanisms to minimize disaster impacts (Kelman and West 2009).

Given the unique circumstances and vulnerabilities of SIDS, it is essential to investigate the variables that influence risk perception so that 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 they fail to take into consideration the specific characteristics of SIDS nations. They also recommend that more attention is placed on local communities. Furthermore, Jeremy Collymore, former director of the Caribbean Disaster Emergency Management Agency, stressed that the public needs to have a more active role in creating resilience (Collymore 2011).
This study answers this call for community-level research on risk perception in SIDS. Here 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 are employed to examine how modeled volcanic risk compared to perceptions of volcanic risk and how sociodemographic factors and geographic proximity to a volcano affect risk perception. In this study, Dominica’s volcanic risk is used as a proxy for understanding risk perception more broadly, since the hazard extends radially from the source of the volcano, making it simpler for participants to map when compared to, for example, earthquake, landslide, or tropical cyclone risk. The sociodemographic variables that were examined include gender, distance from a volcano, education level, and age.
CHAPTER 2
MANUSCRIPT

Introduction

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example, earthquake, landslide, or tropical cyclone risk. The sociodemographic variables that were examined include gender, distance from a volcano, education level, and age.

Background

Defining Hazards and Risk

Although many terms in hazard science are used interchangeably, such as "hazard," "risk," and "disaster," the words have nuanced differences which are debated among scholars (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, meaning every disaster develops out of a hazard (Paul 2011; Thywissen 2006). Essentially a disaster occurs when a hazard is realized (Coppola 2007). 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). The opposite of vulnerability is resilience, which is the ability to respond and recover from disasters (Cutter et al. 2008). While resilience, especially social capital, is an important component to examine to understand risk perception, incorporating resilience into the analysis was beyond the scope of this study.
SIDS Vulnerability

Smith (2013) identifies five key drivers of vulnerability: including economic, social, political, environmental, geographical, and global change, which can be considered within the context of SIDS to understand their specific vulnerabilities. Economic vulnerability is increased by inequality and poverty, which restricts the poor's access to insurance, capital, health care, information, etc. Among SIDS, the percent of populations living below the poverty line varies widely, resulting in some SIDS having high human development—such as Seychelles—and others having low human development—such as Haiti (United Nations 2011). Thus, reducing economic vulnerability will require taking into consideration each island’s unique economic circumstances.

Social vulnerability depends on factors such as age, gender, and ethnicity. The youngest and the oldest members of society tend to be the most vulnerable, partly attributed to their common dependence on others during a disaster (Smith 2013 p. 63). In regard to gender, the difference in survivorship tends to affect women disproportionately, as was exemplified during the 2004 Indian Ocean tsunami, which killed four times as many women as men in Indonesia, Sri Lanka, and India (MacDonald 2005).

Political vulnerability can be derived from less competent or corrupt governments, which can lead to poorly maintained infrastructure and under-confident government employees (Smith 2013 p. 65). Much of SIDS’ political vulnerability is related to international development partners. For example, Dominica has been considered by some to be a “rascal state” due to its relations with “rogue states,” a term used to identify states that threaten world peace (Hubbell 2008). In Dominica, international politics have also had a positive impact on vulnerability. For example,
Windsor Stadium, gifted by the Chinese government in 2007, served as an aid distribution center following Tropical Storm Erika in 2015 (Oranizacao Pan-Americana de Saude 2011).

Environmental vulnerability is amplified by unsustainable agricultural practices, including deforestation, overcultivation, and clearance of mangrove forest (Smith 2013 p. 66). Throughout SIDS, mangroves serve as coastal protective systems. When mangroves are cleared, coastal susceptibility to damage from storm surge increases (Munji et al. 2013). Similarly, deforestation can quicken soil erosion, particularly during storm events (Kaly et al. 2002).

Geographical vulnerability is mostly the result of two factors: urbanization and remoteness. High population densities and the development of slums often accompany urbanization (Smith 2013 p.67). Such conditions compounded the devastation in 2010 when an earthquake struck Port-au-Prince, Haiti. Furthermore, remoteness limits mobility and access to outside assistance. Issues associated with remoteness were also evident in the aftermath of the Haitian earthquake when the country struggled to obtain and distribute foreign aid (DesRoches et al. 2011).

Global change vulnerability is increased through three mechanisms related to globalization: technological innovations, increased global connections, and global interdependence (Smith 2013). An example of technological innovation would be Dominica’s Imperial Road System, completed in 1956. While the road network increased mobility, it has led to many incidents of mass wasting (Yifru 2015). An example of increased global connections would include growing migration rates. Immigration from poorer countries, as well as the emigration of wealthy citizens, increases vulnerability. An example of global interdependence would be SIDS’ general inability to trade competitively on a global scale due to limited trade opportunities, high transportation costs, and island-specific intrinsic restrictions.
Understanding the types of vulnerability that exist and threaten SIDS nations can allow for more careful planning and the implementation of strategies to reduce vulnerability and increase resilience.

**Risk Perception**

Given the highly vulnerable context of SIDS, it is important to understand risk perception appropriately so emergency managers can proactively address the existing beliefs and concerns of their populations. For instance, when Hurricane Matthew was approaching Haiti, some Haitians refused to evacuate out of fear their homes would be burglarized. Haitian emergency managers considered forcibly evacuating residents to save their lives but ultimately could not due to the large numbers of people and limited time. Sadly, many Haitians who did not evacuate lost their lives (Mogul 2016). Thus, more effective public outreach campaigns could be designed if generally held perceptions and concerns, such as the fear of robbery, are taken into consideration.

The study of risk perception is of considerable interest, specifically for policymakers (Sjöberg 2000) and those concerned with reducing vulnerability. The field gained popularity around the nuclear proliferation debates in the 1960s (Sjöberg et al. 2004). Since that time, a number of different theories have been developed to explain how people perceive risk. These theories focus on either the nature of the hazards, such as the psychometric model (Fischhoff et al. 1978; Rippl 2002; Sjöberg 2000), 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 is of greatest relevance for this research. It positions itself around power dynamics associated with variables such as gender, age, class, race, and political alignment. In regard to gender, women tend to perceive threats as having a higher risk than men (Flynn et al. 1994). However, understanding precisely how and why perception differs between the genders is challenging (Gustafson 1998). Cutter et al. (1992) found that women were only slightly more concerned about risk than men and that the most dramatic differences in perception occurred when the hazard had a potential for death or the hazard was societal 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 and disregard warnings (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 that people perceive risk depending on the extent of their knowledge of the hazard (Wildavsky and Dake 1990). The awareness of real risk is a significant factor influencing perceived risk. Research suggests that most people have reasonably accurate risk perceptions. However, the relationship between real risk and perceived risk is often underemphasized in the literature (Sjöberg 2000).

The Commonwealth of Dominica

Dominica is a highly vulnerable SIDS located in the eastern Caribbean. The island gained familiarity in September 2017 when it took a direct hit and was devastated by Hurricane Maria, a
Category 5 hurricane. The first author was in Dominica at the time of the storm, and as a result, data collection for this research was shortened.

Like many SIDS, Dominica has an assortment of vulnerabilities. Across its 751 km$^2$, roughly 72,000 citizens commonly live in disaster-prone structures and locations. For instance, homes are commonly located on steep slopes, prone to landslides, and are often constructed using concrete, an affordable and durable material that can become deadly during an earthquake. Furthermore, the majority of the population live near the island’s coast and/or in low-lying river valleys and are at risk of experiencing tsunamis, storm surges, and rain-induced flooding (Andereck 2007).

The island has nine active but currently dormant (non-erupting but with the potential to become erupting) volcanoes as well as a collection of geothermally active features, such as the world’s second largest boiling lake, multiple warm sulphur pools, and bubbling coral reefs. Thus, Dominica is considered to have a high risk of eruption in the next 100 years and is one of the world’s most geothermally active regions. Furthermore, most of the island’s existing infrastructure, including its capital Roseau, is built on a historical pyroclastic flow (USAID 2006). 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 reduce vulnerability and mitigate future disaster outcomes.

**Existing Data Models and Maps**

The United States Agency for International Development (USAID), in partnership with Dominica's Office of Disaster Management, published a series of hazard risk maps for Dominica
in a report titled, "Development of Landslide Hazard Map and Multi-Hazard Assessment for Dominica, West Indies" (USAID 2006). The objective of this project was to develop individual hazard maps including a volcanic risk assessment conducted by the University of the West Indies Seismic Research Unit. The volcanic risk model generated by the assessment served as a control for this study and is, from this point on, referred to as the scientific model (Figure 1).

Figure 1: Reference map of the Commonwealth of Dominica. Depicted are the location of the island and its volcanos, geothermal features, the eighteen focus group sites, and additional villages for references. Also depicted are the risk levels used in the modeled volcanic risk map, which was the same legend provided in the participant’s individual maps. The risk level data comes from the volcanic risk assessment in the “Final Report Development of Landslide Hazard Map and Multi-Hazard Assessment for Dominica, West Indies” (USAID 2006).
The hazard assessment project was carried out with the understanding that having detailed hazard data would facilitate more appropriate planning and decision making. The assessment strictly considered the physical hazards and did not attempt to include analyses on the loss of life, personal injury, economic or social losses that may be related. The results of the assessment were intended to be used for general understanding only and should not take the place of site assessments.

To develop the volcanic hazard map, the six sites most likely to experience volcanic activity were identified, then the risk levels were calculated ranging from low to very high. The authors of the volcanic hazard assessment (University of the West Indies Seismic Research Unit) noted that the volcanic risk analysis was complicated because the real risk levels are dependent on which volcanic site experiences an event first. Thus, the volcanoes were weighted based on expert analysis to avoid exaggerating the risk (USAID 2006).

For this study, Dominica’s volcanic risk was used as the research focus since volcanic hazards, unlike the island's other hazards, have a risk that extends radially from the point source, therefore making it a simpler hazard for participants to map than the alternatives. The goal of this research is to compare the modeled volcanic risk map to participants’ perceived risk created by Dominicans using participatory mapping methods.

Methods

This study used an explanatory, sequential, mixed-methods approach. Primary data on volcanic risk perception was collected in Dominica between March 2017 and September 2017 using focus group discussions, surveys, and participatory mapping. In each village included in the
study, data was collected at a single community event where all participants completed a survey, a mapping exercise, and then participated in a group discussion. The goal of the research was to study how Dominicans perceived volcanic risk compared to modeled risk. We examined the influence of various sociodemographic variables on risk perception within a SIDS context, including 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 (Appendix A).

**Village and Participant Selection**

Eighteen focus group locations were selected based on four criteria, the distance from a volcano (<6km, >6km\(^1\)), the village type (urban, suburban, rural), the population of the villages (which ranged from approximately 200 to 3,500 residents), and the general location on the island (north, south, east, west, interior). The goal was to select diverse villages (see Figure 1). Initially, the plan was to conduct 25 focus groups. However, after the passing of Hurricane Maria in September 2017, it was logistically impossible and ethically inappropriate to continue data collection. Thus, eighteen focus groups were conducted. All focus groups were held on Saturday afternoons due to the availability of participants.

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 were present. Occasionally a demographic group was underrepresented if

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\(^1\) Six kilometers was chosen as the threshold since it was the median distance that villagers lived from a volcano.
some participants did not show up or over represented if a participant brought along friends who were not originally invited. Overall, the demographics were well balanced among the total sample of 167 participants.

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

Local Support

Before the first focus group, a geography lecturer at the Dominica State College assisted in organizing a pilot focus group with her geography students. Their feedback was instrumental, permitting improvements to be made to the survey instrument that was administered to all attendees. A handful of the students volunteered to help facilitate future focus groups by administering surveys to older participants with difficulty reading. Furthermore, they provided guidance as participants progressed through the activities of the focus group discussions.

