

A longitudinal study of Dominican secondary school students and their perceptions of a multi-hazard environment.

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Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

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For Lis and Bethany Parham, Paula and Robert Boswell, family and friends, both current and past.

Abstract

Risk perception studies compare differences in objective and actual risk and form an essential part of disaster risk reduction (DRR). Criticisms of past risk perception studies emphasise the narrow focus on single hazard environments; focus on just adult groups and short-term approaches. This study addresses these issues through a 5-year longitudinal study (2013-2018) of student perception on the Small Island Developing State (SIDS) of Dominica, to better understand multi-hazard perception trends. As part of this assessment, it uses the 2012 UNESCO report into disaster risk education to test the impact of three educational approaches (interactive, surrogate, field-based) on changing student risk perception. Criticisms of existing student risk perception studies focus on methods deemed more applicable to adults. This study tests an adapted Pictorial Representation of Individual Self Measure (PRISM) method to assess its validity for collecting child risk perception data.

This study, one of the first longitudinal studies assessing multi-hazard perception, showed that PRISM was an effective tool for collecting secondary student risk perception data. Longitudinal trends in multi-risk perception showed consistent student perceived relative risk order. Students showed bias towards perceptions of known or experienced hazards and poor relative understanding of low frequency high magnitude geophysical hazards. Significant large-scale events (e.g., Hurricane Maria) intensified hazard perceptions, however, this effect decayed over time. Highlighting that the relationship between frequent versus less frequent hazards needs further consideration. Equally, location and gender are both factors influencing perception. Boys tended to be more risk averse, while evidence of disaster risk perception spatially suggests a need for bespoke approaches to DRR education.

This study showed that targeted educational pedagogical approaches all impacted risk perception. Participatory approaches were more impactful. Field-based learning caused the greatest shifts in perceptions for less-perceived geophysical hazards. This has important implications for future disaster risk education and outreach. The study showed that careful educational resourcing can improve engagement in DRR, but it should have a local focus. This study underlines the need to develop DRR education into school curriculum. Children should be encouraged to play a more active role in bottom up DRR approaches, within schools to improve risk perceptions.

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Acronyms

CAP – Common Alter Protocol

CAPE – Caribbean Advanced Proficiency Examinations

CCDRR – Child-Centred Disaster Risk Reduction

CDEMA (formerly CDERA)– Caribbean Disaster Emergency Management Agency

CDRT – Community Disaster Training Scheme

CERT – Community Emergency Response Teams

CRC – Convention of the Rights of the Child

CSEC – Caribbean Secondary Education Certificate

DOMLEC – Dominica Electrical Services

DRC – Declaration of the Right of a Child

DRE – Disaster Risk Education

DRR – Disaster Risk Reduction

EAL – English as a Second Language

EOC – Emergency Operations Centre

GDP – Gross Domestic Product

HFA – Hyogo Framework for Action

IMST – Independent Samples Mean Test

KT – Kalinago Territory

KWT – Kruskal Wallis Test

LAT – Lesser Antilles Trench

LIAT – Leeward Islands Air Transport

MDG – Millennium Development Goals

NDP – National Disaster Policy

NEPO – National Emergency Planning Organisation

NGOs – Non-Government Organisations

NOAA – National Oceanic and Atmospheric Administration

NONTECHS – Non-technical skills

ODM – Office of Disaster Management

PPVC – Plat Pays Volcanic Complex

PRISM – Pictorial Representation of Illness and Self Measure

PRISM – Pictorial Representation of Individual Self measure

QTS – Qualified Teacher Status

RDS – Radio Data Systems

RC – Red Cross

SD – Standard deviation

SEM - Standard error of the mean

SEND – Special Educational Needs and Disability

SFA – Sendai Framework for Action

SHS – Self Hazard Separation

SIS – Self Illness Separation

SDG – Sustainable Development Goals

SIDS – Small Island Developing States

SWT – Shapiro Wilk Test

UN – United Nations

UNCED – United Nations Conference on Environment and Development

UNDP – United Nations Development Programme

UNEP – United Nations Environment Programme

UNESCO – United Nations Educational, Scientific and Cultural Organisation

UNDRR (formerly UNISDR) – United Nations Office for Disaster Risk Reduction

UNICEF – United Nations Children’s Fund

UNOCHA United Nations Office for the Coordination of Humanitarian Affairs

USGS – United States Geological Survey

VCA – Vulnerability and Capacity Assessment

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Chapter 1 – Introduction

1.1 An issue of risk

We live in a world of risk where there is the potential for negative occurrences affecting us. Where we live, who we are and what we do, and time determine both known and unknown risk. The decisions we make, help us take action to mitigate this risk. An individual will assess risk based on a variety of factors; who you are; personal or shared experiences; cultural and political beliefs (Adams, 1995). These encounters build experience which leads to adaptation to reduce harm. Despite our knowledge and experience individuals are different. Not all individuals are able to deal with risks in the same way. A variety of factors can determine this including level of understanding, health, wealth, resourcing, access to technology, age, gender, ethnicity, and governance. This results in greater vulnerability for some of the population. Even among populations with similar levels of vulnerability there are still differences to risk response. This adjustment for risk is capacity and can determine actions taken to reduce a threat.

Where you live is integral in the type of risk one faces. This spatial variation tends to account for human-induced risk. But the natural environment can also produce potential risk as natural hazards. These events are those, often of greater magnitude, can increase vulnerability. Less frequent hazards can surprise even individuals who have developed capacity. Consequently, latent disaster risk can reduce awareness. It is, therefore, important to understand the link between people's perception of risk in a multi-hazard environment, to help develop a better understanding of the risk, so to help them develop a greater capacity.

The traditional definition of disaster risk, given by Blackie et al, 1994, shows that it is a function of the natural hazard and an individual's vulnerability. :

$$\text{Disaster Risk (DR)} = \text{Hazard (H)} \times \text{vulnerability (V)}$$

Disaster Risk is a function of a variety of factors, including the magnitude, potential occurrence, frequency, speed of onset and spatial extent of the hazard (H) (Wisner et al, 2012). However, it is also a function of people's exposure to loss, injury or death associated with the hazard (vulnerability). Some people are better placed to manage these impacts as they may have individual or wider protection, for example from local authorities. Therefore, Wisner et al, (2012) suggest a that disaster risk be defined as:

$$DR = H \times (V/C) - M$$

Vulnerability is altered by an individual's capacity (C) to understand and manage the hazard. Even without an individual's ability to protect themselves (C), wider action may be taken by the authorities or large organisations to reduce the overall impact (V) of the risk for the population through mitigative actions (M). How an individual understands disaster risk is a matter of perception. A well-developed understanding may develop mitigative action, increasing risk capacity and reducing vulnerability. Therefore, understanding risk perception is a critical step developing a resilient population.

The act of identifying, assessing, and reducing the risks associated with natural hazards is the underlying theme of Disaster Risk Reduction (DRR). The study of DRR evolved through the 1970s and 1980s, and internationally formalised through the Yokohama Strategy (1994) and then the Hyogo Framework for Action (HFA) in 2005. Since 2015, it has been superseded by the Sendai Framework for Disaster Risk Reduction (SFA) which remains in place until 2030. At an international level, these documents have sought to make disaster risk reduction a national priority, building disaster resilience. The HFA set the foundation for this to be achieved while the SFA, using a similar approach to the Sustainable Development Goals (SDGs) (UN, 2015), set specific targets to quantify and build upon the goals outlined in the HFA. Despite these international approaches, measures taken to implement DRR are varied due to socioeconomic, political, and environmental factors.

At a national and regional scale local authorities and decision makers are tasked with the application of the HFA and SFA to reduce risk for people. Implementing effective DRR requires expertise to understand the difference between actual risk and objective risk perceived by the public. Experts seek to understand actual risk quantitatively, through probabilistic modelling. However, risk is not objective. An individual's perception of risk is affected by a variety of factors such as heuristic bias, social and political institutions, cognitive factors, and culture (Wachinger and Renn, 2010), leaving a disparity between actual and perceived risk. The HFA and SFA outlined goals to reduce this disparity which include improved education, improved awareness through communication, improved understanding, and warning of events and through changes to the built and natural environment. As these measures are of national interest and require investment, they are commonly implemented centrally or through DRR organisations employing a top-down approach. In less economically developed economies, risk reduction may not be a priority and therefore its implementation may not have the same impact or organisations seeking to implement DRR may adopt localised, lower-cost, bottom-up approaches. Consequently, success rates may vary spatially and temporally, dependent on political will.

There is a need to continue to improve the perception of individuals to better understand the risks in their environment, particularly in the developing world. Priority for Action 3 in the HFA outlines a need to *“use knowledge, innovation and education to build a culture of safety and resilience at all levels.”*

1.2 Considering multi-hazard risk.

The role of DRR organisations and experts attempting to reduce risk for populations will often focus on frequent threats to a society, or those with greater immediacy. This is problematic in multi-hazard regions. Over-emphasising dominant hazards may result in a population more vulnerable to the lower frequency or secondary hazard. This is compounded by the issue that research on improving public awareness is commonly associated with one hazard, with some extension into secondary hazards. There are few studies on the perception of multiple hazards in one location, especially where one set of hazards is dominant (Shreve et al, 2016). This creates a bias of awareness which has implications when low frequency events occur. Inevitably the capacity to cope with the low frequency hazard will reduce. This is further compounded by hazard magnitude. Vulnerability increases as the magnitude increases even in known hazards. But what if a population has only faced low – medium magnitude events? Experts will make probabilistic judgements about the frequency of a given magnitude of a hazard; however, individuals may standardise this concept into one view of a given hazard. It is therefore critical to conduct more studies into multi-hazard environments. Understanding the relationship between frequent and less frequent hazards can help identify the gaps in people's perception and provide more informative DRR strategies. Understanding this relationship requires a longitudinal view, yet many studies into perception are short-term. A long-term approach helps develop understanding of perceptions change in and the relationships between hazard perceptions. Building this understanding, in a multi-hazard environment could allow the building of resilience for a range of hazards and meet Action 3 in the Hyogo Framework.

1.3 Accounting for risk perception in vulnerable groups

Adults in developed nations are often the focus of risk perception studies, despite increased vulnerability evident most in the developing world. Any study into an area of risk should focus on the most vulnerable. Women, children, disabled and the elderly are more vulnerable within communities. Children are one of the most vulnerable sub-sections of the population during a hazard event, and proportionately fewer studies exist on their views (Ronan et al, 2001 & 2019). The

'Convention on the Rights of Children', and the *'Declaration of the Rights of the Child'* state that children should not be passive in the actions which can directly affect them. Despite this, recognition of the role children play in disaster reduction is noted, and increasingly the use of child participation in disaster risk reduction has been advocated. Yet, few studies on the longitudinal risk perceptions of children exist. Working with children presents problems, including satisfying ethical issues, safeguarding, developing appropriate communication and pedagogy understanding to educate children effectively. Yet children make up an ever-growing percentage of the population and represent the future of DRR.

Another issue has been the way hazard perception studies are conducted. Disaster risk perception studies are designed for adults, involving the use of semi-structured interviews or questionnaires, containing inappropriate language for children. Consequently, children may misrepresent their views or misunderstand questioning. There is a need for a method less reliant on written communication, to account for lower reading ages. This method would need to allow for explanation of views beyond the simple categorisation of methods such as the well-used Likert-scale.

1.4 Education to reduce disaster risk.

Improving DRR for children is most effective at source, either in schools or community settings. Using technology such as the internet, social media allows direct access to children, but may alienate vulnerable children without access. Face-to-face data collection within a community setting also has practical limitations. The school represents the ideal location as it is here that students collectively receive information (education) to improve their understanding of risk.

While modern curriculums teach a range of thematic subjects, they seldom include the subject disaster risk reduction. Therefore, students learn about disaster risk through science or geography lessons, regardless of a teacher's qualification to deliver this information to a level in accordance with an expert view. Alternatively, a school may use simulation to develop understanding, most commonly through drills, or as a co-curricular programme, i.e., hazards week. This approach limits opportunities to learn about disaster risk. Resourcing may be from external sources, e.g., NGOs, who do not have pedagogical experience to maximise engagement. Thus, increasing the likelihood of isolated learning, a lack of reinforcement or "memory decay" (Johnson et al, 2014). DRR education be a reaction to a pending hazard or a response to a recent hazard, rather part of the continuing curriculum. This approach favours focus on frequent disaster risk, rather than multiple risks, leading to a perception bias toward a frequent risk.

Educational resources are also important in developing the learning of children. Effective resourcing can inspire interest and promote self-learning. Few studies have assessed the usefulness of educational material and their influence on student perception. It is important to understand which types of resources work with which group of students. Available DRR resources are often mass produced therefore not relevant to a local context. Therefore, this leaves a need to test bespoke resourcing to compare its effectiveness in risk perception. Previous studies have suggested that a participatory approach with a bottom-up focus can improve engagement in DRR in local communities. This study seeks to understand how these participatory approaches impact secondary students' perception. Such information will allow authorities to develop sustainable policies towards disaster risk reduction.

1.5 Disaster Risk in SIDS

As mentioned above, DRR education and hazard risk perception studies tend to focus on places with recent events or impending risk. Access to developing countries is largely dependent on factors, such as NGO interaction, research funding, links to educational institutions or government policy, or wider economic and social factors. However, it is these countries with the greatest need to understand risk perception particularly in multi-hazard locations. This is more challenging when multi-hazards risks are spatially variable. In these cases, the management of risk is often dominated by the frequency/magnitude relationship of recent hazards.

Small Island Developing states (SIDS), such as those in the Caribbean, are those vulnerable to external and internal shocks. Natural hazards can impact on energy, trade, food, and job markets, leading to significant regressions in levels of development. Along with relative political instability and a lack of funding, required to make adequate preparation, such populations face a great need for mitigative measures to help maintain social and economic stability. Consequently SIDS, often rely on assistance from outside NGOs or potentially costly investment from bi or multilateral aid to execute disaster risk reduction. This also creates a level of over-reliance on outside organisations in the event of a natural disaster. Therefore, there is a need for a bottom-up approach which makes greater use of the local population involvement, engineering enthusiasm towards programs which have a sustainable impact.

1.6 'Road map' of this thesis

Having explored some of the gaps in understanding in DRR this study has two principle **aims**:

- I. To understand how student disaster risk perception changes longitudinally in a multi-hazard environment.
- II. To evaluate the role of different educational measures in improving student awareness of disaster risk.

The dearth of studies into disaster risk perception of students provides the basis for this study.

There are few longitudinal risk perception studies and fewer conducted in a multi-hazard environment. All studies assessing students' perceptions have used traditional qualitative measures, therefore this study will test a new method aiming to address the existing limitations in student perception studies. It will seek to understand the extent to which students' perception differs from actual risk and how it is influenced by education, community, or other socio-cultural factors. The study focus is the Caribbean Island of Dominica, a SIDS subject to multiple hazards. With spatial variation of disaster risks this study will seek to understand the spatial patterns in risk perceptions.

This research recognises that a limited number of studies have assessed the effectiveness of educational methods used in DRR and will therefore test different DRR educational approaches to understand which is most effective at changing student risk perception.