Once villages were selected, the respective village councils were contacted to reserve their community centers to host the focus groups. Village councils also assisted by inviting participants to attend the focus groups, particularly the older and younger adults since those demographics were commonly challenging to locate independently. For each location, one member of the village council attended the focus groups as a participant and to assist should any dialect or cultural
meanings need translation. Furthermore, a council member accompanied the researchers to canvass the village on the morning of the focus groups to remind invited participants of the event and to invite any needed replacements should any of the original participants be unable to attend. 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 nearly all of the focus groups to provide a question and answer session following the focus group discussions to provide accurate information related to the volcanic hazards in Dominica.

**Focus Groups**

Upon arrival, participants were greeted and worked through the activities at their own pace. This approach was successful as it accommodated individuals arriving at different times and minimized the likelihood of participants working together. During the event, researchers were available to assist participants who had weak vision or could not read.

First, participants received a brief explanation of the research objectives, excluding details that had the potential to skew the results of the study. For example, they were not told their results would be compared by demographic groups. Participants were also given an overview of the activities and the opportunity to ask questions about the agenda. After providing their consent to participate in the study (Appendix B), a short survey was administered to gather socio-demographic information about each participant along with background information about their previous experiences with disasters and hazard awareness (Appendix C). The surveys took roughly
10 minutes for participants to complete and the 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, which corresponded with the same legend used in the scientific model (see Figure 1, Figure 2, Appendix D). The mapping took around 15 minutes per participant. While most participants worked on their maps quickly, there were some who took longer and expressed feeling conflicted about which colors to choose. After participants finished their maps, they were encouraged to take a lunch break, which gave some of the slower participants and late arrivers time to catch up before moving on to the group discussion. The completed individual maps were used to create composite maps during analysis, so the modeled risk could be compared to perceive risk.

After refreshments, participants gathered into a circle and took turns sharing their maps and explained their thought processes in drawing their maps. This portion of the focus group was audio and video recorded so it could be transcribed and coded for data analysis. Participants were welcome to skip participating in this portion of the event if they did not feel comfortable sharing; however, this only happened a handful of times. Additionally, participants were reassured that there was no shame in saying that they guessed. In several of the focus groups, debates were generated as to why or why not certain areas on the island were perceived to be safe. In all, most of the disagreements were in good spirit, and there was only one instance that needed moderation. On average, the group discussions took between 20 and 40 minutes depending on the size of the group.
Figure 2: Example of individual maps. These show the variety that existed among the participants’ drawn risk perceptions.
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.

**Quantitative Analysis**

A series of steps were taken to transform the individual maps drawn by participants into raster images that could be used to construct composites (Appendix E). Upon the completion of each focus group, the individual maps generated by participants were scanned as JPEG files and imported into ArcMap where they were geo-referenced using a world file to match the existing Dominica coastal shapefile. Once the image of each participant's map was geo-referenced, a new coastal outline shapefile was exported to create a new layer for each participant. The participant’s geo-referenced risk map was used as a reference so the participant’s corresponding layer could be digitized. Digitizing was done by hand using the advanced editor toolbar. Each polygon created was ascribed a number corresponding to the four risk levels (low=1, medium=2, high=3, very high=4). Once digitization was complete, the shapefiles were rasterized in batches using the polygon to raster tool so that each pixel of a map was prescribed a number indicative of its perceived risk level.

Next, Python scripts were run in Anaconda (Appendix F) to generate composite maps using the individual map rasters. The individual rasters used to create the various composite rasters were dependent on the social-demographic survey results (Table 2).²

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² When creating the composite maps, the 5th and 95th percentiles of the perceived risk composite (inclusive of all participants’ maps) were used to account for regression to the mean and to enable comparison between the maps of the different demographic variables.
Table 2: Analyses conducted and the statistical tests applied.

<table>
<thead>
<tr>
<th>Analyses</th>
<th>Composite rasters created</th>
<th>Statistical tests applied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeled versus Perceived</td>
<td>Model</td>
<td>T test, Wilcoxon signed-rank test</td>
</tr>
<tr>
<td></td>
<td>Perceived (all participants)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Male</td>
<td>T test, Kruskal-Wallis test</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>Participants within 6km</td>
<td>T test, Kruskal-Wallis test</td>
</tr>
<tr>
<td></td>
<td>Participants beyond 6km</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>Less than high school</td>
<td>T test, Kruskal-Wallis test</td>
</tr>
<tr>
<td></td>
<td>High school</td>
<td></td>
</tr>
<tr>
<td></td>
<td>College</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>&lt;30</td>
<td>T test, Kruskal-wallis test</td>
</tr>
<tr>
<td></td>
<td>20’s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30’s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>40’s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50’s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>60’s</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;70</td>
<td></td>
</tr>
</tbody>
</table>

When comparing two variables, such as modeled versus perceived risk, a difference map was generated. Additionally, statistical tests (T tests, Kruskal-Wallis tests, Wilcoxon signed-rank tests) were applied to assess if the differences between the demographics’ risk perceptions were statistically significant and had meaningful effect sizes (Table 2). Lastly, statistical maps were generated 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.

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3 A T test and Wilcoxon signed-rank test were used to calculate the p-value and effect size for the scientific model vs perceived analysis since the scientific model only has a single sample opposed to the perceived map being constructed out of 167 samples. The statistical analysis for the rest of the demographic analysis were conducted using a T test and a Kruskal-Wallis test (Table 2).
The results of the above analyses only indicate where participants perceived risk and do not give any indication as to why. To answer why participants perceived risk as they did, we drew on the verbal explanations participants provided of their maps during focus group discussions.

**Qualitative Analysis**

Data from the focus group discussions were analyzed to understand factors influencing the way Dominicans perceive volcanic risk. Audio recordings of the group discussions and researcher memos were transcribed and reviewed to look for emerging themes. Next, the transcripts were open coded iteratively according to grounded theory (Appendix G), and similar codes were grouped together to form concepts. By using a grounded theory approach, codes and concepts could emerge from the data, as opposed to being predetermined by the researchers (Creswell and Creswell, 2009; Strauss and Corbin 1990). Next, the coded transcripts were sorted into demographic specific projects so the results could be analyzed according to the variables of interest and emerging theories could be identified.

**Results and Discussion**

**Perceived Versus Modeled Volcanic Risk**

An assessment of modeled volcanic risk compared to perceived volcanic risk was conducted by comparing the composite map, created using the 167 participant maps (e.g., see
Figure 2), to the modeled volcanic risk map created by the USAID in conjunction with the University of the West Indies Seismic Research Center (cf. Figure 1 and Figure 3.a).

![Figure 3: Results of the modeled versus perceived risk analysis. The modeled map (a.), perceived composite map (b.), difference map (c.), statistical map (d.), and summary statistics for the overall analysis. The data shown in panel a. comes from the volcanic risk assessment in the “Final Report Development of Landslide Hazard Map and Multi-Hazard Assessment for Dominica, West Indies” (USAID 2006). The statistical mask shown in panel d. depicts locations where the p-values were significant (p <0.05) and the effect sizes were either mild (0.2 <= d <0.5) or moderate (d >= 0.5).]

A visual comparison of the participants’ individual maps revealed commonalities and differences (see Figure 2). There was a wide range regarding the total number of hazardous regions identified. For instance, some participants drew only one or two risk areas that covered the entire island, while others marked as many as 20 different risk areas. There also tended to be either north/south divisions or east/west divisions of risk areas, which often related to how strongly the
participant associated the volcanic risk with the island’s north-to-south spanning mountain range. Additionally, some participants were careful to ensure a level of continuity between risk levels. For example, with very high risk areas adjacent to high risk areas. Conversely, other participants would draw very high risk levels immediately adjacent to low risk levels.

To understand better how Dominicans as a whole perceived risk, all individual maps were aggregated using a GIS to create a composite map (Figure 3.b). Study participants perceived very high risk to exist primarily in the southern region surrounding the villages of Ladaut and Scotts Head. High risk was perceived to exist surrounding the two zones of very high risk in the south, covering most of the southern region, as well as in the far northern region of the island. The perceived moderate risk was located predominantly in the middle of the island, and low risk was perceived to exist in the northeast region of the island and extending faintly through the interior and brushing a small portion of the west coast.

To understand how the population’s perception of risk compared to modeled risk, the composite map was then subtracted from the modeled risk map to produce a difference map (Figure 3.c). Overall, the pattern of perceived risk was similar to the modeled risk. Both maps emphasize two distinct very high risk zones in the south surrounded by high risk areas, as well as a high risk zone in the far north. While comparable, the far north as well as multiple bands in the southern portion of the island were perceived as less risky than depicted in the scientific model. Although participants identified similar locations of very high risk, they underestimated how expansive the risk is compared to the scientific model.

Neither the modeled nor perceived risk maps have any high or very high risk in the interior. However, the modeled risk map has a low risk interior (Figure 3.a) while the perceived risk map
has a more moderate interior with low risk areas concentrated on the east coast (Figure 3.b). This is hypothesized to be related to the presence of Morne Diablotin and the population’s general 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 (USAID 2006). Regarding Morne Diablotin and the surrounding area, there is an apparent perception gap, which, according to Slovic et al. (1980) occurs when perceived risk is higher than experts’ estimations.

The overall difference between the modeled and perceived volcanic risk was not significant ($p = 0.17$). However, 31.2% of the island had significant differences, with a mild effect size ($p < 0.05$, $d > 0.2$), 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 and with two smaller clusters in the far south (Table 3, Figure 3.d).

Table 3: Summary statistics for each analysis and percentages that met the parameters for mild and moderate effect sizes.

<table>
<thead>
<tr>
<th>Analysis</th>
<th>Results for all values in the maps</th>
<th>Significant with a mild effect size</th>
<th>Significant with a moderate effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modeled vs Perceived</td>
<td>Kruskal-Wallis H p-value Cohen’s d</td>
<td>$p &lt; .05$ and $0.2 \leq d &lt; 0.5$</td>
<td>$p &lt; .05$ and $0.5 &lt; d = d$</td>
</tr>
<tr>
<td>N/A</td>
<td>0.175</td>
<td>31.2%</td>
<td>5.5%</td>
</tr>
<tr>
<td>Gender</td>
<td>4.28</td>
<td>0.03</td>
<td>0.28</td>
</tr>
<tr>
<td>Distance</td>
<td>2.59</td>
<td>0.10</td>
<td>0.20</td>
</tr>
<tr>
<td>Education</td>
<td>2.58</td>
<td>0.27</td>
<td>0.11</td>
</tr>
<tr>
<td>Age</td>
<td>6.24</td>
<td>0.28</td>
<td>0.18</td>
</tr>
</tbody>
</table>

To understand spatial variations in how the various 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.

**Gender**

Overall, men (Figure 4.a) perceived the volcanic risk as slightly more pronounced than women ($p = 0.03$; Figure 4.b). Men perceived 17.6% of the island to have significantly higher risk, with a mild effect size ($p < 0.05, d > 0.2$) in a handful of patches surrounding the interior and a large portion of the southern end of the island. The south also contains a sizeable area (1.3% of the island) where men perceived the risk significantly higher, with a moderate effect size ($p < 0.05, d > 0.5$; Figure 4.d). Conversely, none of the regions where women perceived the risk to be higher were significant with a meaningful effect size, such as in the far north. Women perceiving lower risk than men was somewhat unexpected since much of the literature suggests that men underestimate risk compared to women (Finucane and Alhakami et al. 2000). However, the general trend of women being more sensitive to risk than men has been hypothesized to be dependent on the context of the risk (Eckel and Grossman 2008) and socio-economic status of the women (Finucane and Alhakami 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 has a potential for death or the hazard is societal in nature. Thus, given the context, it was expected that the women would have been more sensitive to the risk since natural disasters have a high potential for death and they are societal in nature.
Figure 4: Results of the gender analysis. The male composite map (a.), female composite map (b.), difference map (c.), statistical map (d.), and summary statistics for the overall analysis. The statistical mask shown in panel d. depicts locations where the p-values were significant ($p < 0.05$) and the effect sizes were either mild ($0.2 \leq d < 0.5$) or moderate ($d \geq 0.5$).

Based on the women mapping the island to be 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. Thus, there is a disconnect between how men and women mapped perceived risk and how they spoke about it. Furthermore, the women’s composite map shows two concentrated very high risk zones in the south while the men’s composite shows a larger but less concentrated zone of very high risk in the south. Overall, the women mapped the various risk boundaries with clearer distinction, including the high risk in the north and low risk in the interior, which aligns more closely to the scientific model.
The literature also suggests that disasters affect women disproportionately, potentially because they are often responsible for the care and safety of dependents (Fritz et al. 2013). In the case of this study, neither group brought up dependents with any regularity. Surprisingly, in every instance when dependents were mentioned, the speaker was male. Based on our data, we are unable to provide any insight as to why this relationship occurred.

When that [volcano] burst, everybody has to come out, and they have to move far or even leave Dominica for the sake of breathing, respiration, and your kids; it is a dangerous place. (Man, Participant 2.13)

Proximity to the Hazard

The distance analysis examined the difference in perception between participants who lived within 6 kilometers of a volcanic peak (Figure 5.a) and those who lived farther than 6 kilometers from a volcanic peak (Figure 5.b). Generally, those living farther from a volcano perceived the risk as safer than those living closer to a volcano. The difference in perception has a general north/south orientation, with those living farther perceiving the risk to be higher in the far northern, western, and far southern parts of the island (Figure 5.c). The northwest portion of the island 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 (Figure 5.d). Conversely, the eastern interior of the island was perceived as higher risk by the near group, though not in a significant way (see Figure 4.c). The overall difference in volcanic risk perception for the distance analysis was not significant \( (p = 0.1) \); see Table 3).
Figure 5: Results of the distance analysis. The composite map for participants who live within 6km from a volcanic peak (a.), the composite map for participants who live beyond 6km from a volcanic peak (b.), a difference map (c.), statistical map (d.), and summary statistics for the overall analysis. The statistical mask shown in panel d. depicts locations where the p-values were significant (p < 0.05) and the effect sizes were either mild (0.2 <= d < 0.5) or moderate (d >= 0.5).

Participants living beyond 6km from a volcano regularly spoke of their own villages as being safe, a place where others would come to in the event of an evacuation:

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 6km from a volcano would at times downplay the level of risk in their villages:
My area, which is south Soufriere, I didn't want to put it completely red. I know we 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, most participants in the far northern or southern parts of the island reside within 6km of a volcano, whereas participants who live in the interior and northeast tend to live farther than 6km away from volcanos. Their patterns of risk perception suggest that people who live near the volcanos have accepted the risk around them and therefore see it as less of a threat. They could also be underestimating the risk as a sort of coping mechanism, a phenomenon Sjöberg (2000) refers to as risk denial, which is a form of optimism. Conversely, the people who live farther from the hazard could be overestimating the risk because it is less familiar to them, which is a common tendency for humans (Slovic 1990).

Educational Attainment

To examine the difference in volcanic risk perception among people with varying levels of educational attainment, participants’ maps were aggregated into three groups based on what they had selected as their highest level of educational attainment in their surveys (less than high school, Figure 6.a; high school, Figure 6.b; college/university, Figure 6.c). Likewise, participant transcripts were sorted accordingly. When comparing their composite maps, the southern region is similar for all three groups (Figure 6). However, participants with some level of college education identified higher risk in the far north than the other two groups. In this respect, the composite map of college-educated participants was more reflective of the scientific model. Regarding low risk areas, those who had been to college identified two distinct areas on the east
and west coasts of the interior, those who completed high school confined their low risk to the northeast coast, and participants who did not complete high school had low risk more centralized in the interior. Statistically, the overall differences between the educational groups’ risk perceptions were not significant ($p = 0.27$; see Table 3). However, the region in the far north, along with eight or so scattered patches, was 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 (Figure 6.d).

Figure 6: Results of the education analysis. 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 statistical mask (d.), and summary statistics for the overall analysis. The statistical mask shown in panel d. depicts locations where the $p$ values were significant ($p < 0.05$) and the effect sizes were either mild ($0.2 \leq d < 0.5$) or moderate ($d \geq 0.5$).
The composite of those who went to college appears like the female composite and could be related to the college group being comprised of 64% women. The composite of those who graduated from high school is reflective of the males’ composite and consisted of 53% men. When canvassing for participants, individuals were not asked about their educational attainment. The fact that there were 14% more women in the college group supports the findings of Bailey (2009) that the tertiary education gender imbalance generally favors women in the region.

Age

To analyze the difference in volcanic risk perception among age groups, participants’ individual maps were aggregated according to their age by decade (Figure 7). The under-30 demographic (Figure 7.a) viewed the island the most moderately and had two distinct very high risk zones in the south. Those in their 30s (Figure 7.b) had greater low risk in the interior, with their southern very high risk areas not as clearly clustered into two groups, but rather blended. They identified the highest risk in the far north of all the demographics. Those in their 40s (Figure 7.c) and 50s (Figure 7.d) perceived the southern portion of the island to be the most dangerous, with extensive very high risk. They perceived the risk in the south higher than the scientific model suggests. Those in their 60s (Figure 7.e) and those 70 and older (Figure 7.f) 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 to be moderate and the safest of all the age groups.
Figure 7: Results of the age analysis. The composite map of participants aged between 18 and 29 (a.), the composite map of participants in their 30’s (b.), the composite map of participants in their 40’s (c.), the composite map of participants in their 50’s (d.), the composite map of participants in their 60’s (e.), the composite map of participants aged 70 and above (f.), the statistical map (g.), and summary statistics for overall analysis. The statistical mask shown in panel d. depicts locations where the p-values were significant (p < 0.05) and the effect sizes were either mild (0.2 <= d < 0.5) or moderate (d >= 0.5).

Although age was not a significant factor overall (p = 0.28; see Table3), there were scattered portions of the age map that were significantly different (p < 0.05): 7.3% of the map was significant with a mild effect size (d > 0.2), and 1.4% of the map was significant with a moderate effect size (d > 0.5; Figure 7.g). Most of the significant regions were located on the southeast side of the southern portion of the island, likely the result of the increased 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, many of them felt and reported, between 1998 and 2000. The quakes were associated with the Plat Plays Complex and Morne Anglais and resulted in the dispatchment of a team of scientists from the Seismic Research Unit in Trinidad to Dominica. During that period, seismologists conducted aerial surveys via helicopter, ground reconnaissance missions, and installed 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 those seismic swarms and may have a stronger memory of these events.

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, and a small number of participants cited being involved with disaster management groups in their communities. However, data from the focus group discussions suggest that, in most instances, the similarity between the maps is the result of a combination of personal experiences and recollection of claims they have heard over the years. In addition to the demographic influencers of risk, three general factors that strongly 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 level, and age were examined.

The Geography of the Island’s Villages

When discussing the risk level across the island, participants categorized specific villages in Dominica as being either dangerous, safe, or moderately safe. In doing so, the participants created mental map that captured their opinions of the physical landscape. Johnston et al. (1986) define “mental map” as “an amalgam of information and interpretation reflecting not only what a person knows about places but also how he or she feels about them.” Lynch (1960) first used a
freehand participatory mapping method to understand differences in how people perceive the same city environment. In this study, a slightly different approach was undertaken to capture participants’ mental maps of how they perceived volcanic risk, since perception is influenced by how an individual understands the structuring of one’s environment (James 2018). Instead of asking participants to freehand draw their maps, as in the case of Lynch’s (1960) study, participants were provided with a simple map along with crayons corresponding to a legend. A similar approach was taken by Manton et al. (2016) to understand how cyclists perceived risk along commonly traveled bike routes.

In our study on volcanic risk, most participants (74%; Table 4) generally described villages as dangerous, especially villages in the island’s south (e.g., Ladau, Wotten Waven, Soufriere, and Scott’s Head). Northern villages—such as Ville Case, Capuchin, and Portsmouth—were considered dangerous, while Bells was brought up on multiple occasions as a dangerous interior village. Conversely, less than half (42%) of participants referred to specific villages as safe.

Safe villages were most commonly those in the northeast, such as Marigot and Wesley. The Kalinago territory, where the Caribbean’s last remaining group of indigenous people live, was also regularly associated with low volcanic risk. For over two centuries, the Kalinago fiercely resisted colonial control of Dominica. By the time the British gained full control of the island in 1763, the Kalinago were occupying 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). It is possible the Kalinago originally occupied the northeast because of ancestral knowledge of risk, as there is evidence of other indigenous groups having long hazard-related oral
histories that have survived within the community until the modern day (Fritz and Kallgeris 2008; King and Goff 2010). However, no reference of long passed down histories about risk was recorded during focus group discussions. On multiple occasions, it was expressed that the northeast villages would serve as evacuation locations in the case of a volcanic eruption.

Table 4: Percentages of demographic groups that spoke about the various factors influencing volcanic risk perception. Villages were coded as dangerous or safe based on the descriptions provided by the participants.

<table>
<thead>
<tr>
<th></th>
<th>Villages</th>
<th>Physical features</th>
<th>Self-confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dangerous</td>
<td>Safe</td>
<td>Topography</td>
</tr>
<tr>
<td>All Participants</td>
<td>74%</td>
<td>42%</td>
<td>52%</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>98%</td>
<td>78%</td>
<td>74%</td>
</tr>
<tr>
<td>Female</td>
<td>63%</td>
<td>33%</td>
<td>37%</td>
</tr>
<tr>
<td>Distance</td>
<td></td>
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<tr>
<td>Within 6km</td>
<td>85%</td>
<td>56%</td>
<td>64%</td>
</tr>
<tr>
<td>Beyond 6km</td>
<td>72%</td>
<td>31%</td>
<td>48%</td>
</tr>
<tr>
<td>Education</td>
<td></td>
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<tr>
<td>&lt;High School</td>
<td>79%</td>
<td>38%</td>
<td>40%</td>
</tr>
<tr>
<td>High School</td>
<td>86%</td>
<td>50%</td>
<td>75%</td>
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<tr>
<td>College</td>
<td>84%</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
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<tr>
<td>&lt;30</td>
<td>94%</td>
<td>37%</td>
<td>83%</td>
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<tr>
<td>30s</td>
<td>77%</td>
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<td>40s</td>
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<td>81%</td>
<td>63%</td>
<td>74%</td>
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<tr>
<td>60s</td>
<td>95%</td>
<td>70%</td>
<td>85%</td>
</tr>
<tr>
<td>&gt;70</td>
<td>82%</td>
<td>32%</td>
<td>68%</td>
</tr>
</tbody>
</table>

Among all the demographics, the various groups spoke about villages they perceived to be dangerous with ranges between 63% for females and 98% for males. Conversely, the percentages of demographics speaking about villages they perceived as safe varied from 31% for participants living beyond 6km from a volcanic peak to 78% for males. The average percentage of all participants who talked about villages they perceived to be dangerous was 82%, while the average percentage of all participants who spoke about villages they perceived to be safe was only 49% (Table 4).
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. For instance, 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 the findings that animals are conditioned to understand safety through the learned absence of danger and that the idea of safety encompasses protection from danger (Rogan et al. 2005). In this context, it makes sense that the participants in our study discussed dangerous places more than safe places since only one volcano must be perceived as threatening an area for it to be considered dangerous. Conversely, for an area to be considered safe, participants would perceive an absence of risk from all nine volcanoes. Therefore, more information is needed for a participant to determine that a location is safe than 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.
The Island’s Physical Features

The second factor influencing risk perception was the island’s physical features, which were generally categorizable as either topographic (mountains or valleys) or geothermal (sulphur springs, bubbling reefs, etc.). Across all participants, 52% of physical feature references were topographically related while 35% were geothermal related (see Table 4).