This chapter will continue to outline the study objectives to determine how these study aims will be achieved. **Chapter 2** outlines a review of the research into risk, risk perception, measures of risk perception and education for disaster risk reduction to build upon the issues outlined in this chapter. **Chapter 3** gives an overview of the sampling approaches and data collection, introducing the PRISM method to collect perception data, as well as justifying the educational approaches used. **Chapter 4** gives a detailed case-study of the multi-hazard environment in Dominica. It will address researched and observed disaster risk and, vulnerability in a historical context. **Chapters 5-7** will address the interdisciplinary nature of the study through empirically themed chapters addressing the PRISM data, response to disaster risk and disaster risk education (DRE). Chapter 8 outlines further recommendations for research and finally concludes the study aims.

1.7 Context of research objectives

People are the ones affected by disaster risk, they are the ones who based on their own decisions or those of authorities, that face the major impacts of disasters. Therefore, an understanding of their perceptions is surely important. Some people are more vulnerable than others. Children and the

elderly are groups which are known to suffer greater levels of threat from natural disaster events. In developing countries, children can make up the significant percentages of the population. Such countries are also more likely to suffer the impact of disasters, especially with the continuing impacts of climate change and issues associated with rising populations. Adults often make decisions for risk reduction of children, is that fair? Often overlooked in risk management practices, children are the future for risk management. Improving their understanding and changing their behaviours can lead to more effective outcomes for societies facing risk in future events. It may also lead more individuals to strive working in the hazard management world. How students learn is also a key consideration. Are existing methods effective? There is still little understanding of how children understand disasters and how this understanding changes over time. This research will seek to address that issue by looking at how the same groups of students' perceptions of risk change over time. It will also test disaster risk education approaches to understand whether the methods used by researchers are effective. The HFA (UNISDR, 2015) set clear priorities which included: i) adopting a multi-hazard approach, ii) adopting gender specific education, iii) factoring culture, age and diversity in DRR, and iv) focusing on developing states. One of the specific priorities for action was to use 'knowledge, innovation and education to build a culture of safety'. Therefore, to address these gaps in DRR and address the aims of the study, this research has 6 objectives:

- Examine student risk perception longitudinally to determine trends and recognise influences of change.
- To test an alternative approach to collecting risk perception data more suited for children.
- To understand longitudinal perception in multi-hazard environment
- Seeking to understand how effective top-down management strategies have been through student learning.
- To understand the effectiveness of different educational resources based on different pedagogical approaches.
- Seeking to understand how students perceive their learning about different hazards.

Success in this study will be determined through improved understanding of:

- a) patterns of long-term perception and recognition of factors which lead to change,
- b) patterns in perception amongst different socio-economic groups or locations,
- c) the effectiveness of contrasting educational methods for changing risk perception,
- d) patterns of perceived learning methods from different student groups.

1.8 Research Questions

To conduct these objectives this research will centre on the following research questions:

1) How effective is the PRISM method to assess changing perception?

This longitudinal study will test a new method to collect perception data, PRISM (Pictorial Representation of Individual Self Measure). This study is the first longitudinal study to use this measure to assess multi-hazard risk perception, seek to understand the validity of the PRISM method. Our evaluation of the measurement tool will evaluate consistency of the method, applicability to children, and the extent to which it addresses issues identified with traditional methods.

2) How does student perception of relative multi-hazard risk vary over time?

Students have a series of influences which alter their perceptions. Investigating the longitudinal perception changes will gain insight into which factors are more important. This study will seek to understand the role of bias on student perceptions. Understanding the relative perception of frequent vs infrequent hazards will help understand the gaps in student understanding and thereby identify potential avenues for future DRR education.

3) Do student risk perceptions reflect the spatial variation of multi-hazards in Dominica?

Different areas of Dominica are subject to varying hazards, how does perception of these vary? Each school has a different sized catchment and therefore students will come from different parts of the island. Student perception will be determined by this location. Principally there are three areas, the urban area of study, coastal villages beyond the study area and upland / river valleys outside the study area. This study seeks to understand how student perception change in these different areas.

4) What role does gender play in student multi-hazard perception?

Previous studies show that successful analysis of risk perception needs to account for the differences between males and females (UNISDR, 2005, Khan et al, 2020). This study will test to understand perception between differences between male and female students. Some risk studies in adult populations (Morioka, 2014, Lightfoot et al, 2020, Liu et al, 2020) show a tendency for males to be more risk averse, will this be the case for student population?

5) Are students with improved social contexts more aware of disaster risk?

Do students with greater affluence in families will be able to make greater preparation for risk reduction. Students whose parents have a higher level of education may also take more precaution

of risk. This may suggest a greater capacity for risk. This study will seek to assess whether socio-economic background reflects action taken at home to mitigate for DRR.

6) Do some participatory educational methods and resources have a greater impact on changing student risk perception?

Studies of risk have shown (Mercer et al, 2008, Peek, 2008, Haynes and Tanner, 2015, Ronan and Towers, 2014; Ronan et al, 2016; Cadag et al, 2017, Wilmshurst, 2017, Pfefferbaum, 2018,) that participatory approaches to risk reduction have a greater acceptance among the local populations. This study will test some of the UNESCO, (2012) recommended participatory approaches to DRR education to understand the impact they have on student perception. Using before and after measurements, this study will determine the immediate impact of given teaching approaches to changing perception. This study will also seek to understand which teaching resource and learning approach is perceived as more effective for student use.

These research questions should help provide greater insight to our study aims which are to understand trends in longitudinal student disaster risk perception and to understand the effectiveness of educational methods in DRR.

Chapter 2 – Literature Review

2.1 Introduction

This literature review will address some of the contextual studies which unpin this multidisciplinary study. This thesis has been inspired by the works of Wisner et al, (2012) and therefore aims to *‘encourage interdisciplinary, non-disciplinary exploration into the world of disaster risk reduction, perception and education’*. Thus, this study combines theories of disaster risk and education in a bid to improve awareness of disaster risk reduction for vulnerable communities, drawing on my interests and strengths as a geographer, an earth scientist, a teacher, and a humanitarian.

The review is therefore divided into 3 distinct areas of theoretical background.

- I. risk, perception of risk and decision making,
- II. an evaluation of risk perception methodology,
- III. the role of children and education in disaster risk reduction.

The section on risk considers the main ideologies associated with risk. It will summarise the concepts of risk and risk perception, seeking to identify the factors which influence perceived risk. It will seek to understand the relevance of perception models and understand the importance of expertise and decision making as part of risk perception to understand the issues linked with the different approaches to perception studies. This will help understand differences between DRR expert perceptions and student perceptions over the study period. It will help understand and contextualise student reasoning behind their changing perceptions.

This study intends to use perception data to assess student understanding to creating educational sessions and resources which can change risk perception. Therefore, this review will evaluate the role of education as a risk reduction tool for children. This review will justify why children are an important focus group in disaster risk reduction. It will also assess the role of pedagogy used in disaster risk reduction. This review will contextualise the educational methods used in this study and seek to understand how students learn effectively and to determine the extent to which our methods are impactful. As this study deals with understanding longitudinal perception change of students in contrasting communities a review of existing methodologies used to assess risk perception is necessary. This review will evaluate existing approaches to and consider these for application to a longitudinal risk perception study. One consideration will focus on requirements for studying child perceptions. This will help determine the extent to which our new method is suitable at assessing perception with children.

2.2 What is risk?

Risk is a part of our everyday lives, but what is risk? UNISDR, (2009) defines risk as *'the combination and probability of an event and its negative causes'*. The likelihood of a negative outcome from an event. This concept by its very definition is complicated. In terms of the likelihood of a risk there is a need to assess the difference between objective (actual) and subjective (perceived) risk. These are not the same as objective risk looks to probabilistically understand the quantified chance of a negative event. Mathematically this presents challenges because the outcome is based on our accurate understanding of that risk (assuming that this is performed by experts of a given field) and the time over which that judgement is made. Perceived risk is even more complicated because it tries to understand how different individuals or groups may view a risk. This will be dependent on a range of variables including experience, frequency, capacity to understand or react, governance, location, culture, political context, or available resources which Wisner et al, (2012) describe in their progression of vulnerability. Therefore, the nature of risk requires a holistic understanding of society, psychology, the physical environment to be able to make a judgement. It is unlikely that anyone has a true understanding of a given risk, therefore the concept of perception is important. Perception studies therefore seek to understand the gap between objective and perceived risk to use as evidence for disaster risk reduction approaches. This can be assessed both qualitatively and quantitatively and has been the subject of over 30 years of study. This study does not aim to add to the risk argument to justify which approach is most relevant. Instead, it seeks to further understand the changing perception of children, in a multi-hazard context.

2.3 Improving expertise in understanding risk.

Expertise reflects skill acquisition which develops, based on the Dreyfus model, from novice to advanced beginner, to competency, proficiency, and expertise (Benner, 1982) . There are a variety of traits which can label one as an expert. Two types of experts exist; epistemological (one based on knowledge acquisition) and performance (one able to apply the skill to a proficient level in multiple situations) (Weinstein, 1993). To develop expertise, Shanteau, (1993), outlines a series of traits; i) continual learning, ii) perceptual abilities to filter important information from background noise, iii) ability to simplify complexity, iv) the ability to communicate to nonexperts, v) adaptability to exceptional circumstances, with vi) the confidence to make decisions, and vii) an ability to adapt strategy in changing circumstances, while vii) taking responsibility for their actions. Some believe that true expertise is an exception (Weinstein, 1993). Despite Kahneman and Tversky's (1982) view that expertise is subject to bias and heuristics, Klein, (1986) suggests that expertise is based on the

adaptation of norms to the situation (Benner, 1982, Klein and Kahneman, 2009 and Shanteau, 1993) through identification of cues to reduce the likelihood of unforeseen outcomes. Kahneman (2012) however suggests that our ability to make decisions in short time spans is subject to System 1 thinking – our intuitive reaction, which is governed by safety, but includes bias. A person fleeing a flood may have the capability to access higher ground but may first seek their lost pet, thereby placing themselves in greater level of danger. Klein et al, (1986) suggest that not all people will react with these heuristics and bias. They show, through the example of firefighting commanders, that experience based on situational familiarity can lead to an automated “*sixth sense*”. Understanding the situational dynamics can help determine whether a situation is standard or elaborate. Therefore, situational awareness is key to perceptual learning. Jasanoff (1998) suggesting that even experts may not understand the boundaries of their expertise and this needs to be rigorously explored before their judgement is accepted. But how can we transfer this level of expertise in disaster situations?

Klein and Snowden, (2011) suggest a need to develop anticipatory thinking, allowance to understand the environment around us to pick out hazardous cues and determine relevant information which can be acted upon. They suggest that anticipatory thinking allows us to match patterns of events, understand the causality and determine how problems may arise in the future. Through simulation this can be achieved. Flin, (2010) looks at decision making under stressful conditions and advocates the development of non-technical skills, the behavioural skills which help determine action in a stressful environment. Building an unexpected element to training can help determine how people might react in challenging circumstances. Fadde and Klein, (2010) focus on the developing expertise through deliberate practice, suggesting that domain (local situational) experience is critical to this. They suggest a culture of building estimation, experimentation, extrapolation, and explanation into simulation so people can identify and learn from their own mistakes and experiences of others to avoid future mistakes and inertia.

Lapple and Barham, (2019) suggest that people look to experts for advice and may follow it regardless of whether it is correct. However equally concerning is that people may use expert advice to supplement their own views (Lapple and Barham, 2019), as people engage their System 1 thinking (Kahneman 2011) which is instinctive rather than reflective. Lapple and Barham, (2019) advocate direct engagement with experts can often improve responsiveness when engaging with advice. Jasanoff (2006) presents a more holistic view to incorporating expertise through co-production. This concept underlines the belief that true understanding is derived from both scientific expertise and social enterprise. This is important for an understanding of the true nature of multi-hazard risk as it implies combining local knowledge and scientific input can create a more sustainable understanding.

2.3.1 Expertise in DRR

Expertise plays a fundamental role in reducing risk as they contribute to identifying actual risk. Disaster risk reduction expertise can take many forms including the formulation of policy, collaboration to create risk reduction programmes or critical decision making to move people from danger in the event of disaster. However, there are limitations of applying expertise in DRR, including the pressures of decision making; balancing risk taking in decision-making with the lives of strangers; and communicating risk reduction effectively in a timely manner, to maximise impact. Expertise contributes most commonly to DRR in top-down programmes used for managing large populations. Top-down approaches allow pre-planning, collaboration with external expertise and the building of appropriate infrastructure. But such approaches can develop complacency among individuals who perceive the role of experts as allowing them to sacrifice their own responsibility of action in response to disaster risk. Top-down approaches may not account for differences in vulnerabilities and access to resources, thereby creating further disparity in response to DRR. Therefore, adopting a bottom-up approach gives a sense of ownership to local people and allows them to effectively take on decision making in times of disaster, reducing reliance on authorities (Jasanoff 2006). However local people are not experts and subsequent empowerment may lead to greater issues in event of a disaster. Therefore, bottom-up approaches should involve training or education to improve understanding and experience of their local domain (Klein et al, 1986 & 2012) through participatory action. Therefore, it is important for experts to feed relevant information to people. It is important that people engage with this information and process it the way it is intended.

To understand the disaster risk perception of a population or community, it is necessary to understand the differences in perceived risk of the layperson and the expert. This study will seek to understand the differences between local experts and student risk perception. However, this study will go beyond quantifying the difference, it will look at relative changes in perception between survey periods to understand how external factors between influence the relative risk perception. This will allow an understanding longitudinal risk perception rather than isolated values taken after an event.

2.4 The changing understanding of risk

Many scientists have tried to understand the key factors which determine our perception of risk, but here are the few major studies which underpin the key developments in risk perception; they are summarised here.

The work of Chauncey Starr (1969), one of the pioneers of risk perception, sought to understand “*how safe is safe enough?*”. His assessment of the weight of benefits versus risks of technological enterprise found that there was an optimum balance between risks and benefits associated with an activity. This led to the term “*acceptable risk*”. From this also came the concept of risk-benefit analysis which helps policy makers and managers make decisions on risk by quantifying this relationship.

Tversky and Kahneman (1974) looked at risk decision making in the context of heuristics and biases. Their work assessed people's judgements on uncertain events based on subjective probabilities. They identified biases affecting the judgement of individuals. While a range of biases exist to influence decision-making, there are some key heuristics affecting perception .

- I. *representativeness* – people linking ideas by association rather than using prior statistics to support their view.
- II. *normalisation* - familiarity and saliency preventing them people considering unlikely outcomes.
- III. *anchoring* - received ‘anchoring values’ swaying judgements near to those, compared to time when receiving no information.
- IV. *framing* – decision making influenced by values which may override experience.

These biases also impacted researchers (experts) who made judgements, regardless of sample size, conforming to their biases, who did not perceive chance as a matter of self-correction and who failed to recognise regression to the mean, leading to overestimation and misreporting of trends. Kahneman and Tversky (1974, 1982) and Kahneman (2012) showed that experts made intuitive predictions, heavily influenced by their own confidence, with potentially false information. Such overconfidence has huge implications for DRR in countries with small populations where the expertise pool is finite. While Tversky and Kahneman's work was criticised for not adopting a real-life application, the notion of their study influences the flawed thought processing of people. Therefore, the perception of disaster risk and subsequent decision making could be argued to be more about emotional response than any logical statistical base.