Study participants perceived very high risk zones to exist primarily in the southern region surrounding the villages of Ladaut and Scotts Head. Focus group discussions revealed that these regions are perceived as risky due to their proximity to geothermal features. The Ladaut and surrounding Roseau Valley region were anticipated to have high perceived risk due to ongoing debates among Dominicans surrounding the safety and benefits of a proposed geothermal power plant for the area (Bertani 2016). Many Dominicans view this development as potentially increasing volcanic risk in the region. Surprisingly, the geothermal plant was only mentioned three times during the 18 focus group discussions: twice as increasing the risk and once as decreasing the risk. Instead, 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 Champaign Beach and the Soufriere sulphur springs.

On occasion, participants spoke about the implications that a volcanic eruption would have on nearby infrastructures, such as roads becoming blocked and the likelihood that the entire capital, Roseau, could be destroyed. A handful of participants mentioned that the island’s main hospital should be relocated farther from Roseau. Although not mentioned by participants, the capital was built on one of the few relatively flat areas of the island, which is a pyroclastic flow fan that was
deposited approximately 30,000 ya. during the largest eruption in the Caribbean within the last 200,000 years (Whitham 1989).

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 due to the volcano’s relation to the island’s tourism industry. Hiking trips to the peak of Morne Diablotin in the north and Morne Trois Pitions in the interior are popular and bring tourism dollars into the surrounding area.

Conversely, the tourism in the south is more closely linked to geothermal features such as going for a soak in the sulphur springs or snorkeling at Champagne Beach. While hiking is also popular in the south, hikers are more commonly drawn to the south to complete the first few segments of the renowned Waitikubuli Trail, which spans the entire country. The southern sections of the trail lead hikers up and around multiple southern volcanoes. Thus, people visiting the south are often “visiting the sulphur springs” or “hiking Waitikubuli segment 1” rather than “hiking the Plat Plays volcanic complex.”

Most of the risk identified in the interior was related to Morne Diablotin, Dominica’s tallest and largest volcano. Due to its age, it is the least likely to erupt and is represented as low risk on the scientific model (see Figure 1). Regardless, participants focused extensively on risk related to Morne Diablotin during the group discussions:
In the north, up at Morne Diablotin area, this is the highest peak in Dominica, and if we were to have a volcano erupt in that area, then all those villages in the north will be affected because it's the tallest peak in Dominica. It will go from both sides from Portsmouth on that side back to Colihaut on the other side. (Participant 15.8)

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 a collection of earthquake swarms over the years. 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 Diabiles (Abraham n.d.). Most notably, 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 the 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. To me, if a volcano is to erupt, I am not saying we will not get maybe the ashes or this sort of thing, but the heavy load of destruction, I don't think it will affect us. (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%; see Table 4). The men referred to specific volcanoes more consistently and expressed a 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 sulphur 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 Soufriere 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)

When evaluating how distance from a volcanic peak influenced participants’ understanding of the island’s physical features in relation to the volcanic risk, more participants living within 6km of a volcanic peak spoke of topography (64%) and geothermal features (43%) than those living beyond 6km from a volcanic peak spoke about topography (48%) and geothermal features (27%) respectively. Participants living nearer to the volcanoes were expected to talk more extensively about the mountains and geothermal features since they live closer and are thus likely more familiar with them. As mentioned above, the participants living closer to the volcanoes mapped the high risk areas (according to the model) to be safer than those living farther from volcanoes. Their mapping pattern implies that although they live near the island’s physical features, they don’t perceive the related volcanic risks to be as far extending as those who live farther than 6km from the volcanoes. This again confirms the findings of Sjöberg (2000) that people who are familiar with a hazard tend to underestimate its risk. Furthermore, 55% of participants living farther than 6km from a volcano mentioned the dangers of Morne Diablotin
even though it is the nearest volcano to the villages many of them considered safe. Conversely, only 8% of participants living farther than 6km from a volcano specifically mentioned any of the six southern mountains, which are in areas they designated as having high risk.

When the physical features were analyzed in relation to educational attainment, the results mirrored the general analysis in that all 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. This difference in perception was evident by comparing the composite maps and participant transcripts.

When analyzed by age, topography was focused on most extensively by participants in their 30s (83%) and 60s (85%). Those in their thirties were also the most focused on the geothermal features, with 50% of this demographic mentioning a geothermal feature. Comparatively, only 25% of those 7- and above mentioned the geothermal features (see Table 4).

Participants’ Confidence in Their Knowledge

The third major factor that influenced 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.

Some participants (20%) made confident statements, for instance by citing personal travel, their occupations, education, and hearing others talking. Conversely, other participants (26%)
made diffident statements about their understanding of the volcanic risk, for instance, saying they were guessing or had a bad memory. Although there were slightly more women in the study (male n=77, female n=90), the men spoke more frequently and on a broader variety of topics. Men talked more than women did about every factor except for being diffident regarding the island’s volcanic risk (see Table 4). Men were more confident regarding the volcanic risk, with 30% feeling confident and 24% feeling diffident. Those who felt confident cited a combination of travel, what they had heard from others, and their occupations:

I know for a fact that we have about nine 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, only 16% of women mentioned being confident, while 32% of women mentioned being diffident. Many of the women who stated being confident attributed their knowledge to recollections of what others had said about the volcanic risk:

Well, I basically colored my map; I don't know much about volcanic… hmm eruptions and so on, but I believe Laudat, Wotten Waven, and the surrounding areas will be greatly affected. Ok. The majority of my map was guesswork [laughs] guess. (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 are in keeping with the findings of Hill et al. (2010) that women are less confident than men in matters related to the sciences. The degree that this manifested was somewhat unexpected as the tertiary education gender imbalance generally favors women in the region (Bailey 2009).

Regarding the confidence levels between the participants living near volcanos (<6k) and those living far from volcanoes (>6km), an almost equal number of participants living far
expressed diffidence (22%) and confidence (21%). However, more participants living near mentioned being diffident (33%) than confident (22%). It is notable that the group nearest to the risk expressed more diffidence in their knowledge. Furthermore, having local/indigenous knowledge has increased resilience in other populations due to awareness of indicators of increased risk. For example, populations in Vanuatu, a SIDS located in the Pacific, recognize increased volcanic activity due to unusual bubbling or gas smells surrounding geothermally active regions (Cronin et al. 2004). However, globalization and advancements in communication networks threaten to result in a loss of local knowledge in SIDS (Mercer et al. 2007).

Twice as many participants who had been to college considered themselves diffident (38%) than confident (16%). Multiple college-educated participants who expressed diffidence mentioned that they did not study a relevant field, such as geography. 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 Soufriere doing Scuba diving research; even under the water, we have bubbles coming on, so that is evidence of volcanic activities. (College, Participant 14.5)

Participants who were educated through high school expressed confidence (30%) and diffidence (27%) with almost equal frequency. A theme for the high-school-educated group was confidence based on travel around the island and, to a lesser extent, occupation:

Based on what the people who are learned are saying, I kind of left almost 3/4 of Dominica in green... but you think I don't know anything, but I worked with a particular company for twenty-one and a half years, and I traversed Dominica. (High school, Participant 7.6)

Participants who did not complete high school mentioned equally being confident and diffident at 24% each. Like the women, the primary reason they gave for their confidence was based on what
they had heard from others. The fact that participants with college-educations expressed 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).

When comparing confidence by age, the participants at both the younger and older ends of the spectrum were less confident. Roughly half of the participants between 18 and 30 expressed diffidence (51%), followed by those in their 30s (44%) and those aged 70 or above (39%). Comparatively, only 26% of those in their 40s or 50s expressed diffidence. 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, so the reason for having this whole area in red is because it is close by. (50s, Participant 11.8)

When recruiting participants, it was easier to find individuals in the middle-age-group categories, which corresponds with their higher reported involvement in community and national interests.

I chose the moderate risk and very high risk here because this area will more or less be the danger zone in terms of the most activity based on several workshops that I have been part of. (50’s, Participant 18.6)

The older participants guessed or stated they did not know more often than the middle-aged group. A participant from Pointe Michel referenced having lived abroad for a period as the reason he/she was not confident in his/her assessment. Although only one person mentioned living overseas, 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:

I lived away for a long time, so I am not aware of any volcanoes or anything in Dominica. Now that I have come back, I have to get more involved because I haven’t been to none of these places you know so I cannot tell you where Petite Savanne is. I ain’t got a clue, so until I come back, then I will get more involved. (70-plus, Participant 12.4)

Others, although having relevant work or personal experience, gave diffident statements based on their age or bad memories:

I was a teacher, but seeing my old age, I forget, but I remember those basic things. So from north to south, central of the island, where the mountain range, where the volcanoes are, I colored it red, red meaning very high risk. (70-plus, Participant 7.5)

The younger and older participants are thought to have expressed the least confidence (see Table 4) due to the following reasons. First, many of the younger adults appeared shy speaking in front of the group, which was particularly evident in those under 30. This may have resulted in some of them stating they had guessed as a means of not feeling embarrassed regarding the accuracy of their maps. The findings of less confidence among older adults correspond with the results of Thomas et al. (2011), who found that, while older adults generally have a deficit in feeling-of-knowledge (FOK), their FOK could be increased by explicitly encouraging older adults to retrieve contextual information on the topic. In this study, older adults were assisted in reading their maps, if they desired, but they were not prompted to recall any information by researchers other than the prompts provided in the general directions.
Conclusion

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

When composite risk maps of the entire island were analyzed to examine differences between demographic groups, the gender of the participants was the only statistically significant factor. However, other demographic factors did result in specific regions of the country being statistically different with varying effect sizes. The perceived risk was statistically different from the modeled risk in a handful of areas across the country (see Figure 3.d). Men perceived multiple areas of the island to be significantly more dangerous than women, but particularly the far southern portion of the island (see Figure 4.d.). Participants living farther away (>6km from a volcanic peak) perceived statistically higher risk along much of the west coast and in the southern tip of the island compared to participants living in closer proximity to a volcano (<6km; see Figure 5.d).

Education impacted perception of risk most significantly in the far northern region of the country, likely due to the college-educated demographic perceiving higher levels of risk than participants who had not attended college (see Figure 6.d). Lastly, age influenced risk perception most significantly in the southeast, where those in their 40s and 50s perceived higher risk than the other age groups (see Figure 7.g).
The study revealed that there were three primary influences of risk perception on the island: 1) safety levels of villages, 2) the island’s physical features, predominantly its topography and geothermal features, and 3) the participants’ confidence in their assessment of the risk. Across all demographics, participants spoke more about the areas they perceived as high risk than low risk. The tendency of participants to focus more on dangerous areas than safe areas is suspected to be related to participants having more exposure to information about high risk areas through peers, media, etc. Regarding the physical features, participants were more focused on the mountains, with the most references to Morne Diablotin, regardless of it being considered low risk in both the modeled and perceived maps. The geothermal features were frequently cited and associated with high risk, particularly in the southern portion of the island. While participants generally focused more extensively on the island’s topography than its geothermal features, the females and participants who had been to college were the only two demographics to give nearly equal attention to topography and geothermal features. Of all the demographic groups, the females, those who lived near (<6km) a volcano, those who had been to college, and the younger and older adults had the least confidence in their knowledge of the volcanic risk. Participants who expressed diffidence commonly cited not having been to school in a long time or not studying specific topics such as geography. Conversely, participants regularly based their confidence on travel, work experiences, and what they heard from peers or the media.

Although the Q&A sessions with Dr. Watts (the on-island volcanologist who attended nearly all focus groups to provide information after the events) were not included in the analysis, they provided additional insight. Participants were eager to speak with Dr. Watts and frequently sought confirmation or clarification on previously held beliefs. For instance, it was common to
hear questions prefaced with phrases such as, "Is it true that....," "I’ve heard that....," etc. Participants also had many inquiries about a variety of the island’s hazards beyond volcanism, such as tsunami and earthquake risk.