Paul Slovic, (1978, 1980 &1982) integrated heuristics to make sense of uncertainty. His work on the psychometric paradigm assessed the difference in understanding between experts and laypeople for known risks. He showed that expert decisions on risk are based on mortality data and prone to bias. A layperson often lacks understanding of risk due to inadequate information and they are motivated by decisions based on emotion. People made decisions on risk where they showed greater feelings of dread or a known-unknown. However, risk with greater familiarity led to greater acceptance of the risk, echoing the normalisation bias. Slovic believed that through education, the goal of risk perception was to increase cognitive levels to bring laypeople’s perceptions in line with experts. This study will determine whether education has the impact of improving cognition by determining the extent to which educational methods bring the values associated with perceived risk closer to actual risk values.

The cultural theory, (Douglas and Wildavsky, 1982), suggested that values and cultural settings influence risk perception. Therefore, the values or globalised views of a social context will help form the perception of an individual, resulting in varying approaches to risk (**Figure 2.1**).

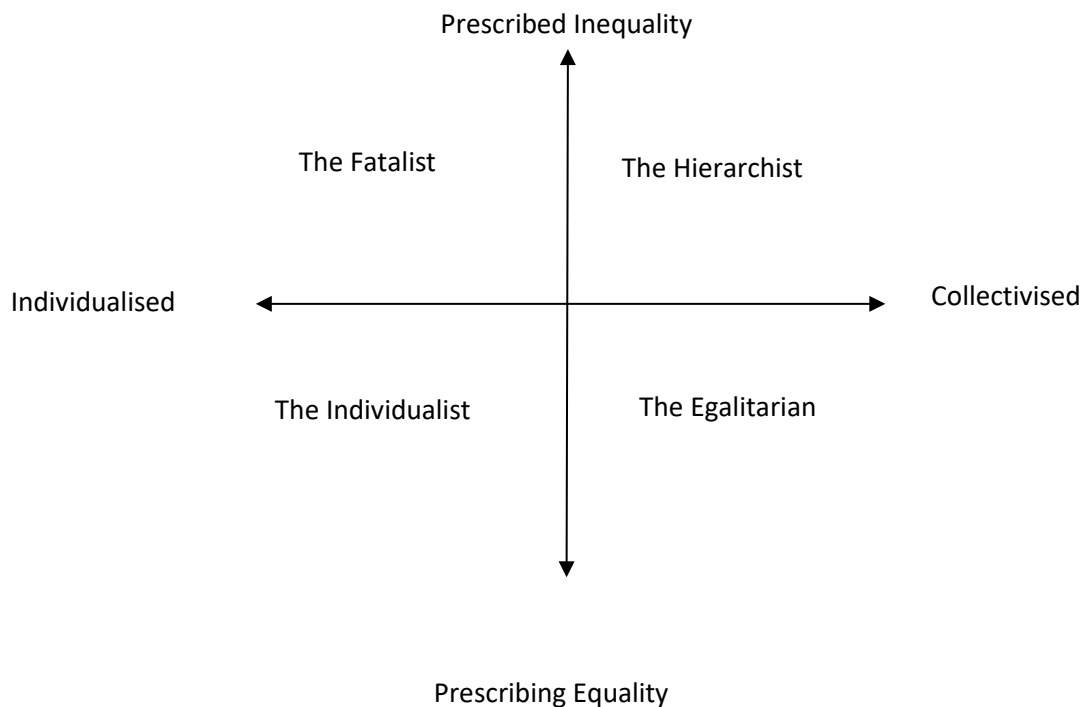


Figure 2. 1The four “ways of life” / myths of human nature which govern risk – (Adams, 1995, Douglas and Wildavsky, 1982, Rippl, 2002)

In **Figure 2.1**, individualists are 'self-made' people who exert control over people and the environment and therefore perceive risk as an opportunity (Rippl, 2002). A hierarchist has strong social boundaries and prescriptions, in a world where people know their place and believe that authorities will take the appropriate decision to mitigate risk. Egalitarians have strong group loyalties but have little respect for imposed rules, other than those imposed by nature and therefore are cynical towards the views of experts. While fatalists have minimal control over their own lives, they resign to fate and therefore worry least about risk (Adams, 1995). These social contexts are one aspect of cultural theory but Wildavsky and Dake, (1990), included economic context. Wealthy individuals or organisations were averse to risk, as they sought to protect themselves from adverse consequences. Wildavsky and Dake, (1990) argued that political context is important. Approaches to risk aligned with political views have implications if you support opposition parties or organisations who criticise measures taken by authorities to reduce risk. This has been evident in the recent COVID pandemic in the USA with republicans adopting a different approach to democrats. Cultural theory argues that social and political context are aligned e.g., egalitarian and liberalism. This has huge implications for changing perception as communication needs to motivate people beyond simple cognitive gains. This study will seek to compare different perceptions of students spatially in different cultural groups. It will seek to determine whether cultural aspects are evident in students.

The social amplification of risk assessed the role of the media in amplifying risk perception (Kapserson, Renn and Slovic, 1989). This research focused on factors which had the potential to amplify risk, thereby distorting the risk communication. Their study highlighted mechanisms by which information was received differently by individuals:

- I. media filtering information,
- II. the context of message reception,
- III. an individual's inability to process information due to heuristics,
- IV. cultural influences,
- V. an individual's ability to tolerate risk.

They found that in the context of risk events, to understand people's perception of risk, one could not ignore the social amplification process. They found that people are affected particularly by media coverage relating to risk exposure and environmental impacts. Kapserson et al, (1989) suggested that the public perception is less influenced by the bias exerted by an individual, but instead by media coverage. This has become particularly relevant in our 24-hour news media society where coverage of hazard events both nationally and internationally can give constant reminders of

risk. This may have consequences for students who are taught risk by an individual but are subject to a variety of risk messages through social media, the internet and television. Therefore, it is important to understand how students receive the messages and learning which may influence their risk perception and understand how learning is influenced by risk amplification. How people encode and decode information (Hall, 1973) determines how they receive information from official sources intermixed with their own person beliefs. This will therefore determine the message they receive and the action they take which can have significant implications in areas of multiple risk. However, as Hall notes (1973) misinterpretation of the message could lead to dire consequences.

Wachinger and Renn, (2010) draw together the different influences of risk perception into realist or constructivist views. Realism aims to bring the perceptions as closer to objective risk through increased information. This is based on assumptions that it is possible to determine objective risk. The constructivist approach assumes that risk is subjective, and people will form their own beliefs regardless. **Figure 2.2** shows the hierarchy of risk perception influencing an individual or collective set of beliefs.

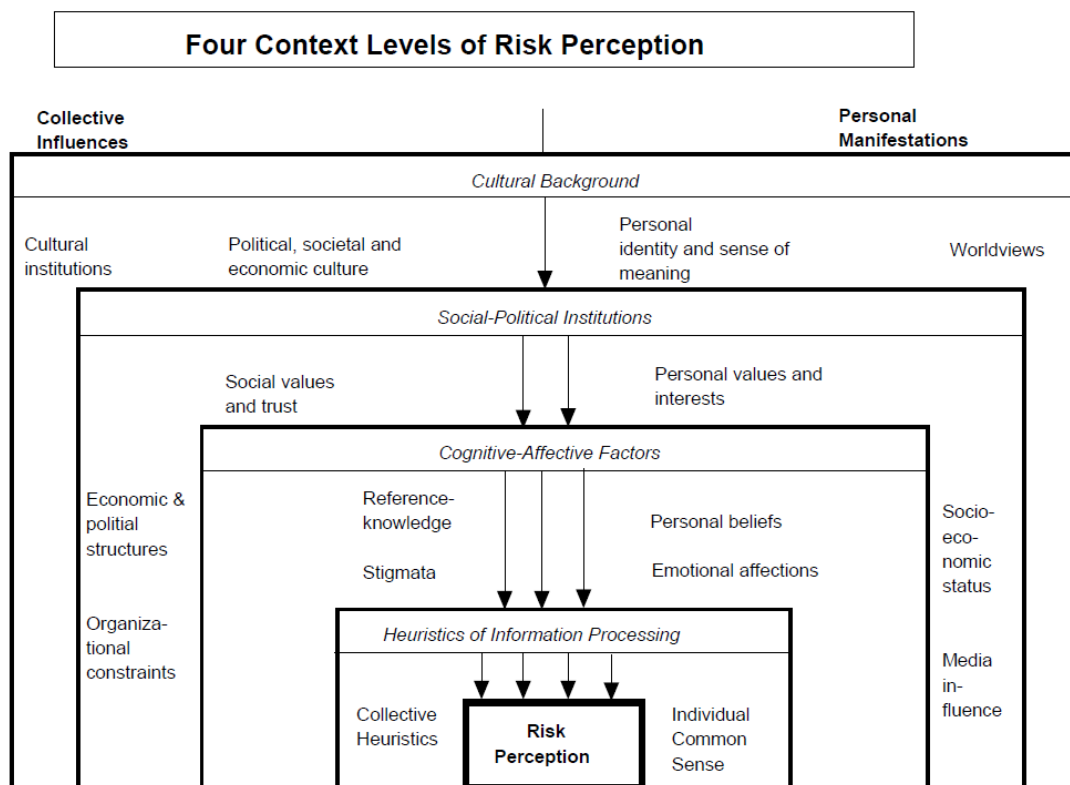


Figure 2. 2The four context levels of risk perception (Wachinger and Renn, 2010, Renn and Rohmann, 2000).

Figure 2.2 explores the levels of influence in risk perception. At level one people's risk capacity is affected by cultural beliefs (Douglas and Wildavsky, 1982) which can have an impact on day-to-day decision making (Gigerenzer and Seltzen, 2001). Understanding that different cultural influences will alter perceptions is important therefore understanding local customs is key to understanding perception influence, although Sjoberg et al, (2000) and Rohmann, (2000) cast doubt on the significance of these factors. At level 2 people are influenced by social and political institutions. One of the key influences is the level of trust individuals have for institutions. These views may, of course, be affected by the media, (Wachinger and Renn, 2010). Cognition and affective factors form the third level and suggest that perception is driven by education and experience (Slovic et al, 1982). Emotional factors are less well studied yet play an important part in an individual's decision making, especially when there may be ambiguity in what is correct (Slovic et al, 2002).

Wachinger and Renn, (2010) believe that this model can help understanding an individual's risk perception though conclude with Slovic, (1992) point that *"a theory of risk perception that offers an integrative, as well as empirically valid, approach to understanding and explaining risk perception is still missing"*. Risk perception is linked to the layers of influence experienced by an individual and their emotional responses to them and there is no one model which can accurately account for this.

Though these theories are relevant to the study of risk, many of the theories are based on regular risks to human life and are not explicitly linked to disaster risk. Natural disasters are events which overwhelm society therefore by definition cannot occur with regularity or expectation. Hence the risk associated with an unperceived large-scale disaster can be likened to Black Swan events (Taleb, 2012) as they stand outside the norms of everyday expectations. The concept of multi-hazard environment further complicates the risk concept presenting a hierarchy of possible frequencies, magnitudes, areal coverage, and complex linkages between hazards. It is important to understand whether these risk theories apply to all members of a community, including children, but also important to understand whether the influences change over time? The complexity of risk perception undoubtedly combines the drivers highlighted by these models, however, do children favour social, cultural, knowledge based or heuristics as the key influence in their decision making about risk?

2.5 Disaster risk

Disaster risk is attributed to extreme events occurring in the context of the natural environment. UNISDR, (2009) defines disaster risk as *"The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some*

specified future time-period". This differs from an actual disaster which is *"a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources."* Or indeed a hazard which is a *"process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage."*

Based on these definitions' hazards are the natural processes which could cause disruption within society. A hazard which exceeds human or societal capacity is considered a disaster. Disaster risk is the potential loss because of a disaster occurring, which would be assumed to be beyond the means of the society in question. As outlined in Chapter 1 we will use the, Wisner et al, (2012) risk equation:

$$\text{Disaster Risk} = \text{Hazard} \times (\text{Vulnerability} / \text{Capacity}) - \text{Mitigation}$$

This definition of disaster risk builds on Blackie et al, (1994) equation to include mitigation. To reduce disaster risk at an individual's scale requires an increase in risk capacity or a reduction in vulnerability. Mitigative action by authorities will simply further improve or worsen that situation. Reducing vulnerability is multi-faceted and has no simple solution, but education is one approach. It is therefore necessary to understand how the individuals perceive change in a hazard over time, to improve their relative perception in relation to their own capacity. Understanding this will help create methods and resources to improve awareness of disaster risk.

2.5.1 Disaster risk perception studies

In **section 2.3** the key theoretical influences on risk perception were outlined. It is, however, important to understand the key drivers of risk perception studies linked to natural hazard events and disaster risk environments. These studies aim to identify differences quantitatively or qualitatively between actual and perceived risk, normally after an event, to make judgements about the risk perception of a sample population. However, these fixed-point perception values do not account for perception change, or relative perception values. Risk perception is fluid and needs to be addressed over time (Lindell and Perry, 2000), requiring benchmarking of perceptions and tracking changes. It is this relationship which needs to be tested to truly understand what changes risk perception and awareness. This longitudinal approach allows contextualisation of the study area and group but is not practical for most academic studies.

The following section will review a series of existing risk perception studies to understand the key factors influencing risk perception in disaster risk environments. Most studies into disaster risk perception are conducted relating to the dominant risk in study. Although this study is multi-hazard, it is dominated by hydrometeorological risk and volcanic risk, which will therefore provide focus of examples.

Studies of risk perception in volcanic areas were pioneered by Lindell and Perry (1994, 2000 & 2008). Their work sought to understand the factors affecting perceptions of volcanic hazards among residents and non-residents. They sought to understand the impact on perception of a major event. They did not find evidence to support Slovic's theory that 'dread' motivated individuals, instead they found that personal loss was a key motivator. People reacted when the impact was on the individual, as they reached a 'threshold' or risk capacity in decision making. Perry, (1981) found that increased threat was more likely based on proximity to impact, certainty of impact and likely severity of impact. Therefore, suggesting people are aware of risk but only act when necessary! In a comprehensive review of earthquake perception studies, Lindell and Perry, (2000) identified a range of factors influencing perception to include demography, experiences, the influence of media and quality and flow of information.

Johnston et al, (1999), showed, after the Ruapehu eruption, 1995, that greater experience of risk led to an improved "*threat knowledge*" and therefore perceived risk. They identified the concept of "*normalisation bias*", "*systematic underestimation*" (Kahneman and Tversky, 1974) or "*negative fallacy*" (Taleb, 2007), where experience of an event can create belief that they will be better prepared for a future event. Burningham et al, (2008) also showed the importance of experience and exposure especially among higher class citizens, while Tanaka, (2005) showed that experience improved readiness for earthquakes.

In a study seeking to understand the link between perceptions of primary and secondary hazards, Solana and Kilburn, (2003) showed that locals did not appreciate these links. Locals showed awareness of landslides but did not appreciate how they could affect local settlements. Like Johnston et al, (1999) this false familiarity led to bias in judgement undermining DRR attempts. These studies underlined the importance of the disconnect between knowing of a hazard and taking appropriate action to reduce its risk.

Boholm, (1998) identified the importance of societal factors in controlling risk perception. Paradise, (2013) showed how cultural barriers, such as religion can negatively influence the accuracy of risk perception and the engagement of some groups within communities. Haynes et al, (2008) showed that perceptions of risk varied depending on socio economic group and political governance.

Support for different political groups led to a distortion in interpretation of risk communication and a resultant lack of trust in authority, leading to perceived inconsistencies of risk. Siegrist and Cvetkovich, (2002) and Viklund, (2003) and Paton, (2008) reinforced the concept of trust, especially when lay people lack understanding. Zhu et al, (2011) also showed that trust in the source of information and greater credibility of information increased influence on risk perception. Barberi et al, (2008) showed that locals appreciated the consequences of risk, but that day-to-day concerns, shrouded their risk perception. Their study underlined a need to include locals in emergency decision making to reduce the feeling of alienation and improve ownership of mitigative actions. This view was reinforced by Wachinger et al, (2013) who showed that increased participation in the issue of risk led to improved perception.

Bird et al, (2009) and Barberi et al, (2008) underline the importance of information and communication in perception. Barberi et al, (2008) and Fischhoff, (1995) show that improved communication through regular education could allow a positive response in an emergency context. In the Bird et al, (2009), despite meticulous planning by authorities, communication failures which could increase risk and undermine planning for populations with direct exposure, in the “red zone”. This lack of communication was evident in the Nevado del Ruiz tragedy in the 1980s which led to the deaths of over 30000 people in Armero (Voight, 1996).

Sattar and Cheung, (2019) highlighted several factors affecting perception, including importance of income, occupation, education type, size of business and geographical factors. They observed spatial variations in expert perception of actual risk based on varying levels of experience. Experts often underestimated perceived risk. They also noted the importance of gender differences in perception as females were more risk perceptive than men, a view echoed outside of disaster risk studies by Harris et al, (2006).

These examples highlight the complexity of factors influencing risk perception in areas related to a dominant hazard. Clearly risk is a product of social, economic, political factors as well as a reflection of individual knowledge and bias. Do studies conducted in multi-hazard environments find an equal level of complexity?

2.5.2 Disaster risk perception in a multi-hazard environment

Few studies acknowledge the complexity of risk perception in multi-hazard environments. Some studies which have taken place in multi-hazard environments have sought to understand the relationship between hazard frequencies. Bird et al, (2009) showed that residents living in a multi-hazard zone in Iceland showed a greater understanding of the dominant hazard but underestimated

secondary impacts. This view is supported by Manandhar et al, (2015) who found less difference in the perceptions of frequent hydrometeorological hazards between locals and experts. Wiley and Giannotti, (2017) also showed that perceived risk was close to objective for prevalent hazards, which led to protective action taken in some cases. Clearly frequency of hazard has an important influence on public hazard perception. Familiarity breeds awareness but is magnitude accounted for? Avvisati et al, (2019) showed in an Italian multi-hazard environment that again experience led to greater knowledge, but this varied in events of different magnitude. Like Solana and Kilburn, (2003) they found that people understood the interrelationships between these hazards poorly. They all found that this greater experience did not correlate with improved response.

Response was a theme of Lindell and Perry's, (2008) study as they showed that threat over loss posed greater in the minds of impacted individuals than understanding of the hazard. Hua et al, (2020) showed that in a multi-hazard environment media, effective governance and experience were key factors in understanding but that education was important for mitigative action.

These studies highlight similar themes as the perception studies for one dominant hazard. Another limitation of many studies in risk environments was the one-off nature of data collection.

Longitudinal studies could have greater success at balancing out variation in perception and understanding the impact of events on an individual's life and decision making.

In one of very few studies of secondary school children in a multi-hazard environment, Khan et al, (2020) showed that students in Pakistan had a poor grasp accurately perceiving hazards in a multi-hazard environment. However, they agreed that the key motivation to action is through fear or level of awareness. The role of education to improve understanding is important. However, in a multi-hazard environment, regular messaging needs to be promoted through other channels such as media and government agencies. Messages need focus on multi hazards not just the dominant one. This study seeks to understand the changing influences on perception linked to multiple hazards and how changes in educational approaches affect these. This will help contextualise future educational methods for multi-hazard environments.

2.5.3 What causes people to act to reduce risk?

In **section 2.4** several studies highlighted motivators to act in reaction to risk. This is an important consideration as DRR need to act to influence perception but encourage action. Attitudes towards action can influence outcomes. Ronan and Johnston, (2010) show that anxiety levels can influence level of action or function. Too little anxiety led to a lack of concern for a given action, whereas too much anxiety led to inhibited actions. Moderate anxiety was associated with optimal actions (Ronan

and Deane, 1998). Fatalism linked to a sense of resignation, or a lack of control could link to the actions taken by an individual (Ronan and Johnston, 2010). A greater fatalistic attitude can be attributed to decreased readiness in earthquake activity (Turner et al, 1986).

Level of control is seen as a determinant of willingness to act (McClure et al, 2001). However, increased control or preparation by authorities is a reason not to act or for increased complacency (McClure et al, 2001). Lindell and Perry, (2000) show that perceived likely occurrence of risk or injury or loss leads to increased personal awareness and action. Ultimately, Ronan and Johnston (2010) suggest that individuals will decide the worthiness of action as a factor of cost, time, whether there are children in the household or level of knowledge. Suggesting that decisions over actions taken will be dependent on the level of family wealth or levels of education. In this study, one focus will be to determine the extent to which levels of readiness, based on existing mitigative measures employed, is determined by socio-economic background.

The influence of media campaigns and educational awareness programs can also lead to changes in preparation and willingness to act (Mileti and Darlington, 1997, Ronan and Johnston, 2010). Improvements in short-term warnings can lead to preparative action, however, can equally be ineffective if warnings do not materialise or people prioritise this over daily life. Mileti and Darlington, (1997) suggest frequent communication from a variety of channels to improve absorption of message and encourage action.

Although the aims of this study do not specifically focus on causes of action, these factors are important to help understand what has driven people to make decisions. This understanding will contextualise student comments to understand how they learn and how they may react in the event of a hazard event. Do these factors apply to children, and do they apply to a multi hazard context?

2.5.4 Introducing relative disaster risk perception.

Vulnerability to risk is determined by the perception of that risk. Individuals exposed to the same disaster risk may not respond or view the risk in the same way. This relative belief underpins the very nature of disaster risk perception. To understand this, we need to understand the factors which underlie a person's perception, summarised in **Figure 2.1**. As Sjoberg, (2000) risk perception is "*hard to understand*". It is difficult to place one theory which encapsulates all of perception. This shows that risk perception is influenced by a variety of factors which are bespoke to circumstance. Key to this concept is the notion of place. While hazards exist in multiple locations understanding the location of a given event will determine the hazard and then its perception. This complicates the

concept of perception because while it is possible to compare perceptions of a given event between locations, these perceptions are relevant to the location of a given event.

The perceptions however are governed by a variety of factors which influence our day to day lives and are interlinked. Experiences of a disaster risk strongly influence perceptions towards a future risk despite not accounting for actual variations in the hazard. Education levels can provide an improved understanding of the environment. Coupled with experience, they can serve to improve relative perception. Linked to this is the importance of available information. Served correctly this can, in real-time, help individuals make decisions about forthcoming risk. Poor access or filtered information can alter risk perception less objectively. Psychology of risk determined by mental awareness, beliefs, and values, which are often attributed to the personal circumstance, family history, or cultural upbringing will heavily influence information processing and perspectives creating a series of biases (heuristics). Their overall vulnerability will be determined by these factors and can determine their actions and awareness dependent on their capacity for risk. Consequently, an entire population can respond differently to risk, and it is not possible, in the context of disaster risk reduction to achieve a desired outcome with ease. Therefore, assessing an individual's perception creates a benchmark of awareness. Understanding the relative changes to this benchmark and expert perceptions is key to improving individual awareness. Accounting for the impact of changing influences on risk perception creates a fluid perception of risk over time. Understanding this level of perception for an individual allows for an assessment of change when introducing measures to alter risk perception and awareness. This may consequently lead to a change in action. **Figure 2.3** summarises the impact of influences on individual risk perception.

We will be seeking to understand the extent to which changing risk is determined by any one of these factors in a multi-risk environment. This study will seek to understand the trends in longitudinal risk perception for multiple hazards. How does understanding of one hazard impact that of another, and how well linked are risks in student perception? In this section studies have shown that risk frequency can determine both perception and understanding, therefore this study will seek to understand this for a secondary school student. This study will also seek to understand the role of risk magnitude in perception. Do larger events significantly alter risk perception? What are the key factors which underpin changing perception of risk and to what extent do these match the influences borne out in the studies aforementioned? What role does gender, socio-economic status have in affecting risk and how does proximity to risk influence perception of it. While these questions have been researched for adults, children have often been overlooked in this type of study particularly in longitudinal studies, therefore this study will seek to understand whether secondary school students have similar perception influences as adults.

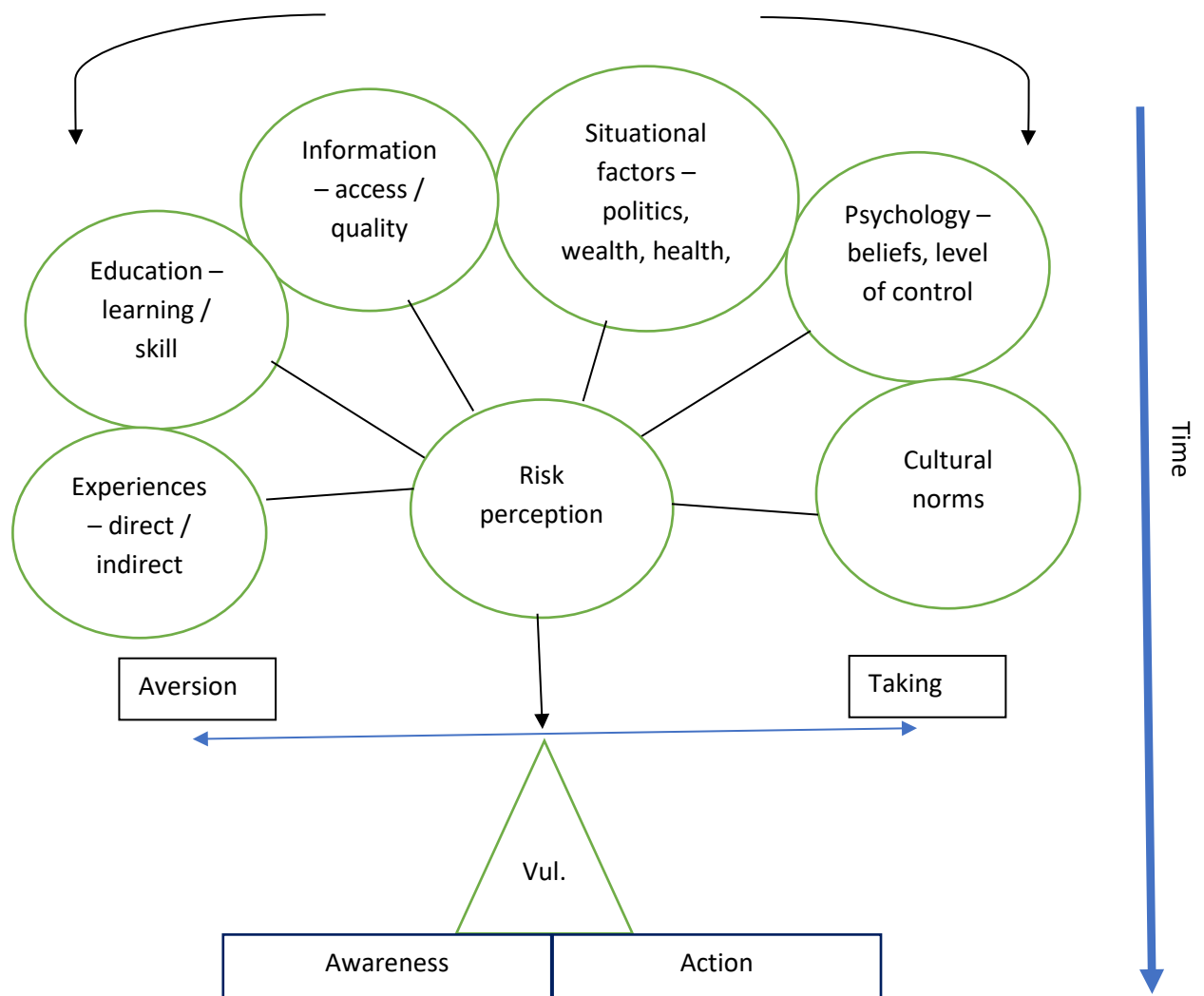


Figure 2. 3 Factors determining risk perception.

2.6 Children and disasters

2.6.1 Why study children in a disaster risk context?

Studies show that one third of the world’s population are children and that 50% of fatalities linked to disasters are children (SOWC, 2016, Amri et al,2017; Mitchell et al, 2008; Peek, 2008). The inclusion of children in disaster perception studies has historically been overlooked, hence a dearth of research into student risk perceptions. Despite the recent inclusion of studies focusing on gender or minority groups, children have been largely invisible (Matthews, 2003). It is easy to see why; children are less capable in decision making (Hart, 1992), they do not have a voice in decision making or setting the agenda (Anderson, 2005); or children are on a transition from infant to adulthood and therefore need protecting (Matthews, 2003). Approaches towards child perception have historically

been top-down in approach, where 'experts' know best, and the children passively follow in the stated views. This approach cannot be considered sustainable as children have a right to be included. Hart, (1992) stated that *"it is important for young people to participate in programmes that directly affect their lives"*, especially as they are vulnerable and suffer higher mortality rate (UNISDR 2001, Peek, 2008). Mitchell, (2008) and Pfefferbaum et al, (2018) highlight the Convention of the Rights of the Child (CRC) which acknowledges that children can form their own views and have a right to express them based on their age and maturity. The Declaration of the Right of the Child (DRC) refers to children as people rather than objects, agreeing with Hart that there is a need for children to be part of the collaboration process for DRR measures. Both the Millennium Development Goals (MDG) and Sustainable Development goals (SDG) cite a need to include young people for *"long lasting and effective dividend"* towards meeting future goals. Crucially adults have a critical role in formulating and guiding children in participation to establish networks for effective action (Pfefferbaum et al, 2018). Matthews, (2003) suggests that adults need to be able to relinquish the power they have in decision making to adopt a practice, language and custom which drives future engagement of young people in disaster risk reduction strategies.

2.6.2 The value of child risk perception

Children have their own unique perspectives and experiences in disasters and their own unique capacities and vulnerabilities (Peek, 2008). Adding their experiences allows a more complete understanding of the disaster experience (Pfefferbaum et al, 2018). The benefits of including child perceptions and participation in disaster risk reduction programs can offer rewards which extend beyond the realm of *"simple disaster reduction"*. Hart, (1992) recognises that inclusion can increase child social responsibility, allowing a greater confidence in actions, leading to better community links as the adults and students work together, building bonds. Collaborative working within the community allows greater confidence in young people offering their voice, allowing self-determination through a development of trust (Mitchell et al, 2008). Matthews, (2003) suggests that more effective approaches are inclusive and allow confidence building without the risk of exclusion. However, Pfefferbaum et al, (2018) identify a need for children to accurately perceive others. Ultimately, Peek, (2008), summarises that while children may be a vulnerable group and their needs may be neglected, they are not passive and their creativity and links with family and the community can play a valuable role in both preparation and recovery from disastrous events. Ronan and Johnston, (2001) add that not only does inclusion in DRR bring benefits to the wider community but for the individual child it can increase awareness, enable more realistic risk perceptions with greater knowledge of the different risks which can then lead to increased levels of home-based

adjustment; the child will often share their experiences with the family (Wisner et al, 2018). They advocate that the school is therefore a valuable tool and focal point for DRR activities (Cox et al, 2017). Inclusion in post-disaster recovery programmes act as an outlet for young people (Cox et al, 2017). Children can offer help in the community and develop companionship which acts to give emotional support and offer an avenue for emotional release. Children can offer opinions on the importance of place and symbols in the recovery process, and this can be achieved through a range of activities (Peek, 2008). In this context what have previous studies shown us about the perceptions of students and how does this compare with similar studies conducted by adults?