Based on the findings of this study, a series of recommendations are proposed. First, while an eruption could occur in Dominica’s near future, perhaps in the next 100 years, it is unlikely one would occur without ample warning (Lindsay et al. 2005). Since Dominicans are generally aware of the island’s volcanic nature, but unsure how a volcanic eruption would unfold, more information should be shared regarding the specific types of volcanoes that exist in Dominica and what types of warning times would be expected. Additionally, clarifying information should be shared about Morne Diablotin’s unlielihood of erupting and the risks associated with the southern volcanoes.

Second, efforts should be made to provide increased community-level outreach and dialogues regarding the natural hazards that threaten Dominica. For instance, those knowledgeable about local hazards could facilitate community discussions, similar to what was accomplished by Dr. Watts. If this were done, it is anticipated that levels of confidence would rise among citizens as they gained familiarity with the risks around them.

Third, it is recommended that the results of this study be used to develop more targeted outreach campaigns to address the currently held beliefs within communities and demographic groups. By doing so, emergency managers would be better situated to work with communities and individuals to increase resiliencies and diminish vulnerabilities.

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 Dominica or to other SIDS with similar contexts that have many vulnerabilities and hazards in common with
Dominica. For instance, research may find that people living near hazards, such as along river banks that pose a risk of mass wasting, have lower perceived risk of mass wasting than those living farther from the rivers.

Fifth, the participatory mixed methods used in this study could be replicated and applied to understand risk perception in a variety of contexts beyond those similar to Dominica. First, the methods could apply to other regions, both SIDS and non-SIDS. For instance, 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 the higher percentage of indigenous people groups. Second, the methods could be applied to other types of hazards such as studying risk perception of violent crime in urban centers. Third, the methods could be used to understand hazards at varying scales ranging from local to global hazards. It is encouraged that others utilize these methods to understand differences in perception among other subfields of hazard research.

Sixth, while the methods are encouraged to be applied to a variety of contexts, there remains a need for additional risk perception studies to be conducted within a SIDS context. Such studies are crucial since SIDS are highly vulnerable nations that tend to be disproportionately affected by natural disasters.

Seeking to understand how and why demographic variables influence risk perception farther allows emergency managers and organizations to meet society's needs through understanding existing concerns and beliefs and enabling disaster managers to provide clarifying information about hazards and how to respond in the event of a disaster. Thus, by following these recommendations, at-risk nations like Dominica could become increasingly prepared and resilient.
CHAPTER 3
WHITE PAPER

Small island developing states (SIDS) face high vulnerability to natural hazards. Understanding risk perception in SIDS is an essential step towards reducing vulnerability on these at-risk island states. A mixed-method participatory methodology has been developed to increase the capacity of individuals and organizations within the field of disaster management to understand existing perceptions of risk among the populations they serve. The methods developed include focus groups to collect data and share information, the use of geographic information systems (GIS) to understand where participants perceive risk, and a qualitative analysis of focus group discussions to understand why participants perceive risk. A case study in the Commonwealth of Dominica was conducted using these methods as a means of understanding the existing perception of volcanic risk and how such perceptions compare to modeled volcanic risk. Key findings of the study are shared below as an example of one of the hazards and contexts to which these methods could be applied. Understanding risk perception and the factors that influence it in any given population facilitates the development of specifically tailored public outreach campaigns and strategic approaches that could minimize disaster outcomes and save lives when disasters threaten SIDS in the future.

According to the United Nations (2011), “SIDS are a distinct group of developing countries facing specific social, economic and environmental vulnerabilities.” These vulnerabilities include their isolated nature, limited resources and infrastructure, and the tendency to have economic sectors, such as tourism, that are particularly susceptible to disasters. Furthermore, SIDS are often located in hazardous regions such as along subduction zones and in hurricane-prone regions. As a
result, SIDS are exposed to a wide variety of hazards including earthquakes, volcanic eruptions, tsunamis, wind damage, landslides, storm surge, flooding, and drought. Since SIDS are disproportionately exposed and vulnerable to hazards, it is essential to understand how perceptions influence the vulnerability of SIDS’ populations as most people living in SIDS are not afforded the same opportunities to take precautionary measures as people living in a non-SIDS context. For instance, evacuating a population ahead of a hurricane is not realistic due to SIDS’ isolated nature, and emergency preparedness kits are more expensive for populations to obtain due to the high costs of imported goods.

The impact or risk perception was demonstrated in the aftermath of Hurricane Matthew in Haiti. Many Haitians refused to evacuate their homes because they perceived the risk of burglary to be greater than the risk posed by the hurricane. Haitian emergency managers considered forcibly evacuating residents to save their lives but ultimately could not due to the large numbers of people and limited time. Sadly, many Haitians who did not evacuate lost their lives (Mogul, 2016). Had the existing perceived risk of burglary been better understood, perhaps the risks associated could have been mitigated.

Risk perception is often understood by taking either a hazard-based approach or a person-based approach. The hazard-based approach takes into consideration the characteristics of the hazard that influence how it is perceived—e.g., how catastrophic the hazard is or if people are being willfully exposed to the event (Fischhoff et al., 1978). Alternatively, the person-based approach examines the characteristics of the people exposed to the hazard to understand how risk perception is influenced (Chauvin et al. 2007). The methods recommended in this thesis were designed to evaluate specifically political risk theory, which is positioned around power dynamics
associated with variables such as gender, age, and class, and knowledge risk theory, which assumes that people perceive risk depending on the extent of their knowledge of the hazard (Wildavsky and Dake 1990).

The series of methods were designed to enable emergency managers to understand better a population’s currently held risk perceptions and are organized into three main components: 1) a participatory, community-based component to collect data and share information; 2) a quantitative GIS-based component to understand where people perceive risk; and 3) a qualitative component to understand how and why people perceive risk. The methods will be described in the context of the case study conducted in the Commonwealth of Dominica to understand perceptions of volcanic risk.

Focus groups were conducted in 18 villages throughout Dominica; each focus group consisted of approximately 12 participants. Surveys were administered to all focus group participants to collect sociodemographic information such as age, gender, educational attainment, and proximity to volcanoes. Subsequently, participants were provided with a map of Dominica and were instructed to color their perceived boundaries of volcanic risk ranging from low to very high, which corresponded with a model of volcanic risk that had been developed through the USAID, Dominica’s Office of Disaster Management, and the University of the West Indies Seismic Research Center. Next, participants shared their thought processes while mapping, which was audio recorded to be analyzed later. After the needed information had been collected, Dr. Robert Watts, an on-island volcanologist, provided a question and answer session to ensure that accurate information was shared about the volcanic risk.
Once the data had been collected, participants’ hand-drawn maps were brought into a GIS, and a series of steps were taken using GIS and Python scripts to convert the raw data into maps that could be aggregated based on the collected sociodemographic information. Steps taken included geo-referencing, digitizing, rasterizing, and developing composite maps. Once the composite maps were created, difference maps were generated to compare various demographic groups’ perceptions of volcanic risk. Lastly, statistical analyses were applied, which indicated where the differences between perceived risk were significant with meaningful effect sizes.

The explanations participants provided about their thought processes while creating individual maps were transcribed, coded, and analyzed qualitatively to identify trends in the way the volcanic risk was understood among various demographic groups.

When composite risk maps of the entire island were analyzed to assess differences between demographic groups’ risk perceptions, the gender of the participants was the only statistically significant factor. However, all demographic factors resulted in regions of the country being statistically different with meaningful effect sizes. The perceived risk was statistically different from the modeled risk in a handful of scattered areas across the country. Men perceived multiple areas of the island to be significantly more dangerous than women, particularly the far southern portion of the island. Participants living farther away (>6km from a volcanic peak) perceived statistically higher risk along much of the west coast and in the southern tip of the island compared to participants living in closer proximity to a volcano. Education impacted perception of risk most significantly in the far northern region of the country, likely due to the college-educated demographic perceiving higher levels of risk than participants who had not attended college. Lastly, age influenced risk perception most significantly in the southeast where those in their 40s
and 50s perceived higher risk than the other age groups, perhaps because of their recollections of the earthquake swarms which took place in the south between 1998 and 2000.

Furthermore, three influencers of risk perception were identified in addition to the demographic variables: 1) the perceived safety levels of villages, 2) the island’s physical features, and 3) the participants’ confidence in their assessment of the risk. Across all demographics, participants placed higher emphasis on the dangerous villages over the villages they perceived to be safe. This may be related to participants having more exposure to information about high risk areas through peers, media, etc. Regarding the physical features, participants were more focused on mountains while discussing the risk. However, they tended to map higher risk with an increased association to the island’s geothermal features such as the sulphur springs and bubbling reefs. Additionally, participants more commonly expressed a lack of confidence in their assessment of the volcanic risk by stating that they had guessed or forgot. However, those who expressed confidence tended to cite travel, work experiences, and what they heard from peers or the media as their sources of hazard knowledge.

The following recommendations are based on the case study in Dominica. First, information should be disseminated on the specific types of volcanoes on the island and what a potential eruption might look like. Second, community-level outreach and dialogues should be increased. Third, the results of the case study could be used to develop outreach campaigns tailored to specific communities and demographic groups within Dominica. Fourth, how the findings may apply to other scenarios with similar contexts should be considered. Fifth, the participatory mixed methods employed could be replicated and applied to understand risk perception in a variety of contexts. Sixth, additional risk perception studies need to be conducted within a SIDS context. By
following these recommendations, at-risk nations like Dominica could become increasingly prepared and resilient.

Given the highly vulnerable nature of SIDS, it is critical that increased efforts be made towards understanding existing risk perceptions among SIDS populations so emergency managers and organizations can better meet society's needs. This paper outlined some of the challenges facing SIDS and proposed a novel mixed-methods participatory approach to understand risk perception. The methods explored and employed could be applied to other hazards and contexts so that risk perception will continue to be understood and become an integrated component of creating resilience in SIDS. The full report of the case study introduced in this paper can be obtained by contacting the researchers. The researchers are willing and eager to provide training materials on the method as well as the Python code used to conduct the above analyses.
REFERENCES


King DN, Goff JR (2010) Benefitting from Differences in Knowledge, Practice and Belief: Māori Oral Traditions and Natural Hazards Science. Natural Hazards and Earth System Sciences 10(9): 1927-1940


Appendix A:

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER
Approval Notice
Initial Review

13-Jan-2017

TO: Hannah Eboh
   Geography

RE: Protocol # HS17-0006 “Risk perception in small island developing states: A case study in the Commonwealth of Dominica”

Your Initial Review submission was reviewed and approved under Expedited procedures by Institutional Review Board #1 on 13-Jan-2017. Please note the following information about your approved research protocol:

Protocol Approval period: 13-Jan-2017 - 12-Jan-2018

If your project will continue beyond that date, or if you intend to make modifications to the study, you will need additional approval and should contact the Office of Research Compliance and Integrity for assistance. Continuing review of the project, conducted at least annually, will be necessary until you no longer retain any identifiers that could link the subjects to the data collected. Please remember to use your protocol number (HS17-0006) on any documents or correspondence with the IRB concerning your research protocol.

Please note that the IRB has the prerogative and authority to ask
further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Unless you have been approved for a waiver of the written signature of informed consent, this notice includes a date-stamped copy of the approved consent form for your use. NIU policy requires that informed consent documents given to subjects participating in non-exempt research bear the approval stamp of the NIU IRB. This stamped document is the only consent form that may be photocopied for distribution to study participants.

It is important for you to note that as a research investigator involved with human subjects, you are responsible for ensuring that this project has current IRB approval at all times, and for retaining the signed consent forms obtained from your subjects for a minimum of three years after the study is concluded. If consent for the study is being given by proxy (guardian, etc.), it is your responsibility to document the authority of that person to consent for the subject. Also, the committee recommends that you include an acknowledgment by the subject, or the subject's representative, that he or she has received a copy of the consent form. In addition, you are required to promptly report to the IRB any injuries or other unanticipated problems or risks to subjects and others. The IRB extends best wishes for success in your research endeavors.
Appendix B:

FOCUS GROUP CONSENT FORM
Hello, my name is Hannah Eboh; I am a master’s student at Northern Illinois University. Thank you for your interest in my study on risk perception and for being here today. This event will last approximately two hours.