2.6.3 Child-Centred Disaster Risk Reduction (CCDRR)

In 2001, Ronan et al, concluded that there was a dearth of studies dedicated to children in the context of disasters, especially on the perception of children. This was despite recognising that children exhibited a more accurate perception than adults (in comparison to results from Slovic, 1987), for high frequency hazards and the low frequency events. Most existing studies tend to focus on child participation in disaster risk reduction. In the past 15 years the growing recognition that children are mis-represented in disaster risk reduction has led to the rise of Child-Centred Disaster Risk Reduction (CCDDR) which is defined as *“recognising and drawing on the rights, needs and capacities of children in reducing risk and enhancing the resilience of communities and nations”* (Ronan, 2001). Newham et al, (2019) note that *“adolescents should be participants in disaster recovery”*, however, note that putting theory into practice is unclear.

Hart, 1992 notes that CCDRR approaches also need to engage children so that they are interested. This is not to say that all activities should be fun, instead they should be relevant to the individual and should create the atmosphere for children to communicate without boundaries.

2.7 Future CCDRR needs

Ronan, (2001) highlighted existing studies tend to focus on school curricula or the psychology of students dealing with the aftermath of an event. There is a need for studies to concentrate on changing perception and the impact of Disaster Reduction Education (DRE). Disaster risk education is a form of education designed specifically to reduce disaster risks. Traditionally this has been achieved through educating students about hazard risk and the associated environment, preparations for the hazards to encourage action and response to disaster risks, theoretically or in

simulation. In this section we look at a selection of studies evaluating the role of Child-Centred Disaster Risk Reduction to determine recommendations for future CCDDR.

2.7.1 Making schools the focus.

Schools are the logical place to educate children about CCDDR as they provide a communal focus common to all children (Cox et al, 2017, Bandecchi et al, 2019). One limitation of some schools is the autocratic top-down management style employed which does not foster an inclusive child-centred approach where children have a voice in practice and policy. While such organisation leads to perceived reduced risk it limits child resilience and creativity. To achieve this, teachers and senior managers need specific crisis management training to help prepare students prior to an event and to accommodate the post recovery psychological needs of the students (Wisner et al, 2018). Mutch, (2017) suggests increasing child contribution to CCDDR through allowing contribution to school design, through an assessment of school premises.

The curriculum is a key area where CCDDR measures can be better integrated. Few schools have dedicated allocation to specific DRR curricula. Sakurai et al, (2015) believe that CCDDR measures should be integrated into the school curricula to reflect both the local hazards faced, and to create opportunities to apply knowledge through further activities. Currently the extent of school provision for risk can be seen in the practice of drills to simulate their dominant risk e.g., fire or earthquakes. However, Ronan et al, (2016) suggest the need to develop DRR education programs beyond school drills and knowledge transfer to identify a range of factors which can lead to potential successes and failures in educational programs and their implementation. As few schools actively include disaster risk in their curriculum student exposure to DRR is limited.

2.7.2 Trained teaching staff

In **section 2.6.1** the issue of teacher knowledge was cited as a potential problem for CCDDR. Requirements for teacher status vary by country and despite needing a degree education in much of the developed world, in other areas teachers may have limited qualifications. Regardless of education few teaching staff are trained in DRR. Tuswadi and Hayashi, (2014) suggest that poor teacher knowledge of DRR issues leads to incorrect information taught to students and poor behaviour. Consequently, student awareness risk was inconsistent, and they lacked understanding of the links between primary and secondary hazards. Wisner et al, (2012) show that improved student knowledge led to wider benefits in the community as information is shared in a bottom-up

format. Therefore, subject knowledge and effective resourcing is critical to improve student engagement.

Elangovan and Kasi, 2015 highlighted the importance of training teaching staff to deal with the psychological impacts of an event. They show this is likely to lead to reduced student anxiety which can have inhibiting effects on other aspects of their life. Ultimately, giving young people the tools to understand the problem and make decisions, showing them how pre-emptive preparation could lead to a greater awareness. Therefore, student engagement is critical in improving CCDDR measures, which can partly be achieved with specific staff training to understand local risks.

2.7.3 A participatory approach

Hart, (1992) was one of the first advocates of DRR activities through child-participatory approaches. His “*participation ladder*” model has formed the basis for much of child-participation in DRR activities yet too many approaches fail to get beyond low-child participation stages. This is because adults find it difficult to relinquish control and lack trust in a child-centred approach with critical decision making (Matthew, 2003). In a recent reflection of his own work Hart (2008) noted that adults misunderstood the original notion of child-participation as they failed to grasp their own contextual role in encouraging this participation. Consequently, today child centred participatory approaches are still uncommon, despite many still advocating their use (Pfefferbaum, 2018). Despite this, participation is advocated as the way to improve child involvement in CCDDR.

Amri et al, (2017) advocate child participation but also the need for greater use of control groups to compare the impact of DRR education and longitudinal studies to assess student engagement. They specifically identify the lack of “*before and after*” comparison to truly understand the impact of DRR education interventions. They also state a need to increase the scope of study beyond developed nations and should include more primary school pupils. This study will be focused on a developing state and will adopt the before and after approach outlined by Amri et al to understand longitudinal impact of CCDDR educational approaches. It aims to be one of the first to adopt this approach.

Ronan and Johnson, (2003 & 2014) and Ronan et al, (2008, 2012 & 2017) have conducted numerous studies to understand student psychology with focus on what improves student engagement and motivates students to act to improve resilience in a DRR context. They show that students' ability to cope is based on a range of demographic factors including age, gender, ethnicity, and pre-existing emotional problems. Major life stresses, such as divorce or family death, often negatively impact on the efforts of DRE programs. The major factor in their research limiting improved resilience and capacity building is student anxiety. This reflects anxiety shown by parents or a lack of knowledge

about the true risk. Ronan et al, (2008) point to interventions to increase coping capacity and reduce “fear” through Cognitive Behaviour Therapy. This approach requires understanding the students in the CCDRR programme and developing a bespoke approach befitting everyone. This study seeks to understand the individual perceptions of students over time and captures their personal context to understand changes in perception. The aim is therefore to create educational approaches which are relevant to the learning needs of those individuals.

The work of Morais, (2019), Delicado et al, (2017), Tanner and Haynes, (2009) and Tanner, (2010) look at the role of active and participatory methods in improving participation in CCDRR. Morais, (2019) summarises that the lack of opportunity given to under 17 students from Portugal to engage with emergency preparation, due to top-down approach resulting in increased vulnerability. In contrast, students who played a more active role in community preparations had greater pride therefore felt more resilient towards risk. A study (Tanner and Haynes, 2009) from the Philippines showed that students acting alone, without the assistance of parents, organised campaigns to relocate their school away from the threat of landslides, forcing their involvement through empowerment. Despite the small-scale nature of this study, these students showed greater engagement with emergency planning and this approach was successful in creating a resilient community.

Student participation is also advocated through effective resourcing provided by NGOs (Tanner et al, 2009). But Anderson, (2005) suggests that many CCDRR are written by external agencies, and these are too generic. Few studies have been conducted to assess the extent to which these resources, written by non-teaching professionals, achieve their goals and whether they reach their intended audiences. Therefore, this study will be one of the first to assess the impact of educational resources, making a before and after judgement on their effectiveness at changing student perception.

2.7.4 Building variety into education

Hart (1992 & 2008) suggests that participation alone will not lead directly to action. Such behavioural change can occur by changing the conditions in which students receive the CCDRR messages. One way this can be achieved is through providing a variety of approaches to improving student understanding of local hazards. Peek, (2008) suggests that participatory actions need to include a range of activities such as mapping, clubs, evacuations drills, competitions and videography which work beyond traditional lessons to help create realistic perceptions. Use of a questionnaire-based approach, adopted by many studies, does not allow for a holistic understanding of the

disaster impact or risk faced by an individual. Peek, (2008) advocates the method should be suitable to the age of the student. Several authors (Ronan and Johnston, 2001, Ronan, Johnston and Daly, 2001, Peek, 2008, Tanner et al, 2009) suggest a need to include opportunity to express creativity and feeling to aid psychological recuperation for post disaster activities. Berse et al, (2011) encouraged the use of spatial thinking in pre-disaster planning, undertaking activities which build an improved perception of the DRR opportunities within the local environment. However, their use of specialist GIS technology may be a limitation to schools in areas with less developed technology. This study will seek to test a small range of contrasting methods applicable to limited resourcing, to understand the extent to which they are more effective at improving and changing student awareness of local hazards.

2.7.5 Linking authority and education.

So far, the need for CCDDR approaches within schools has been outlined but are top-down government policies acting as barriers to effective implementation? In a study of 27 schools, Bandecchi et al, (2019), conducted an evaluation of seismic and geo-hydrological risk awareness. They showed a disconnect between the information provided by the government authorities and what is taught in schools, resulting in low knowledge acquisition reducing student understanding of DRR. In a study of 96 schools in the Philippines, Comighud (2018) showed a disparity between the perception of school students, school administrators, and local authorities in the implementation of the DRR management programme of the Bayawan City Division. Authorities felt they had a comprehensive plan, school administrators believed they were well placed for disaster reduction, but students did not all show the understanding to match.

In a study of Indonesian schools Sakurai et al, (2015) criticised the over-reliance on NGOs to provide material DRE efforts. This reflected a lack of investment by local educational authorities and willingness of teaching staff and principals to engage with programs, leading many to stagnate within a year of initiation. They suggest a consensus of DRR needs between the local community and the school and an annual budget dedicated to DRR resources. Ultimately to enforce these standards they recommend schools comply with a mandatory checklist of basic standards which are monitored by local authorities. So far, this circumstance has not been successfully reported by many communities, except for areas of New Zealand and Australia who act as pioneers for this approach (Ronan et al, 2016 & 2018). Less developed and emerging countries often have no uniform approach and DRE could be considered ad hoc, reactive to recent events or a result of NGO work.

Developing a comprehensive framework is important as part of CCDDR and the government needs to engage with the school community and ensure standards are upheld. If this study can show effective DRR education, it may form the basis of larger scale DRE planning at government level.

2.7.6 Scalable DRE?

One issue which has challenged researchers is the need to make DRR education scalable in the wider community. Wisner et al, (2012) show the benefits of bottom-up approaches in the wider community. Codreanu et al (2014) however, found only limited support for this notion. Although in their study, all the examples were from a class-based setting, and few incorporated any extra-curricular element. While isolated cases showed success, these are not adopted with a scalable approach. Suggesting that there is still a need to link disaster preparedness with behavioural change in research to encourage scalability.

2.7.7 Adopting a longitudinal view.

Matthew (2003) advocates that successful CCDDR cannot be achieved through one-off activities with small groups, where young-people play “*bit-part*” roles, even though it is the most common approach to DRR education. Several studies (Matthew, 2003, Peek, 2008, Ronan et al, 2012, Amri et al, 2017) therefore advocate a longitudinal approach. Indeed, Ronan, Crelin and Johnston (2012) acknowledge that DRE approaches have a half-life and without reinforcement there will be decay over time, suggesting that longitudinal studies focusing on before and after disastrous events are important to truly understand change in understanding and action (Peek, 2008). Matthew (2003) suggests a need for governments to opt for a long-term sustainable approach to promote child centred DRR. This would enable a national coverage in CCDDR approach, building a culture of risk reduction (Peek, 2008), which will reach a range of children and therefore increase capacity across diverse groups within a geographical area (Anderson, 2005). This will develop approaches which adapt to different cultures and therefore have the relevant cultural meaning rather than a generic approach, which is often adapted (Mitchell et al, 2008).

While the number of studies is on the rise there is a need for further studies in the field of CCDDR particularly in the effectiveness of education programs (Ronan et al, 2016). The HFA (UNISDR, 2015) outlined a need to use education to improve resilience at all levels. The SFA also aims to reduce global disaster mortality and to reduce the number of people affected by disaster by 2030 therefore CCDDR has an important role to play.

The recurring themes in CCDRR call for a need to include children in disaster risk reduction, both in practice, formulation of plans and evaluation of outcomes. They highlight the need to use schools to act as a community focal point to disseminate the message in a bottom-up approach to learning and for studies to employ longitudinal approaches rather than one off measures. They call for greater input from teaching staff to share their local knowledge but to act as mentors for the children rather than relying on NGO provision. CCDRR needs to be a continuing theme within the curriculum, rather than one off measures and there needs to be a movement away from drills to include more participatory measures which require decision making. This study will seek to address these by adopting a bottom-up approach that uses the input from local teaching staff and NGOs. It will seek to understand, through changing student perceptions and feedback from educational sessions, the impact of a particular DRR approach. One criticism of previous studies is the lack of educational theory used in the formulation of resourcing. The next section will look at the role of educational theory to underpin CCDRR and DRE.

2.8 Educational practice in a disaster risk context

The recommendations for improved CCDDR and DRE largely rest with the provision of impactful education which can lead to improved awareness. In this section we address the educational recommendations at a global scale and look at how an understanding of educational theory may promote successful CCDDR approaches.

2.8.1 Global policy

The Hyogo Framework for Action (HFA) 2005-2015 which replaced the Yokohama Strategy, 1994, outlined approaches to reducing risk from natural hazards. Priority 3 of the HFA identifies specific actions to promote disaster risk reduction through education. These include:

- To include disaster risk reduction knowledge in relevant areas of school curricula
- To implement a risk assessment of local risk and preparedness into educational institutions
- To implement programs to improve learning to minimise the effects of hazards. (UNISDR, 2005)

The Sendai Framework, 2015–2030 [UNISDR, 2016], built on the principles of HFA and sought to achieve a *“substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries.”* However, unlike the Hyogo Framework, the role of education is not explicit in the

Sendai Framework's Priorities for Action. Since 2005, annual UN global platform meetings have served to reinforce the aims of integrating DRR into the education curricula by 2015 (UNISDR, 2005, 2015). Although education was promoted at the 2011 Global Platform, by 2013, the deadline to integrate DRR into school curricula had disappeared (Kagawa, 2013). This exclusion of DRR education could be a product of the difficulty to implement it within curricula, despite half of countries reporting to HFA that DRR education was included in national curriculum (Ronan, 2015).

In response to the HFA, a comprehensive framework produced by UNESCO outlining the educational requirements (“*dimensions*”) for DRR (Kagawa and Selby, 2012, 2015, Selby and Kagawa, 2015).

While this study acts as a guide for educational approaches in DRR, several studies have highlighted a series of problems with: i) the study design and implementation, and ii) the delivery of educational content to meet the needs of the audience (Johnson et al, 2014, Ronan and Towers, 2014, Ronan et al, 2016, Amri et al, 2017a, Haynes and Tanner, 2015 , Amri et al, 2017b).

2.8.1.1 Study design

The study design refers to the organisation or methodological approaches employed by DRR educators. Relatively few studies exist on the limitations of study design for DRR education, however, some themes exist. Commonly, DRR education programmes are produced and delivered by disaster agencies or non-governmental organisations (NGOs) who may not consider local context or may not be involved in delivery of programmes at community level (Johnson et al, 2014). This can result in low uptake and poor continuation after the initial inputs end (Johnson et al, 2014). There is a tendency for studies into DRR education to focus on one age group or have small sample sizes (Johnson et al, 2014). Many of these studies currently exist in developed countries where there is funding (Amri et al, 2017b). Few studies are conducted longitudinally (Ronan and Johnston 2010) and those assessing DRR education fail to benchmark student perception or understanding, therefore limiting the ability to assess impact through comparison of “*before and after*” judgement (Amri et al, 2017b). The tool to assess impact of the DRR education method is commonly conducted using questionnaires or surveys. These often lack consideration for age-appropriate reading, font size, length, or syntax, and are further limited if conducted indirectly (Johnson et al, 2014).

2.8.1.2 Delivering DRR educational material

The delivery of educational DRR is important to ensure that its impact is maximised. One key issue is the teacher's knowledge, i.e., do they have a sufficient grasp of the content to give an accurate representation of risk and mitigation? (Johnson et al, 2014). Past studies suggest there is too much focus on delivering “*knowledge transfer*” (Johnson et al, 2014) or “*drills*” [Sharpe, 2009, Sakurai et al, 2015, Ronan et al, 2016) while some studies have indicated that a participatory approach should be used to teach DRR education to children [Ronan and Towers, 2014, Haynes and Tanner, 2015].

2.8.2 Pedagogy in DRR

Pedagogical (educational theory) approaches are not a common consideration in DRR education, however, they play a key role in teaching and learning in educational theory. Table 2.1 shows the key pedagogical theorists recognised in education.

Table 2. 1 Notable educational theories applied to DRR (adapted from Aubrey and Riley, 2019, Gardner, 1999, Dweck, 2017, Schunk, 2012).

Educational Theorist	Summary	Potential application to DRR
Jean Piaget	Learning through developing “Schemas” (building blocks of knowledge). Cognitively developing these through ‘assimilation and accommodation’.	‘Active engagement’ of students with focus on them offering opinion and suggestion based on their learning
Lev Vygotsky	Social learning is integral to learning through culture in a zone of proximal development (learning from immediate environment), Scaffolding (enabling learning from others with speech and collaboration) and ‘More Knowledgeable Offer’ (learning from experts).	Working with DRR specialists Simulation activities Use of games to trigger learning. Use of local language in local context. Student teaching.
Bloom's Taxonomy (Anderson and Krathwohl)	Stages of cognitive learning from knowledge, understanding, application, analysis, synthesis, and evaluation. Since revised in 2001 by Krathwohl and Anderson to remembering, understanding, applying, analysing, evaluating,	Decision making exercises / problem solving. Participatory approaches

	and creating. Linked to this are the Affective Domain (feeling and emotion) and psychomotor domain (physical movements linked to learning).	Psycho-social discussions about DRR.
Robert Mills Gagne	Five conditions of learning (verbal, intellectual, cognitive, motor skills and attitude) which were dependent on 9 levels of learning.	Practice based learning with opportunity for evaluation and assessment.
Jerome Bruner	Teaching complex concepts to children if structured / presented in a correct way (Spiral Curriculum) – based on reinforced learning through repetition, increased complexity, and progressive use of terminology.	DRR curriculum planning with consideration for pyramidal learning.
Abraham Maslow	Learning is hierarchical based on acquisition of needs from physiological to self-actualisation.	Enthusiasm in the teacher / student relationship – understanding values to change behaviours.
Howard Gardner	Theory of Multiple Intelligences – 7 intelligences – linguistic, mathematical, musical, bodily-kinaesthetic, spatial, interpersonal, intrapersonal. Gardner added an 8 th intelligence naturalist to perceive the environment around them.	Behavioural change Emotional discussion – regarding fear / feeling and motivations. Use of fieldwork.
Erik Erikson	Psychosocial beliefs that at each age we undergo a dilemma to become a well-adjusted adult. For example, for 12-18-year-olds students ask about 'Who they are' and what they wish to do.	Community participation / beliefs Discussion based activity. Empathetic tasks
David Kolb	Learning through knowledge / experience achieved through circumstance (Experiential learning).	Fieldwork Experience reflection DRR professional interaction
Dugan Laird	Sensory theory - visual learning represents 75% of knowledge.	Fieldwork / visits / simulations
Burrhus Skinner	Operant conditioning – positive reinforcement leads to repeated behaviour.	All education

<p>Carl Rodgers</p>	<p>Humanism theory - Believes all people wish to learn but the process of learning is important. Students control their own learning and teacher facilitate.</p>	<p>Class teaching Student voice Evaluation of teaching</p>
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These studies underpin different learning styles and are at the core of education in secondary education. However, these have not yet been fully integrated into DRR education. In a review of studies since 2007, which included DRR education [Cadag and Gaillard, 2012, Schunk, 2012, Johnson et al, 2014, Sharpe and Izadkhah, 2014, Sakurai et al, 2015, Ronan, 2015, Cvetkovich et al, 2015, Amri et al, 2017a, Amri et al, 2017b, Mendonca et al, 2017, Pfefferbaum et al, 2018, Mendonca et al, 2019, Proulx and Abound, 2019, Kamil et al, 2020, Hosseini and Izadkhah, 2020, Munoz et al, 2020, Shoji et al, 2020), only two Mendonca et al, (2017) and Sharpe and Izadkhah, (2014) consider pedagogical methods. Overlooking pedagogical methods removes an understanding of how best to deliver learning from the student perspective. Not all educational pedagogy has direct relevance to the DRR educational field (Kitagawa, 2019). However, consideration of what motivates and encourages learning should be considered (Gardner, 1999). Kolb's theory of experiential learning underlines the importance of experience in learning (Kolb, 1984) helping students remember through interaction and experience with their environment. This is particularly significant for accommodating students with different learning styles, e.g., kinaesthetic, visual or aural, as these experiences introduce a range of learning media. Banduras "*social cognitive theory*" and Vygotsky's "*social learning*" show that children learn best through continued observation (Aubrey and Riley 2019). They suggested that one-off learning did not take place immediately therefore ideas had to be embedded. This can occur through action-orientated and decision- making approaches or discussion with experts. Bloom's Taxonomy (Aubrey and Riley 2019) developed by Anderson and Krathwohl (2001), recognises that improved learning takes place through stages of cognition. Higher level cognition occurs as learners are required to apply, analyse, evaluate, and create; an approach lending itself to student-centred approaches and decision making. These approaches indicate a level of interaction and involvement which goes beyond didactic class-based exercises; a traditional fallback for educators (Johnson et al, 2014, Ronan et al, 2016). This is particularly important for addressing the range of learning needs of students who may learn visually, audially and kinaesthetically and therefore increasing the likelihood of messages being received. Although individually these approaches bring benefits it is the experience of the educator which helps understand which is important for a given audience in each circumstance. Therefore, it is imperative that those involved in providing DRE work closely with trained educators. The design of this study is

novel because it integrates a researcher with an appreciation of academic requirements for DRE and integrates over 20 years of educational experience to ensure that the targeted students are engaged.

In recognition of the need to develop DRR education in the HFA, UNESCO produced a report summarising educational approaches in a DRR context (Kagawa and Selby, 2012). This report recommended five dimensions for education in DRR (**Table 2.2**) but recognised that existing programmes of education often failed to extend beyond dimension 1 and 2. Therefore learners had a limited opportunity to apply their understanding, or engage in continuing DRR education, which reduced their capacity for risk. Subsequently, any benefits of DRR education were not felt beyond the classroom and had limited impact on student awareness of the disaster risk.

Table 2. 2 Five dimensions of DRR for implementation in education (Kagawa and Selby, 2012)

Dimension	Statement of need	Examples of application
1	Improving knowledge and understanding with focus on the science and mechanisms of natural disasters.	Use of teacher-led class-based sessions with textbooks. Conducted in either science or geography to develop understanding of natural processes. If possible, to work with DRR professionals.
2	Develop applied learning through practicing safety measures and procedures	Use of drills, instruction, safety awareness measures and learning about decision making.
3	To develop an understanding of risk drivers and how hazards can become disasters	Developing student understanding of vulnerability – what factors drive vulnerability, and how this might change during the stages of a disaster
4	Building community and risk reduction capacity	Developing capacity through action-orientated (participatory) learning. Building an understanding of mitigation and adaptation through work in the community.
5	Building an institutional culture of safety and resilience through the school and student community.	Developing the DRR ideals beyond the school into the community. Developing student voice. Involvement in policy.

The UNESCO report (Kagawa and Selby 2012) recommended a series of learning styles which could improve the learning of DRR principles in a school curriculum (**Table 2.3**). It states that a blend of these approaches is necessary, considering the learning audience, to successfully produce DRR education which has impact. These learning styles all advocate the use of participation which has been cited as an essential ingredient to improve DRR education (Hart, 2008, Mercer et al, 2008, Kagawa and Selby, 2012, Selby and Kagawa, 2012, Sakurai et al 2015, Kamil et al, 2020).

There have been isolated examples of success in the use of these methods in DRR education in a range of contexts. Somatic and expressive learning have shown increased engagement in DRR related activities, promoting deeper understanding of primary school age students (Ronan and Johnston, 2001, Sharpe and Izadkhah, 2014, Paton et al, 2018; Munoz et al, 2020). Affective methods have been successfully employed to help students recover from disastrous events (Amri et al, 2017b, Pfefferbaum et al, 2018, Wisner et al, 2018, Munoz et al, 2002, Shoji et al, 2020).

Table 2. 3 Teaching styles applied to DRR in education (adapted from Kagawa and Selby, 2012)

Learning style	Link to DRR education
Interactive learning	Use of group discussion, multi-media resourcing
Inquiry led	Use of inquiry-based approach, hypothesis testing through data collection. Developing independent research skills
Affective learning	Psycho-social approaches, sharing feelings, developing emotional responses and empathy for people and situations
Surrogate learning	Use of contrived circumstances through games, role play and film to enact and evaluate
Field-based learning	Outdoor education, visiting DRR professionals, conducting hazard mapping, evaluating land use, and formulating emergency plans for the community.
Action Learning	Linking community into activities, student outreach, campaign development. Assessing DRR principles in home and community.
Imaginal learning	What if scenarios to test likely outcomes using visualisation.
Somatic and expressive learning	Expressing feelings through creative arts.

Some studies have also shown the benefit of a participatory approach to raising awareness of disaster risk for secondary school students from countries with varying levels of development (Wisner, 2006, Kagawa and Selby, 2012, Ronan and Towers, 2014, Haynes and Tanner, 2015). This study will seek to investigate the impact of three participatory methods which have been covered less extensively in DRR education to improve student awareness: field-based, interactive, and

surrogate learning (Kagawa and Selby, 2012). Rather than testing these in isolation, as per other studies, this study will seek to understand how the same students' perception of local hazards changes because of these teaching approaches.

This study will test the recommendations of the UNESCO report (Kagawa and Selby, 2012) to assess recommended participatory methods which have thus far been overlooked in studies; interactive learning, surrogate learning and field-based learning. Interactive learning is a method employed by many NGOs as it seeks to encourage collaboration of the students, through class or group discussion, to share ideas to understand an issue. This method is different from a traditional teacher-led which places a greater emphasis on the teacher as the knowledge giver. Surrogate methods are employed through studies to elicit perception change using different stimuli, which may or may not be directly relevant to the student. For example, the use of computer games to simulate a hazard is common, but the focus may not be on the local area of the learner. As several studies advocate the use of participatory methods this study will test the benefit in hazard perception. In school this is easily accommodated through field trips. Reiss (2020) reminds us of the importance of fieldwork in application of subject knowledge, understanding of the environment but through the development of community. To assess the educational impact of the outlined methods, this study will use relative perception as a measure of change. The next section reviews the existing methods of risk perception to identify key considerations for this study.

2.9 Methods used to assess risk perception.

2.9.1 Collecting risk perception data.

Much of the work on risk perception highlights the importance of devising a methodology that can account for a diverse range of influences on belief systems (Al Rawad and Al Khattab, 2015). It emphasises that to be satisfactory any such methodology must enable a clear distinction between the views of so called "*experts*" and local perceptions amongst the population at risk (Kahneman and Klein, 2009), recognising that even the views of "*experts*" are subject to bias (Jasanoff 2006, Egan, 2018). While true risk expertise is debated (Fischhoff 1995, Sjoberg 2000) an ability to document cognitive ability and experience, the key components of expertise, combined with ability to adapt to the locational and contextual situational is required; further underlying the need to collect time sensitive data and appreciate cultural norms (Douglas, 2001).

Collecting risk perception data allows insight into a sample of beliefs, from a defined area or community, of the likelihood and severity of impact of an event. Borque et al (1997) consider the

importance of establishing representative surveys which accurately reflect the voices of groups within communities and, if in response to an event, reflect the views of those with direct and indirect experiences. To achieve this, current research methods almost exclusively use a form of interviewing or questioning to collect these views, usually in either qualitative or quantitative forms, rarely in both. In a review of 128 disaster risk perception studies, Witt and Lill (2018) revealed that qualitative methods account for 66% of all studies, with 28 quantitative and 7% mixed. The use of interview focus groups, and questionnaires account for almost all the methods employed in these studies. Overall, this study recognises that there is a need to incorporate both qualitative and quantitative methods in a study, and ideally to find a way to integrate them in a single interaction between a researcher and each study participant.

2.9.2 Traditional formats of risk perception methodology

Table 2.4 summarises issues and recommendations for disaster risk perception data collection. In an extensive review of the use of questionnaires in perception studies, Bird (2009) assessed questionnaire format, mode of delivery, sampling techniques and response rates, arguing that current perception research can often neglect these. The study identified a useful checklist for researchers to use in their survey construction and called for greater transparency in survey questions. King (2002) argued that longitudinal surveys were more productive as they can produce a measure of change in perception, relative to occurrences of hazardous events or interventions. This would allow an analysis of the hazardous events on participants' risk perceptions. In such circumstances Bourque et al, (1997) suggested use of replicated questions to reduce memory decay in participants. This will prevent participants giving conflicting responses to different questions framed on the same concept. Haynes et al, (2008) show that the use of mixed method approaches allows the capture of the complex social nature of hazards. This implies that both qualitative and quantitative methods are necessary, a point underlined by Witt and Lill, (2018). With a variety of approaches used to collect perception data, Hawkes and Rowe et al, (2009) question whether differences in identified risk perception are due to the differences in people's perceptions or the differences in the framing of the question.

While this study does not advocate a standard form in perception data collection, there is a need for researchers to think carefully and test their methodology to eliminate some of the issues presented here (Hawkes et al, 2009). With communities and groups within those communities offering a diversity of views, the toolkit for data collection should not be so rigid to continuously resort to the use of one method. There is a need to accommodate the full range of variation in ability of the survey participants, and consider those with lower reading ages, such as younger or otherwise more

vulnerable children or disabled people. Designs of such surveys need to be more focused on the groups that they are intended to sample, and ideally piloted to ascertain suitability. Some of these limitations are summarised in **Table 2.4**.

Table 2. 4 Issues associated with traditional risk perception survey formats.