**What this study is about:** I am conducting research in Dominica because I study natural hazards and risk perception so that emergency management plans can be created that consider the specific circumstances of island nations. I believe emergency managers are better able to communicate life-saving information when they understand what people think about natural hazards. I have invited you to be a part of my study because by involving many Dominicans in risk management research we can make Dominica, and other islands, safer when disasters do happen. Also, you are not expected to know anything about the hazards we will be discussing. Regardless of your current familiarity, your involvement is important and greatly appreciated.

**Risk and Benefits:** I do not anticipate any risks to you participating in this study other than those you encounter in your day-to-day life. I cannot and do not promise that you will receive any benefits from this study.

**Taking Part is Voluntary:** Your participation in this study is voluntarily. You may withdraw at any time and may choose to skip questions or activities if you do not wish to participate.

**If you have questions:** Please take with you a support services card from the back table before you leave. The card contains email addresses and phone numbers you can call if you have questions or concerns about this study. I am happy to talk with you confidentially at any time.

**What we will ask you to do:** This research will consist of four activities:

First, you will individually map where you believe risk exists in Dominica. After the event, your map will be collected and I will keep it.

I consent to participate in this activity ______________________

Second, all participants will share their maps and compare them before repeating the previous activity as group. The group will create a single map, which I will keep. This activity will be video recorded.

I consent to participate in this activity and to be video recorded:____________________

Third, participants will come together to discuss the maps created. This activity will be audio recorded.

I consent to participate in this activity and be audio recorded:____________________

Fourth, you will complete a brief survey that I will keep. Questions will be related to natural disasters and demographic / household information.

I consent to participate in this activity:____________________

Throughout this event photographs may be taken to be used to share the progress or results of this study.

I consent to be photographed:____________________
Appendix C:

FOCUS GROUP SURVEY
Participant Number ______________

Natural hazard definition: An extreme event that occurs naturally and might have a negative effect on people or the environment. Example: earthquake, tsunami, hurricane, volcano, etc.

1) How concerned are you about natural hazards?
   - Not concerned
   - Hardly concerned
   - Somewhat concerned
   - Concerned
   - Highly concerned

2) Which natural hazard do you think is the most dangerous?
   - Hurricane
   - Volcano
   - Tsunami
   - Flooding
   - Landslide
   - Earthquake
   - Other ____________

3) Which natural hazard do you think you are most likely to experience while in your village?
   - Hurricane
   - Volcano
   - Tsunami
   - Flooding
   - Landslide
   - Earthquake
   - Other ____________

4) Have you ever been personally impacted by a natural disaster?
   - Yes
   - No

4B) If you answered yes to question 4, what type of disaster was it? (Choose all that apply)
   - Hurricane
   - Volcano
   - Tsunami
   - Flooding
   - Landslide
   - Earthquake
   - Other ____________

4C) If you answered yes to question 4, please briefly describe
   ____________________________________________________________
   ____________________________________________________________

5) Has anyone in your family ever taught you about natural hazards?
   - Yes
   - No

5B) If you answered yes to question 5, who taught you?
   - Parent(s)
   - Grandparent(s)
   - Children
   - Other ____________
6) Have you ever been taught about natural hazards through a class or program?
   □ Yes
   □ No

6B) If you answered yes to question 6, how were you taught? (Choose all that apply)
   If you select Radio/TV/News Paper, please indicate which station/publication
   □ In primary school  □ Radio station: __________
   □ In high school   □ Television station: __________
   □ In college      □ Newspaper publication: __________
   □ At a community event □ Other: __________

7) Including yourself, please indicate the age of each person living in your household, their relationship to you, and if they would need physical assistance seeking safety during a disaster?

<table>
<thead>
<tr>
<th>Age</th>
<th>Relationship</th>
<th>Physical assistance needed (yes/no)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

PERSONAL INFORMATION

8) Age: _____

9) Village where you grew up: ______________________

10) Occupation: _________________________________

11) Gender:
    □ Male
    □ Female

12) Education Level
    □ Less than high school
    □ High school
    □ College/University

13) Trained in a specific skill (ex: Fishing, Sewing, First Aid, etc.)
    □ No
    □ Yes, indicate skill: _____________________

Comments (Optional) ____________________________________________________________________
_____________________________________________________________________________________
_____________________________________________________________________________________
Appendix D:

FOCUS GROUP BLANK MAP
Appendix E

GIS ANALYSIS
Appendix F

PYTHON CODE
In [1]:
import pandas as pd
import rasterio
import numpy as np
import matplotlib.pyplot as plt
import scipy.stats as stats

%matplotlib inline

In [2]:
attrib_file = 'Coded surveys.xlsx'
raster_dir = 'All rasters/'

df = pd.read_excel(attrib_file)
df.head()

In [3]:
def stacker(fns, path='./', verbose=False, return_georeferencing=False):
    # load the first raster to get width and height
    read_success, I = False, 0
    while not read_success and I<len(fns):
        fn = fns[I]
        try:
            with rasterio.open(path + fn) as src:
                I = src.read(1)
                af = src.affine
                gt = src.get_transform()
                crs = src.get_crs()
                nodata_value = src.get_nodatavals()[0]
                raster_size = np.shape(I)
                read_success = True
        except:
            I = I+1

    if read_success:
        # Create composite, including a spot to count unloadable rasters
        composite = np.zeros((np.sum(len(fns)), raster_size[0], raster_size[1]), dtype=np.float)
        loaded_count = 0
        bad_list = []
# Load the rasters
for i, fn in enumerate(fns):
    if verbose:
        print(fn)
    read_success = False
    try:
        with rasterio.open(path + fn) as src:
            l = src.read(1)
            gt = src.get_transform()
            crs = src.get_crs()
            nodata_value = src.get_nodatavals()[0]
            raster_size = np.shape(l)
            read_success = True
    except:
        print('Could not read:', fn)
        bad_list.append(i)
    if read_success:
        nodata_mask = l == nodata_value
        composite[i] = l
        loaded_count = loaded_count + 1

# Eliminate the bad loads and return the stack
composite = np.delete(composite, bad_list, 0)
composite[:, nodata_mask] = np.nan
print(np.shape(composite)[0], 'rasters loaded.

if return_georeferencing -- True:
    metadata = {  
        'affine': af,  
        'geotransform': gt,  
        'crs': crs,  
        'nodata_value': nodata_value,  
        'raster_size': raster_size  
    }
    return composite, metadata

else:
    return composite

else:
    print('\nCould not read any rasters!  Try specifying the path to them?\n')
    return None

def normalize(stacks):
    # Process per item normalization:
    stacks = list(stacks)
    stacks = [(item-np.nanmean(item)) / np.nanstd(item) for item in stacks]
    stacks = tuple(stacks)
    return stacks
In [4]:

def raster_statstest(stacks,test,popmean=0,nan_policy='omit',equal_var=False):
    if not type(stacks)==tuple:
        stacks = (stacks,)

    raster_size = np.shape(stacks[0])[1],np.shape(stacks[0])[2])
P = np.zeros(raster_size,dtype=np.float)
P[:,:,] = np.nan
    if test=='ttest_1samp':
        if np.ndim(popmean) > 0:
            stacks = (stacks[0] - popmean,)
popmean = 0
        T, P = stats.ttest_1samp(stacks[0],popmean=popmean,axis=0,nan_policy=nan_policy)
        return T,P
    elif test=='ttest_ind':
        T, P = stats.ttest_ind(stacks[0],stacks[1],axis=0,equal_var=equal_var,nan_policy=nan_policy)
        return T,P
    elif test=='mannwhitneyu':
        U = P.copy()
        for i in range(raster_size[0]):
            for j in range(raster_size[1]):
                result = stats.mannwhitneyu(A[:,i,j],B[:,i,j])
P[i,j] = result[1]
        U[:,i,j] = result[0]
        return U,P
    elif test=='f_oneway':
        F = P.copy()
        for i in range(raster_size[0]):
            for j in range(raster_size[1]):
                this_stack = []

        for k in range(len(stacks)):
            this_stack.append(stacks[k][i,j])
            result = stats.f_oneway(*this_stack)
P[i,j] = result[1]
        F[i,j] = result[0]
        return F,P
    elif test=='kruskal':
        H = P.copy()
        for i in range(raster_size[0]):
            for j in range(raster_size[1]):
                this_stack = []
            for k in range(len(stacks)):
                this_stack.append(stacks[k][i,j])
                try:
                    result = stats.kruskal(*this_stack)
                except:
                    result = (np.nan,np.nan)
P[i,j] = result[1]
        H[i,j] = result[0]
        return H,P
    else:
        print('Test not yet supported.')
        return None
In [5]:
# The most general form of Cohen’s D, to which two stacks of rasters are provided. These uses a weighted pooled sd to
# support the calculation using different sample sizes.

# Identically to https://www.psychometrica.de/ effect_size.html #1 using Hedges g
# formula at https://stats.idre.ucla.edu/other/mult-pkg/faq/general/effect-size-power/how-is-effect-size-used-in-power-analysis
# Also identical to Leenes, 2013 Formula 1.

def pooled_sd(a, b, axis=0):
    N1 = np.sum((np.isnan(a) == False), axis=axis)
    N2 = np.sum((np.isnan(b) == False), axis=axis)
    SD1 = np.std(a, axis=axis)
    SD2 = np.std(b, axis=axis)
    psd = np.sqrt(((N1 - 1) * (SD1 ** 2) + (N2 - 1) * (SD2 ** 2)) / (N1 + N2 - 2))
    return psd

def cohen_d(a, b, axis=0):
    M = np.mean(a, axis=axis) - np.mean(b, axis=axis)
    D = M / pooled_sd(a, b, axis=axis)
    return D

# Calculate Cohen’s D based on results from a one-sample t-test.
# See Equation 7 (Leenes, 2017) and https://www.youtube.com/watch?v=yGcfua3O1I4&t=381s.

def cohen_t(T, N):
    D = T / np.sqrt(N)
    return D

# To be used for independent / between-subjects design to convert T to D. Should be nearly
# identical to cohen_d above. See equation 2 and subsequent approximations in

def cohen_ds(T, N, N2=None):
    if N2 is None:
        ds = 2 * T / np.sqrt(N)
    else:
        ds = T * np.sqrt((1/N) + (1/N2))
    return ds

# See file:///C:/Users/Thomas%20Engel/Desktop/Effect_Sizes.pdf, equation 5
# cited by

def cohen_from_F2(F, N1, N2):
    D = np.sqrt(F * (((N1 + N2) / (N1 * N2)) * ((N1 + N2) / (N1 + N2 - 2))))
    return D

# See https://en.wikipedia.org/wiki/Mann%E2%80%93Whitney_U_test
# and https://www.youtube.com/watch?v=pqi86z7V3UK
#
# Z is an approximation, which holds for large sample sizes
# Additional calculations based on http://www-01.ibm.com/support/docview.wss?uid=swg21476421
#
# Validated against #11 at https://www.psychometrica.de/ effect_size.html
def cohen_from_u(U, N1, N2):
    mu = N1*N2/2
    stdu = np.sqrt((N1*N2*(N1+N2-1))/12)
    Z = (U - mu) / stdu
    eta_squared = (Z**2) / ((U+N2-1))
    return eta_squared

# Mask a resulting effect size raster using a minimum specified effect size and p-value.
def d_mask(D, P, d=2, p=.05):
    Dmask = D.copy()
    Dmask[np.abs(D)>d] = np.nan
    Dmask[P==p] = np.nan
    return Dmask

# Mask a resulting effect size raster using a minimum specified effect size and p-value.
def d_mask(D, P, d=2, p=.05):
    Dmask = D.copy()
    Dmask[np.abs(D)>d] = -9999
    Dmask[P==p] = 9999
    Dmask[Dmask<-9999] = 1
    Dmask[Dmask>9999] = 0
    return Dmask