Issues	Discussion	Suggestions
Survey design	Inconsistent design can elicit variable response from a similar audience (Hawkes et al, 2009) promoting memory decay (Borque et al 1997)	Format should include a mixture of qualitative and quantitative methods to capture complexity of the hazard (Bird, 2009). Conduct pilot studies to assess survey suitability for intended audience (Farinella et al, 2016)
Sample delivery	Face to face can lead to bias whereas postal delivery can lead to low response rates. Online surveys may isolate members of the community without or with limited internet access (Bird, 2009).	Phrasing of questions must limit bias. Interviewer’s facial expressions must be controlled after participant response. Careful use of follow-up questions to limit negative bias. Establish links through local community groups to reach a wide range of demographic groups (Bird, 2009).
Response rates	Understand the implication of non-response rates (Bird, 2009).	Where possible, establish community links to foster trust in participants. Use of community groups to conduct questions (Bird, 2009).
Likert-style questions	<p>i) Anchoring effect – narrow range of values may avoid extremes or solely encourage use of them resulting in skewed data (Jamison (2004).</p> <p>ii) Lack of defined meaning to ordinal points.</p> <p>iii) Ordinal points on the scale provide ranked data with a presumption of equal intervals (Jamison, 2004)</p>	<p>i) Use of Likert values – beyond 1-5.</p> <p>ii) Use of categorical Likert scaling should carefully define descriptive summaries of each ordinal point to which respondents can associate meanings (Carifio and Perla, 2008, Bishop, 2015).</p> <p>iii) Use of linear visual analogue scales to give a sliding scale between polarised ends of scale (De Vaus, 2002).</p>

<p>Use of language</p>	<p>Inclusion of the following problematic constructs (De Vaus, 2002, Choi and Pak, 2005):</p> <ul style="list-style-type: none"> - Double-barrelled questions - Leading / loaded questions. - Negative language - Unnecessarily detailed questions - Technical jargon - Uncommon words - Ambiguous language 	<p>Questions should be ideally piloted for both acceptable content and language suitability for the audience in question. Researchers should be careful not to use terms which may have a different meaning in different languages, for example the term “<i>extreme risk</i>” which may take on different meaning in translation (De Vaus, 2002, Choi and Pak, 2005, Farinella et al, 2016).</p> <p>Questions should elicit “<i>slow thinking</i>” which enable reflection (Kahneman, 2012).</p>
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2.9.3 Logistics of risk perception studies

One key limitation to risk perception studies is the short-term implementation of the work. Research grants, by their nature, are often 2-3 years, leading to short time periods during which risk perception data is collected (Siegrist, 2013). For many researchers this could represent a period of days to weeks which may only provide a “*dose*” sample (Borque et al, 1997) of the collected views. The timing of such risk response studies is also important. Too quick after an event may provide exaggerated views of a disaster. However, leaving a time gap could lead to “*memory decay*” (Borque et al, 1997). Therefore, it is important to get a range of views which give a balanced reflection of risk perceptions. One solution to this is the use of a longitudinal survey. Despite these being potentially expensive and difficult to arrange with larger sample groups (Bubeck and Botzen, 2013), they help understand the complex changing relationship people have with the impacts of a disaster event over time. They help develop a relationship between researcher and participant which may elicit more personalised responses, and a willingness to participate, while developing an appreciation of cultural influences at work in the community. Such studies can help understand both pre- and post-disaster risk perceptions, providing benchmarks for populations which may help understand drivers to action for a disaster event. In multiple hazard areas a longitudinal approach can help gauge the impact of one disastrous event on another and help determine the factors that help people prioritise risk towards different hazards (Mayorga and Johnson, 2018). Currently there are few longitudinal studies and none which focus on multi-hazard environments and the changing perception of students. Idealistically 5-year studies, such as the one, can give a much greater insight into changing

perception of individuals, so that disaster awareness programmes can be written to reflect the needs of the population more accurately at risk. This study therefore presents a novel approach to disaster risk perception studies and offers an insight into student perception which has not been undertaken before.

2.9.4 The use of disaster risk methodology with children

As noted in **sections 2.5 and 2.6** there have been relatively few studies which focus on child perception of disaster risk, with most studies focusing on DRR programmes in response to a disaster. In an evaluative study of methods linked to educational programmes to reduce disaster risk in education, Johnson et al (2014) found that the majority of the 38 papers reviewed used written questionnaires and the use of mixed method designs was rare. The main overall criticisms of child-centred studies were thus small samples, a lack of baseline data or control groups (Johnson et al, 2014, Amri et al, 2017).

The overwhelming reliance on questionnaires in risk perception work with children allows collection of large amounts of data with larger samples. However, their use is often limited by inappropriate reading levels, long question length and small font size (Bird, 2009). One key limitation is the need for children to write answers without consideration of the child's ability to understand questions, terminology and accurately express their responses in written form. Questionnaire surveys reflect student knowledge at a point, rather than accepting that this could change in response to external factors, experiences, or education over time. This study will seek to understand the benefit of using a method based on visual metaphor which should overcome the longstanding issues of question misinterpretation identified in previous studies due to the limited requirement to communicate through written text. This method will therefore address some of the issues identified in **Table 2.4**.

Johnson et al, (2014) suggests that all child-centred studies need to employ mechanisms which allow a "*drastic shift*" in risk perceptions rather than evaluating immediate outcomes from intervention measures. Longitudinal studies provide a solution here, yet few existing studies assess disaster risk perception beyond a month. The use of longitudinal data collection in this study should help create time-series student perceptions of multiple hazards enabling assessment of the factors which cause these to change, rather than taking each perception value in isolation. This will offer a unique perspective on changing perception, allowing an establishment of baseline perceptions and variance and the impact of disastrous event in comparison to these. This approach will also be the first to assess the impact of educational approaches.

2.10 Summary

This chapter has sought to address some of the key background for this study, focusing on i) the concept of risk and disaster risk; ii) disaster risk perception; iii) the role of children in risk environments; iv) the role of education to reduce risk and v) methods to measure disaster risk. These concepts underlie the major themes of the study and provide context for the research questions. **Table 2.5** summarises these concepts in the context of the research questions and outlines the gaps in existing study.

Table 2. 5 A summary of literature and research gaps in the context of research questions.

Research questions	Key themes from literature review	Gaps in understanding
1) How effective is the PRISM method to assess changing perception?	PRISM is an innovative tool for understanding a patient's relationship with changing health circumstances, widely used in the health sector. PRISM uses visual metaphor to show relative perceptions, thereby bypassing issues with existing methods for assessing risk perception, potentially making it a more suitable method for school children.	How effective is PRISM as a tool to record information outside health? This study will seek to assess its use to measure risk perception and test the benefits for use with children, from different cultural backgrounds.
2) How does student perception of relative multi-hazard risk vary over time?	Many studies into risk perception aim to understand the changing perceptions before and after known events. Or many studies look at risk perception at one point in time, or over a short time – 3-6 months. Most existing studies of perception focus on adult populations or general community groups and there are few long-term studies of student populations.	This study seeks to understand the long-term relationship in changing risk perception. To understand the inter-relationship between the perception of students over a time (which includes periods with disastrous events). This is the first longitudinal study focusing on multiple student groups across an area, rather than in one location.
3) Do student risk perceptions reflect the spatial variation of multi-hazards in Dominica?	Most studies of risk perception focus on the impact of one dominant hazard which have the potential to affect an entire geographical area. The study area Dominica has known hazards which are more geographically sensitive. For example, coastal locations are at risk from	There are few studies on multi-hazard risk and fewer which look at the relative perception of these risks spatially. This study seeks to understand the different in student perception spatially to

	flooding, and storm damage, while upland / valley locations are subject to landslide and flooding.	assess the extent to which this follows the national pattern.
4) What role does gender play in student multi-hazard perception?	Women are a major vulnerable group in disasters. In disaster risk studies women are viewed as understanding and reacting to risk more.	Does this same trend apply in a multi-hazard risk environment? Do school students represent the same risk behaviours as adults in the context of gender?
5) Are students with improved social contexts more aware of disaster risk?	Vulnerable populations are more likely to be at risk if they lack the means to understand and act on risk. This is the case for small magnitude risk events which enable populations to make decisions about protection. Those with a greater education are often more able to make socio-economic decision to help reduce risk.	Few studies have looked at risk perception relative to socio-economic status and the differences between them in a multi-hazard environment. This study seeks to understand whether students from families with lower socio-economic levels have a different risk perception of multi-hazards?
6) Do some participatory educational methods and resources have a greater impact on changing student risk perception?	Educational approaches for disaster risk reduction (DRE) lack consideration for learning mechanism. Participatory methods have been shown to have some success in improving awareness in DRR. Kagawa and Selby released suggested DRE methods in a 2013 UNESCO report outlining pedagogic approaches to be used in improving understanding.	Few studies have considered the use of surrogate and field methods for disaster risk education. Fewer studies have assessed the impact of these methods over time and sought to compare their effectiveness. Very few (if any) studies truly assess the impact of the resources used in DRE education – this study will seek to understand these issues.

Chapter 3 – Methodology

This chapter presents the methods used to collect the quantitative and qualitative data for this study, how data was processed, and statistical methods used to analyse data. This is followed by a timeline of the study period to highlight key changes faced by Dominica, the schools and individuals which influenced the collection of data during the study period.

3.1 Adopted research philosophies.

The nature of this study is interdisciplinary and therefore does not easily fit into one research philosophy. Saunders et al (2009) and Bryman (2016) outline the importance of the different philosophies to understand the assumptions upon which the study is based. They outline for key theoretical approaches; Pragmatism, Positivism, Realism and Interpretivism. This study has three major themes: i) understanding the nature of multi-hazard risk in the environment, ii) understanding how peoples (students and disaster risk stakeholders) perception of this risk changes over time and iii) understanding the impact of educational approaches to change perception and hazard awareness. In this section it is necessary to outline some of the philosophies adopted for each of the study focuses and explain the assumptions linked to them.

To understand the multi-hazard nature of the study area sites in Dominica a positivist approach was adopted. This was achieved combining secondary research combining existing research on different disaster risk phenomena in Dominica and through direct observation. The direct observation of the multi-hazard environment, through taking field notes and photographic evidence, allowed a confirmation of the secondary data. It also provided an ability to formulate specific perspectives on the local hazards which would allow for a benchmark of relative local risk, for the perception element of the study. This was achieved objectively through quantitative observations which were verified by experienced field geologists and local experts. Ontologically, however, it is important to note that the nature of hazard risk is not fixed. Therefore, the epistemological facts gained were viewed as reference points to the potential of risk. This approach assumes that studied risk represents the range of possible outcomes but accepts that this may not completely represent the reality of the unknown risk.

As shown in **section 2.9.2** the study of perception adopts a subjective (Saunders et al, 2009) approach because the reality is based on social construction. Ontologically perception studies adopt a constructivist approach and epistemologically they are interpretivist (Al-Saadi, 2014). These

approaches have their disadvantages, namely they are subject to bias. But the issues outlined in **Table 2.4** have been considered for this study and this has justified the use of a novel approach to measuring perception which aims to add a quantitative element to the data collection and avoid some of the issues previously considered. Despite dealing with perceptions the quantification of them using PRISM allows for a relative positioning of perception values, which, owing to the nature of this longitudinal approach, allows for comparison over time. Therefore, reducing the disadvantages that exist with collecting singular perceptions after a disaster event which may be subject to bias. To inform these quantitative relative positions, provided by PRISM, it is necessary to add a qualitative element to the study (as per other semi-structured studies). This would allow an appreciation of the perspectives behind the different perceptions. This combination of qualitative and quantitative approach to measure perception allows for an understanding of the meanings behind the relative perceptions measured. The PRISM method, devised by Sensky and Buchi (1998) formed the basis of collecting the student perceptions. The method was designed for collecting views on patient suffering during a period of illness. Prior to deciding on the use of this method discussions were made with Tom Sensky about the potential validity of using this method with students. After discussions about the mechanics of the method and the differences with traditional methods of collection this method was adopted.

This study sought to understand the changing nature of student perception. Students were chosen partly because of their relative absence in disaster risk literature but also because of the career experiences the author had with this group. As such this choice reflected a realism approach. It was necessary to appreciate that student perception would change over time and that they are subject to outside bias, which itself might change. The fact that students from different cultural settings were included reflects this realism. Students' location to an extent determined their cultural upbringings and influence, for example, those from the rural setting of Castle Bruce with links to the Kalinago indigenous people have different perspectives to those from the more affluent Roseau. Understanding whether there were differences in multi-hazard perceptions were critical to this study to determine whether the generic DRR approaches employed by the authorities were a valid approach, or whether focus on DRR education and awareness should be localised. The use of the PRISM method to measure student perceptions was also linked to the realism approach. Previous studies in **section 2.9** highlight the problems with use of traditional methods. Therefore, this visual metaphor approach allows for student perceptions to be measured differently accounting for the issues with reading and understanding and avoiding the potential bias of the researcher.

The longitudinal nature of this study resulted in the impact of different disaster risk events during the study period. To understand these, it was necessary to appreciate the response of disaster risk organisations. **Chapter 4** outlines the national approaches taken to manage disaster risk in Dominica. Therefore, a focus only on the long-standing disaster risk stakeholders were included and an inductive approach was implemented to understand their approaches to the changing landscape of disaster risk throughout the study period. This approach allowed for an understanding of changes to their approach over time to determine how they dealt with changes to the risk environment.

The final theme of the study sought to understand the educational approaches. This required an understanding of local approaches to education. To allow for this observation of existing examples of teaching and learning were undertaken to deduce the common approaches. The formulation of the teaching resources used in this study were based on existing theory. These therefore heavily influenced the format of each session which needed to reflect these approaches. However, the delivery is not formulaic. Having accumulated 20 years of teaching experiences allowed for a teaching and learning approach which was adapted to the audience. This approach was based more on experience and adaptability than a singular research philosophy. This enabled the student audience to engage with the resourcing produced.

3.2 An outline of longitudinal data collection

The unique feature of this study is the longitudinal nature of it. Building upon **section 3.1**, this section will outline the practicality and details of this approach. It will be followed by sections outlining specific methods on the qualitative and quantitative methods used to achieve objectives.

This longitudinal study took place in Dominica between October 2013 and October 2018, after a weeklong preliminary visit in December 2012 which allowed familiarity with the island and to arrange study logistics, including seeking permission from the Ministry of Education to work in different schools and meeting with school principals from the different secondary schools to discuss student selection and plans for the study. It was also an opportunity to understand hazard risk on the island, through visits to sites, meeting local historians, and the DRR stakeholders, including the director of the Red Cross and the Office of Disaster Management team.

The longitudinal approach was fundamental to the success of this study. It allowed a deep understanding of the nature of multi-hazard risk in different locations through repeated visits to sites and building a relationship of trust with local people. This was particularly important considering the island was hit but disastrous events during the period of the study. It allowed a

unique perspective on the changing perception of a student cohort through their secondary education. It also allowed for a long-term evaluation of a novel approach to measure perception, PRISM, as validation for the method being used to measure disaster risk perception. The longitudinal approach also important to implement the teaching and learning component of this study, as it allowed for the necessary observation of teaching and learning styles, building a rapport with staff and students, and understanding their level of DRR awareness allowing improvements in the taught component of this study.

3.2.1 Study outline

To achieve the study aims set out in **section 1.6** three it was important to explore three themes: i) the nature of disaster of multi-hazard risk in Dominica to benchmark the frequency and magnitude of multi-hazard potential, ii) to understand changing risk perceptions (both student and DRR stakeholders) over time, and iii) to assess the relative success of educational approaches in changing student perception. This section outlines the methods used to address each theme, the timetable of study and a summary of the data collected and a justification of what was included in this study.