# See https://www.researchgate.net/post/Anyone_know_how_to_calculate_eta_squared_for_a_Kruskal-Wallis_analysis_for_eta_squared
# D calculated as above from Mann Whitney U

def cohen_from_h(U, N, k):
    eta_squared = (h**k) / (h-k)
    eta_squared[h>k] = 0
    D = 2 * np.sqrt(eta_squared / (1-eta_squared))
    return D

def stack_counts(stack):
    Ns = np.sum(np.isfinite(item,axis=0) for item in stack)
    return Ns

def fix_bad_pixels(stack):
    stack = list(stack)
    for i in range(len(stack)):
        A = stack[i]
        A[A==A] = np.nan
        stack[i] = A
    return tuple(stack)

In [6]:
variable = 'gender'
variable_values = ['male', 'female']
stack = []
aggregates = []

for var_value in variable_values:
    idx = df[variable] == var_value
    A, md = stacker(df.loc[idx, 'filename'].values, path='All rasters/', return_georeferencing=True)
    # Fix bad values
    A[A == A] = np.nan
    A[A == A] = np.nan
    aggregates.append(A)
    aggregates.append(np.nansum(A,axis=0))

stack = tuple(stack)

# Normalize if desired
# stack = normalize(stack)

# Count total responses per cell
N = np.sum(stack_counts(stack), axis=0)

# Count total number of responses for each raster
counts = [len(item) for item in stack]
```python
# Calculate statistics and masks
H,P = raster_stattest(stack,'kruskal')
D = cohen_from_H(H,N,k=len(stack))
Dmask = d_mask(D,P,.2,.05)
Dbad = d_mask_r(D,P,.2,.05)

# Calculate statistics by individual
values = []
for i in range(len(stack)):
    values.append(np.nanmean(stack[i],axis=(1,2)))
values = tuple(values)
h,p = stats.kruskal(*values)
n = np.sum([len(item) for item in values])
k = len(values)
eta_squared = (h-k+1) / (n-k)
d = 2 * np.sqrt(eta_squared / (1-eta_squared))
print('N: ',n)
print('num groups (k): ',k)
print('counts: ',counts)
print('Kruskal-Wallis H: ',h)
print('p-value: ',p)
print('cohen's d: ',d)

print("Mild effect size ",100 * np.nansum((D>=.2) & (D<.5) & (P<.05)) / np.nansum(np.isfinite(D)))
```

```
In [9]: # Save the masked D values

plt.imsave(variable + '_D_masked.png',Dmask,cmap='YlOrRd',vmin=.2,vmax=.8,dpi=300)

with rasterio.open(variables['D_masked_bnd.tif'], 'w', driver='GTiff',
    height=md['raster_size'][0], width=md['raster_size'][1],
    count=1, dtype=np.float32, transform=md['affine'],nodata=np.nan) as src:
    src.write(Dmask.astype(np.float32), 1)

with rasterio.open(variables['D_masked_bnd.tif'], 'w', driver='GTiff',
    height=md['raster_size'][0], width=md['raster_size'][1],
    count=1, dtype=np.float32, transform=md['affine'],nodata=np.nan) as src:
    src.write(Dbad.astype(np.float32), 1)
```
In [10]: # Write out individual composites
   # Prior analysis put the 5th and 95 percentile for all participants at:
   # array([0.12275645, 3.14916463])
   vmin = 1.62
   vmax = 3.42
   cmap = "coolwarm"
   
   for i, var_value in enumerate(variable_values):
       filename = variable + "_" + var_value
       with rasterio.open(filename + '.tiff', 'w', driver='GTiff',
                          height=md['raster_size'][0], width=md['raster_size'][1],
                          count=1, dtype=np.float32, transform=md['affine'], nodata=np.nan) as src:
           src.write(agggregates[i].astype(np.float32), 1)

   plt.imsave(filename + '.png', aggregates[i], cmap=cmap, vmin=vmin, vmax=vmax, dpi=300)

In [11]: # If there are only two, write out a difference raster
   difference = aggregates[0] - aggregates[1]
   
   plt.imsave(variable + '_difference.png', difference, cmap="coolwarm", vmin=-1, vmax=1, dpi=300)
   
   with rasterio.open(variable + '_difference.tiff', 'w', driver='GTiff',
                      height=md['raster_size'][0], width=md['raster_size'][1],
                      count=1, dtype=np.float32, transform=md['affine'], nodata=np.nan) as src:
       src.write(difference.astype(np.float32), 1)

   
   
In [12]: variable = 'participant'
   
   # Load the stacked raster, call it A
   idx = df['participant']=='yes'
   A, md = stacker(df.loc[idx, 'filename'].values, path="All rasters/", return_georeferencing=True)
   N = np.sum(np.isfinite(A), axis=0)
   A_ = np.nanmean(A, axis=0)
   
   # Load the comparison raster, call it B
   idx = df['participant']=='no'
   B = stacker(df.loc[idx, 'filename'].values, path="All rasters/")
   B = np.squeeze(B)
   
   print(np.shape(B))
   
   # Supply the B raster as the population raster
   T,D = raster_stats_test(A, 'test_isamp', popmean=B)
   
   D = coheni(T,N)
   Dmask = d_mask(D,P)
   
   plt.imsave(variable + '_D_masked_D.png', Dmask, cmap="YlOrRd", vmin=.2, vmax=.8, dpi=300)
   
   with rasterio.open(variable + '_D_masked_D.tif', 'w', driver='GTiff',
                      height=md['raster_size'][0], width=md['raster_size'][1],
                      count=1, dtype=np.float32, transform=md['affine'], nodata=np.nan) as src:
       src.write(Dmask.astype(np.float32), 1)
In [13]:

```python
# did participants perceive the risk differently than the model
stats.wilcoxon(np.nanmean(A-B,axis=(1,2)))
```
Appendix G
CODING MATRIX
<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Summary Statements</th>
<th>Thoughts for farther inquiry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Specific demographic groups were mentioned.</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>Children</td>
<td>Children were brought up. &quot;Leave Dominica cos for the sake of breathing and respiration and have your kids, you can't let, you can't, it is a dangerous place leaving on standing ground.&quot;</td>
<td>The participant was concerned about the safety of children in the event of an eruption.</td>
<td>No</td>
</tr>
<tr>
<td>Older adults</td>
<td>Older adults were brought up. &quot;...the BoilingLake hmm and thing and in fact, going through elderly people and so on and talking...&quot;</td>
<td>Participants mention older people in a context suggesting that they expect older generations to have more insight about where risk exists</td>
<td>No</td>
</tr>
<tr>
<td>Direction</td>
<td>Participant refers to a general region/direction of the island.</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>East</td>
<td>Participant refers to the east. &quot;...the east I colored it LowRisk since they are so far</td>
<td>Generally, the east is considered to be Low risk to moderate. No one mentioned them as being dangerous.</td>
<td>How did the Kalinago end up in</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
<td>Summary Statements</td>
<td>Thoughts for farther inquiry</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td>away from the south.&quot;</td>
<td></td>
<td>this region?</td>
</tr>
<tr>
<td>Interior</td>
<td>Participant refers to the interior. &quot;...because the risk are getting decrease as we move up into the interior.&quot;</td>
<td>Participants tended to refer to the interior in relation to mountains but surprisingly considered low risk rather frequently.</td>
<td>Farther investigate the differences between why some people think it is high risk and others think it is safe.</td>
</tr>
<tr>
<td>North</td>
<td>Participant refers to the north. &quot;...in the north as well as we had tremors of late and the Catholic church been yes destroyed.&quot;</td>
<td>There is also a lot of disagreement about the risk level in the north. The north is brought up in regards to the earthquake and the volcano. A dormant/active volcano is mentioned; people are not in agreement about its status.</td>
<td>Compare to the comments on the tremors.</td>
</tr>
<tr>
<td>South</td>
<td>Participant refers to the south. &quot;Well, as you all can see at the southern part of the island, that is Soufriere and ScottsHead and also Laudat and WottenWaven, these are the</td>
<td>Well understood to be high or very high risk, with multiple reference to its many volcanos and its geothermal activity-which is confused with actual activity on occasion.</td>
<td>No</td>
</tr>
<tr>
<td>Name</td>
<td>Description</td>
<td>Summary Statements</td>
<td>Thoughts for farther inquiry</td>
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<tr>
<td>West</td>
<td>Participant refers to the west. &quot;...moderate risk on the west coast by Salisbury Mahaut Canfield.&quot;</td>
<td>Largely considered to be moderate risk</td>
<td>No</td>
</tr>
<tr>
<td>Experts</td>
<td>Participant mentions advice the nation has received to make the country a safer place. &quot;Environmentalist say that we should have our hospital relocated.&quot;</td>
<td>There is talk about foreigners (Trinidad) (environmentalists, volcanologists) making recommendations regarding the relocation of facilities, possible imminent eruptions. Two people expressed disagreement with the recommendations.</td>
<td>No</td>
</tr>
<tr>
<td>Impacts</td>
<td>Potential impacts participants believe a volcanic eruption would have.</td>
<td></td>
<td></td>
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<tr>
<td>Evacuation</td>
<td>Referenced that people would need to evacuate Dominica or certain regions. &quot;when that burst, everybody have to come out there, and they have to move far or even leave Dominica.&quot;</td>
<td>Participant are generally talking about the need to evacuate should there be volcanic activity there is talk about going to Marigot or leaving Dominica in that case. There is also discussion about the limited access to communities.</td>
<td>No</td>
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<tr>
<td>Health</td>
<td>Perceived health impacts. &quot;... even leave Dominica cos for the sake of breathing and respiration...&quot;</td>
<td>Respiratory issues are mentioned as well as the vulnerability of the Hospital.</td>
<td>Code other references to hospital here as well.</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Perceived impacts on infrastructure. &quot;...volcanic eruption was to occur hmm it will definitely impact our houses, infrastructure,&quot;</td>
<td>Ash and rocks falling on property is a concern along with landslide destroying or cracking buildings and blocking roads.</td>
<td>No</td>
</tr>
<tr>
<td>Wind</td>
<td>Wind is seen as influencing the volcanic risk. &quot;If that volcano erupt, the wind will blow it down towards Capuchin, MorneALouis.&quot;</td>
<td>There is consideration of how the wind patterns will affect the distribution of ash during an event.</td>
<td>No</td>
</tr>
<tr>
<td>Physical Features</td>
<td>References to places/attractions on the island excluding mountains.</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>Boiling Lake</td>
<td>Boiling lake is mentioned. &quot; Well I know about Laudaut because that is where I have the lake, the</td>
<td>Laudat is almost always mentioned as well as Wotten Waven and Grand Fond. They valley of desolation and Trios Pitons are also mentioned regularly. The lake is</td>
<td>No</td>
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<tr>
<td>Boiling Lake</td>
<td>Boiling Lake. it is very dangerous.&quot;</td>
<td>given as evidence of current active volcanoes.</td>
<td></td>
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<tr>
<td>Champaign reef</td>
<td>Champaign reef is mentioned. &quot;all you have to remember the SulfurSpring, champagne reef.&quot;</td>
<td>Given as evidence of volcanic activity. Pointe Michele is frequently mentioned. One participant said that the village would be spared since it is uphill from Champaign which implies they believe an eruption would happen from the beach itself.</td>
<td>No</td>
</tr>
<tr>
<td>Cold Soufriere</td>
<td>Cold sulphur springs are mentioned. &quot;But instead of the water been hot, the water is cold, so that is why it is cold Soufriere&quot;</td>
<td>People mentioned that the spring is itself a volcano.</td>
<td>No</td>
</tr>
<tr>
<td>Fresh Water &amp; Borie Lakes</td>
<td>Fresh Water &amp; Borie Lakes are mentioned. &quot;now my reason for being that Laudat right, we have the FreshWaterLake and the BoeriLake and if it comes down to GrandFond area down, we are safe because we are between two valleys,&quot;</td>
<td>Participant believes they are safe because they are on a ridge between two vales so the lava and debris would go around them.</td>
<td>No</td>
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<tr>
<td>Mountains</td>
<td>Participant spoke generally of mountains. &quot;Dominica is a mountainous country and there have a range of mountain in the center of the country.&quot;</td>
<td>Believed that most of the mountains are volcanoes. Some believe that the flatter mountains are not as dangerous, such as in Warner. There is talk of the mountains/volcanoes making a chain down the center of the island running north to south.</td>
<td></td>
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<tr>
<td>Mt. A Louis</td>
<td>Mt. A Louis is mentioned. &quot;I put the top and MorneALouis to a certain extent as VeryHighRisk.&quot;</td>
<td>Associated with northern villages. Only mentioned by one participant in a northern village.</td>
<td>No</td>
</tr>
<tr>
<td>Mt. Anglais</td>
<td>Participant mentioned Morne Anglais. &quot;I will say ModerateRisk cause they have MorneAnglais, I think its active.&quot;</td>
<td>Participant thinks it is active.</td>
<td>No</td>
</tr>
<tr>
<td>Mt. Aux Diables</td>
<td>Participant mentioned Mt. Aux Diables. &quot;MorneAuDiable is in Portsmouth there, its a volcanic&quot;</td>
<td>Believed to be active. Brought up by people in the north.</td>
<td>No</td>
</tr>
<tr>
<td>Mt. Diablotin</td>
<td>Participant mentioned Mt. Diablotin. &quot;I</td>
<td>Most frequently mentioned volcano. One person mentioned that it has been dormant for 400 years and is</td>
<td>Fact check some of</td>
</tr>
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<tr>
<td>Mt. Micotrin</td>
<td>Mt. Micotrin is mentioned. &quot;...if you still have an eruption, let us say MtMicotrin by BoilingLake and so on and so forth.&quot;</td>
<td>Mostly considered extinct. Tallest peak in Dominica. One person said it might erupt now.</td>
<td>These claims.</td>
</tr>
<tr>
<td>Mt. Prosper</td>
<td>Mt. Prosper is mentioned. &quot;Laudat, Mt. Prosper&quot;</td>
<td>Mentioned being near the boiling lake, and near Mt. Anglais, Mt. Watts, Mt. Plat Payes</td>
<td>No</td>
</tr>
<tr>
<td>Mt. Trois Pitons</td>
<td>Participant mentioned Mt. Trois Piton. &quot;MtTroisPiton, it that I dream of that. when that burst, everybody have to come out there, and they have to move far or even leave Dominica cos for the sake of</td>
<td>Said to be dormant for 400 years and can wake up. It is mentioned that the bells area at the base of trios pitons is safe because it is open. Generally considered very high risk.</td>
<td>Fact check.</td>
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<tr>
<td>Mt. Watts</td>
<td>Mt. Watts is mentioned. &quot;Well as we all know, Dominica, Soufriere and a whole is in a valley and most of the active volcanoes is in MorneWatts.&quot;</td>
<td>Believed to have most of the active volcanoes</td>
<td>No</td>
</tr>
<tr>
<td>Sulphur Springs</td>
<td>Sulphur springs / hot springs are mentioned. &quot;This side here where they have the SulphurSprings and the I believe they have more something like they can have eruption there.&quot;</td>
<td>People had a lot to say about the springs. Though of as high or very high risk. Though to be active volcanoes. The hot water could cook an egg. There are many all over the island, not just the well-known locations. These places are tourist attractions.</td>
<td>No</td>
</tr>
<tr>
<td>Valley of Desolation</td>
<td>Valley of Desolation is mentioned. &quot;So I kind of color Laudat, as you know the ValleyofDesolation and the BoilingLake and the hmm close to it will be PonCasse</td>
<td>Though of as dangerous with visible steam coming from it.</td>
<td>No</td>
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<tr>
<td></td>
<td>will be affected not VeryHighRisk, GrandFond close to Laudat&quot;</td>
<td></td>
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<tr>
<td>Valleys</td>
<td>Participant mentioned valleys. &quot;the rest of my map are green right, because we are very mountainous it wont have much effect on the rest of the island, it will just pass through valleys and things like that.&quot;</td>
<td>Dangerous because the lava and steam will follow the valleys.</td>
<td>No</td>
</tr>
<tr>
<td>Proximity</td>
<td>Proximity is mentioned. &quot;... this area close to the HighRisk the VeryHighRisk area I will consider them to be at HighRisk since they are in close proximity to the to this area as well and also to the North.&quot;</td>
<td>Generally high risk or moderate.</td>
<td>It would be interested to identify which maps have the zones in continual sequence from very high &gt; high &gt; moderate &gt; low.</td>
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<tr>
<td>Qualifications</td>
<td>Comments made to indicate the a participant is either knowledgeable or unknowledgeable about volcanic risk.</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>Qualified</td>
<td>Participant feels qualified.</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>Ancestors</td>
<td>Participant feels qualified based on what their elders have told them.</td>
<td>Their family came from Martinique and their ancestors experienced the 1902 eruption.</td>
<td>No</td>
</tr>
<tr>
<td>Media</td>
<td>Participant feels qualified based on what they have seen on TV.</td>
<td>They follow the news/ weather reports/ weather channel.</td>
<td>No</td>
</tr>
<tr>
<td>Occupation</td>
<td>Participant feels qualified based on their occupation.</td>
<td>Cited their work experience as including travel or being related to somehow such as working for the government or as a teacher or fisherman.</td>
<td>No</td>
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<td></td>
<td>government and when it is hurricane time I use to work all over Dominica.&quot;</td>
<td></td>
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<tr>
<td>Past experiences</td>
<td>Participant feels qualified based on their past experiences with disasters. &quot;we have certain tremors, tremors from the, well a lot of people don't know about that and so on, you feel, this people feel it heavier than we especially in the southeast and so on, so based on this little experience that is how why I put my map&quot;</td>
<td>Participants reference their experience with tremors and some even their lack of experience with volcanoes. Another man described his fear of disasters after the trauma experienced in Hurricane David.</td>
<td>No</td>
</tr>
<tr>
<td>People talking</td>
<td>Participant feels qualified based on things they have heard others say. &quot;from the time I know myself, I heard people talking about the volcano.&quot;</td>
<td>Most participants do not specify who they heard talking just that they have hear it said….</td>
<td>No</td>
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<tr>
<td>School</td>
<td>Participant feels qualified based on what they have heard in a class.</td>
<td>References to geography and history classes as well as workshops that have been attended.</td>
<td>No</td>
</tr>
<tr>
<td>Travel</td>
<td>Participant feels qualified based on traveling they have done. &quot;...anywhere I have hot water tell you what that area is. so during my hiking and things so when you see me putting red and thing that what I meant.&quot;</td>
<td>Thoughts are based on their personal experiences and things they have seen while in different parts of the country, such as at the top of Mt. Diaboliitin or Soufriere</td>
<td>No</td>
</tr>
<tr>
<td>Unqualified</td>
<td>Participant feels unqualified.</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>Bad memory</td>
<td>Participant feels unqualified because they feel their memory is bad. &quot;I didn’t probably been long I haven't been to a geography class.&quot;</td>
<td>Participants mentioned it has been a long time since they have been in school, or they are forgetful.</td>
<td>No</td>
</tr>
<tr>
<td>Guessing</td>
<td>Participant feels unqualified because they are guessing. &quot;OK so, honestly, I do not know much about volcanoes and</td>
<td>Most people in this group guessed entirely, while some made educated guesses.</td>
<td>Make a composite of these maps</td>
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<tr>
<td>Lived Away</td>
<td>Mentioned living away as a reason they are not familiar with volcanic risk. &quot;I lived away for long time so I am not aware of any volcano or anything in Dominica.&quot;</td>
<td>This participant was unfamiliar with many of the locations in Dominica.</td>
<td>No</td>
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<tr>
<td>Triggers</td>
<td>Participant indicates a potential cause of volcanic activity</td>
<td>N/A</td>
<td>No</td>
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<tr>
<td>Extractions</td>
<td>Participant mentioned that mining could cause volcanic activity. &quot;Colihaut are because they do a lot of hmmm extraction there so</td>
<td>One was concerned about the quarry extractions in Colihaut</td>
<td>No</td>
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<tr>
<td>GeoThermal</td>
<td>Participant thinks the geo thermal harvesting is related to the volcanic risk on island. &quot;Ok, let me make a point now, after the man (inaudible) geothermal and then play with the volcano, we can never get a small volcano if it blow up.&quot;</td>
<td>Participants are concerned that the geothermal site near Laudat has disturbed the volcanoes and can increase the chance of an eruption and result in a larger eruption.</td>
<td>No</td>
</tr>
<tr>
<td>Villages</td>
<td>Village names are mentioned</td>
<td></td>
<td></td>
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<tr>
<td>Dangerous</td>
<td>Villages that participants perceive to be dangerous. &quot;...well we all know that area where you find HotSprings are volcanic areas, so I put them in HighRisk, like</td>
<td>Villages that are commonly considered as dangerous: Laudat, Wotton Waven, Pichelin, Portsmouth, Scott’s Head, Villie Case, Roseau, Colihaut, Soufriere, Pointe Michele, Delices, Grand Bay,</td>
<td>Do a word count</td>
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ScottsHead, Soufriere and the other villages in the vicinity."

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<tr>
<td>Moderate</td>
<td>Villages that participants perceive to be moderate. &quot;PointMichelle, Roseau, Canefield will be moderate because they are close but not so close to ScottsHead and Soufriere.&quot;</td>
<td>Villages that are commonly considered moderate: St. Joseph, Calibishie, Castle Bruce, Bells, La Plaine, Salisbury, Pon Casse, Canefield, Dublanc, Do a word count</td>
<td></td>
</tr>
<tr>
<td>Safe</td>
<td>Villages that participants perceive to be safe. &quot;you see VielleCase Marigot probably safe but no other place in Dominica safe.&quot;</td>
<td>Villages that are commonly considered safe: Wesley, Kalinago Territory, Cabrits, Marigot, Portsmouth, Concord, Calibishie, Castle Bruce, Warner, Roseau, Giraudel Do a word count</td>
<td></td>
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<tr>
<td>Their village</td>
<td>Participant refers to their own village. &quot;then GrandFond, because we on the road, so if a volcano erupt in the (inaudible) we always get the</td>
<td>As expected there is a mix between high and low risk perceptions in their own villages. Some people expressed hesitance to putting their own village as dangerous. One admitted bias while selecting low risk. some villages, such as grand fond, have participants saying it is both low and high risk. I could look into how people rank their village compared to how the USAID</td>
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<tr>
<td>Volcano related</td>
<td>Participant mentioned factors directly related to volcanos.</td>
<td>N/A</td>
<td>No</td>
</tr>
<tr>
<td>Fumes</td>
<td>Fumes are mentioned. &quot;The wind generally blows in that direction so they will get some ok of the fumes.&quot;</td>
<td>People marked high risk based on areas where sulphuric fumes can be detected. Also, that the wind would cause fumes from an eruption to travel far distances.</td>
<td>No</td>
</tr>
<tr>
<td>Lava</td>
<td>Lava is mentioned.&quot;...if we had a volcanic eruption maybe it won’t break the house as much but they will get lava&quot;</td>
<td>Much discussion about the perceived patterns of lava flow. There is also the idea that the mountains and valleys will prevent lava from flowing uphill to villages at higher elevations away from the initial eruption. Lots of references to valleys.</td>
<td>No</td>
</tr>
<tr>
<td>Smoke</td>
<td>Smoke is mentioned. &quot;It will have an effect on all of us. all of us. cos you see that poom, that smoke, we have to watch ourselves.&quot;</td>
<td>Reference to smoke making trees die and being a health hazard</td>
<td>No</td>
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