As outlined in **section 3.1** understanding the nature of multi-hazard risk in Dominica involved both secondary and primary data collection. A contextual study of hazards in the Caribbean was conducted (**chapter 4**) using secondary sources, assessing both past academic studies, governmental and NGO reports and literature from Dominica. During the visits in 2013-2015 field days were built into the visits to identify field evidence for hazards in the 3 study locations: Roseau, Portsmouth and Castle Bruce. These areas were chosen for the differences in cultural background of residents and based on the researched relative risk in each area, for example Roseau has a much greater risk to geophysical hazards than Castle Bruce. Further details of this are outlined in **section 4.6**. During field days a field diary and photographic evidence were collected to record observations. The focus of these observations were coastal and river sites and, geological outcrops. The source of these were discussed with local experts and the Office of Disaster Management. During the 2017-2018 visits, specific locations for the field-based educational approach were selected based on accessibility, proximity to local schools with the help of local experts (ODM / Red Cross advice) and the guidance of Dr Simon Day and Dr Robert Watt.

Perception data was collected with the PRISM technique. Further details of this are outlined in **section 3.3**. A small comparative pilot study was conducted during the 2014 visit comparing the PRISM method with standard questionnaires. While this did not form part of the findings of this study it was useful to compare the differences between questionnaires and PRISM. A small group of

students were asked about local disaster risk perceptions using both techniques without assistance. After the two surveys were conducted, students were briefly interviewed to clarify their responses. The pilot study showed, greater inconsistencies using the questionnaires compared to the PRISM study, largely due to question misinterpretation. This small pilot supported the continued use of PRISM in the study, but also helped evaluate the issues of using PRISM (**shown in section 3.3**). PRISM studies were conducted in every visit with the students (whether taught or not) and were conducted before and after educational methods to show the change in relative perceptions. This approach allowed confidence in whether the educational method had an impact on student risk perception.

To collect the changing views, and actions, of the DRR stakeholders – namely those in government, in the ODM and the Red Cross, different approaches were conducted. PRISM surveys were conducted on each visit (time permitting). Open ended interviews were also conducted to understand the changes in DRR related activity since previous meeting. While it was intended to visit each stakeholder on each visit this was not always possible. Information about meetings with stakeholders is included in **section 3.2.2**.

To assess the relative success of educational methods in raising hazard awareness PRISM tracked before and after changes. The nature of the resources created were based on testing learning approaches from the UNESCO report by Kagawa and Selby (2012) which identified effective measures for DRE. Lesson observations between 2013-2015 gave an insight into traditional teaching and learning approaches. The author combined their 20 years' experience in resource production along with collaboration from local school staff to ensure the suitability of the resources. These are outlined in **section 3.4.4**.

3.2.2 Study timetable

Table 3.1 outlines the visit timetable for the study. Originally visits were planned in the October of each academic year, however, after Tropical Storm Erika in 2015 the schedule had to be amended (**section 3.5**). All visits took place in either October or April, which corresponded with UK teaching holidays and periods where Dominican students were at school. It was not possible to travel at other periods either due to my full-time employment or because Dominican students were on holiday periods. April became a preferable time slot because October half term coincided with October/November Independence Day celebrations in Dominica and access to students was difficult.

There is an acceptance that student perception would vary depending on time of year e.g., during hurricane season.

Table 3. 1 Field visit timetable for Caribbean / Dominica visits (times for each activity in brackets).

Date (Trip length)	Perception study conducted	Teaching conducted	Meetings conducted	Fieldwork conducted
Visit 1 October 2013 (Sun 19th-Sun 2nd Nov) Students in 1 st form (12 days)	Use of original 1-to1 PRISM board interviews. PRISM study conducted in 4 schools over 4 days with 1 st form students. Completed control studies with Y5 students (leaving school with no intervention) – small samples.	None – observations made in classrooms to show normal practice by teaching staff in each location. (4-5 days in schools)	Red Cross - director ODM - director WA – seismic expert (2 days)	Sites between Portsmouth and Capuchin Field-sites along the west coast highway. Trafalgar / Roseau valley Castle Bruce (5-6 days)
Visit 2 October 2014 (Sat 18th- Sat 1st Nov) Students in 2 nd form (12 days)	Use of 1-to-1 PRISM board interviews. PRISM study in 4 schools for 2 nd form students). Compared questionnaire results to PRISM study. Each school = 1.5 days	No lessons taught. Observed lessons from Geography teachers in each school to understand how form -1-3 and form 4 and 5 lessons were taught. (7 days in schools)	Red Cross – director ODM - director LH – expert local historian WA – seismic expert (2 days)	Revisited sites above and visited Morne aux Diabes, Scots Head, Trafalgar Falls, Central uplands. (2 days)
Visit 3 April 2016 (Fri 8th-Sun 17th) (Delayed from October due to Tropical Storm Erika). Students in 3 rd Form (10 days)	From this date forth use of adapted PRISM technique. PRISM in 4 schools (3 rd forms students)	Observations in each school. Session 1 - interactive teaching comparing Caribbean hazard trends with global. (5 days)	ODM – old director Red Cross - director WA and locals to assess impact of Tropical Storm Erika. MoE – Chief Education Officer (2 days)	Road assessment of Tropical Storm Erika impact –from Atkinson to Roseau; west coast highway; southern road from Roseau to Grand Bay (2 days)

Visit 4 October 2016 (Sat 15th-22nd Oct) Students in 4 th form (7 days)	PRISM in 4 schools (4 th form students)	Session 2 – surrogate teaching - multi-hazard impact in Dominica (4 days)	MoE director Red Cross - director WA seismic expert ODM (new team). (2 days)	Reki trip around Castle Bruce, Portsmouth and Roseau to develop 5 th form teaching programme. (1 day – plus time around schools)
Visit 5 April 2017 (Fri 7th-Sat 15th) Students in 4 th form (8 days)	PRISM in 4 schools for 4 th form students)	Observed lessons – no teaching. (4 days)	MoE chief officer Red Cross WA seismic expert SRC Trinidad (2 days)	Fieldwork teaching – reki visit for fieldwork sites around Portsmouth, Castle Bruce and Roseau. (2 days)
Visit 6 October 2017 (Tues 10th-Fri 13th) (4 days in Caribbean)	Did not visit Dominica – but travelled to Caribbean region to understand the region impact of Hurricane Irma and Hurricane Maria.		Visit to CDEMA (Barbados). Barbados ODM SRC Trinidad (3 days)	Did not visit Dominica
Visit 7 April 2018 (Thu 5th-Sat 15th) (Delayed visit due to Hurricane Maria) Students in 5 th form (10 days)	PRISM with 4 schools (5 th form students)	Session 3 – fieldwork approach - local hazards (6 days)	Red Cross interim director MoE chief officer Trinidad SRC WA seismic expert LH – local expert historian (3 days)	Fieldwork teaching in Roseau Valley, Portsmouth, and Castle Bruce
Visit 8 October 2018	PRISM exercise with new 1 st formers	Observed lessons in schools – gave some talks to students. (4 days)	(temporary) New Red Cross director	Fieldwork to assess the impact of Hurricane Maria, near

<p>Thu 12th-Sat 21st) (1st form students post Maria) (9 days)</p>	<p>Discussions with past students about Hurricane Maria</p>	<p>Israelaid – lead Barbados ODM Teaching staff at study schools (2 days)</p>	<p>Bellevue Chopin, Grand Bay (but not part of this study). (2 days)</p>
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During school days, the focus was to conduct PRISM activities and exercises with the focus students. During a school visit day, the students would be allocated between 1-2 hours to conduct a set of PRISM exercises and review their experiences. During a taught session day (2016-2018 visits) students would be allocated for up to 3-4 hours. School days ran from 8-1pm so this represented most of a school day.

Interviews with DRR stakeholders were organised dependent on location. Often 1-2 hours was allocated in time with them. During this time, the interviewee would be able to update on their experiences with DRR in the context of their roles in community. During these meetings, notes were taken using a field notebook and in later meetings recordings were taken using an iPhone. These meeting notes were subsequently written up or transcribed.

During field days detailed notes and sketches were taken at site locations of interest. The aim of these sites was to note evidence of activity related to disaster risk reduction. The focus of these sites could include engineering solutions to manage disaster risk, geological evidence of disaster risk deposits, evidence of structural damage to buildings or holistic walks to assess the interaction between human activity, landuse and geomorphology.

3.2.3 Ethical considerations for conducting the study and working with secondary school students.

During the 2012 pre-study visit to Dominica a series of meetings were conducted with local stakeholders to gain permission for fieldwork around the island. Meetings with the Land Registry department in Roseau were conducted to gain permission to work in the chosen study locations. Contact was made with national park owners e.g., Cabrits or the Botanical Gardens, to access the site. The permission was granted based on notifying whereabouts and sharing information with local historian Lennox Honeychurch. Local village guides were used for visits to remote central locations. During meetings with DRR stakeholders’ participants were informed of the nature of the study and

agreements were made regarding anonymity. For small organisations such as the Office of Disaster Management and the Ministry of Education agreement was made not to share any reference to names, to protect the views of these individuals. Therefore, names will not appear with any transcribed content or quotes used in this study, only reference to the named organisation.

Working with the students played a critical part of the entire study, therefore it is important to outline the procedure undertaken to work with the student groups. Prior to the 2012 trip contact was made with the Ministry of Education (Chief Education Officer) in Dominica to establish potential school contacts. Contact was made by email with schools outlining the basis of the study and initial agreement was made with school principals to work together. During the 2012 trip permission was sought from the Ministry of Education to working with Dominican school students (Appendix G). Part of this agreement was that all student conversations and perceptions would be anonymized (in line with UK safeguarding rules) during the study period and beyond. Student selection was made by local school principals, however as these students had only recently joined the school little information on prior attainment was known about them other than incomplete junior school reports. Therefore, it was difficult to understand the representation of the chosen student group within the sampled year. Although student selection was made by school principals it was subject to parental consent, sought locally by the principals after parent-student meetings. Parents were informed that participation required students to commit, where possible, to the entire period of the longitudinal study. Parents had the opportunity to ask questions to the local principals and reserved the right for their child not to participate. Students were assumed to have limited or no DRR input from primary school, however, it was not possible to establish this until they were first met in the 2013 / 2014 academic year after they had agreed to participate.

As a result of 14 years teaching experience (in 2013) and both Qualified Teacher Status (QTS) and Advanced Teaching Status in the UK (in 2012), the Ministry of Education and school principals allowed unrestricted access to the student groups subject. Ethical consideration for the study as granted by the University of Portsmouth (Appendix H).

3.3 Quantitative data collection

3.3.1 Risk perception data using PRISM.

As outlined in **section 2.9** perception study data are frequently collected using questionnaires or surveys. The design of the questionnaire determines the extent to which qualitative and

quantitative data has been collected. Traditional open and closed questions are considered qualitative data. However, the inclusion of categorical data in Likert style scales has been considered **quantitative**. To measure risk perception in this study there is a recognition (**section 2.9**) that traditional questionnaires have limitations for collecting perception data, specifically applicable to children. Therefore, to address some of the concerns mentioned in **section 2.9** and to collect longitudinal perception data this study uses a novel approach which emphasizes visual metaphor; the PRISM method (Pictorial Representation of Illness and Self Measure). As outlined in **section 3.2.1** the PRISM method, designed originally By Sensky and Buchi (Buchi et al, 1998, Buchi and Sensky, 199), was created as a tool used for clinical psychologists to understand how a patient copes with illness related suffering through different stages of treatment. It has gain increasing recognition and acceptance for its use in quantifying suffering (Higginson and Carr, 2001, Reinhardt et al 2006, Kils et al, 2008, Kassardjian et al, 2008, Streffer et al, 2009, Gielissen et al, 2013, Krikorian et al, 2013). Beyond medical practice other studies (Zimmerman et al, 2013, Parham et al, 2015, Yildiz et al, 2020, Parham et al, 2020) have shown its potential as a method for assessment of beliefs both in individuals and as a survey tool.

The basis of PRISM, as devised by Sensky and Buchi (1998, 1999), is a visual representation of a spatial metaphor that uses distance between markers on the PRISM board (**Figure 3.1**) to represent the strength of the relationship between the life of the subject (the patient or informant) and an object (the patient's illness or some aspect or consequence of it that is causing suffering to the patient). The concept uses an A4 board representing an individual's life, with a fixed circle representing the individual within their life ("self"). Other disks are placed relative to the fixed "self" disk to represent relative importance to the individual. The distance to "self" represents the relative importance. Therefore, disks placed closer to the individual are shown as being more important and perceived as such. This study used the disks to determine relative importance of disaster risk for individuals in their given location.

In **Figure 3.1**, the subject is represented on the rectangular PRISM board by a fixed "self" marker (a 7 cm diameter yellow circle in the lower right-hand corner of the board. Patients are asked to place markers, representing the object relative to the "self" marker. Informants were then given a disk (5cm in diameter), representing their illness, and asked to place this on the board to reflect the importance of their illness at that moment.

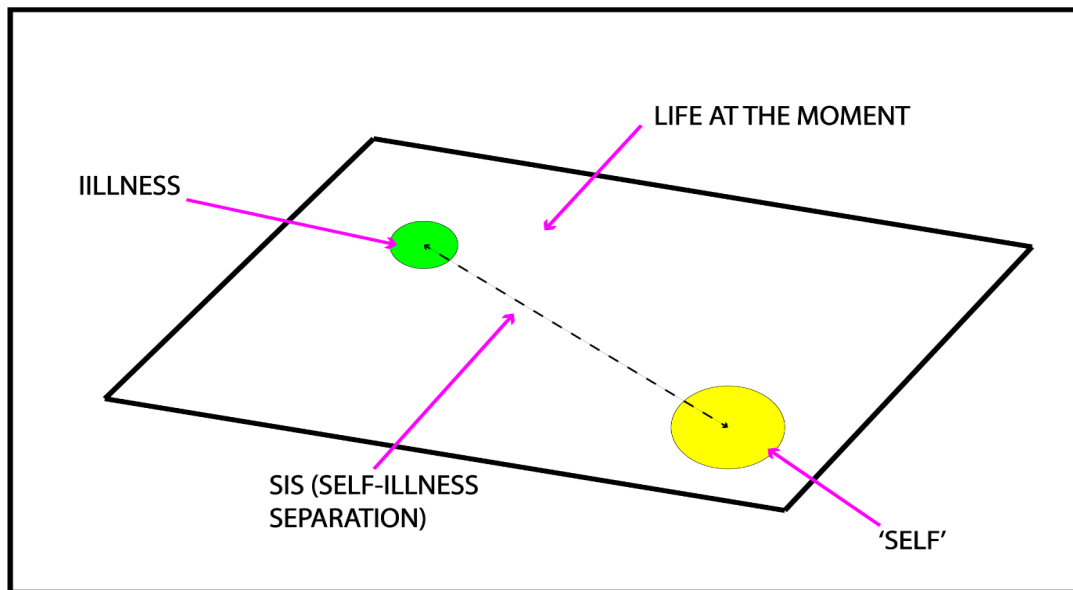


Figure 3. 1 Representation of PRISM board (after Buchi et al, 1998, Buchi and Sensky, 1999).

The distance between the centre of “self” and the disk (termed SIS – “Self-Illness Separation”) was measured allowing a quantification of the relative importance of the illness to the informant (**Figure 3.1**). The SIS provided as a measure of suffering: a smaller the SIS value represented a position closer to the “self” circle indicating greater the suffering of the individual relative to that disk (object). In subsequent tests, other disks were given to participants to represent other influences on the informant’s life, such as work or family, and these were placed relative to the self-marker allowing a comparison between illness and other aspects in the patient’s life. The use of a rectangular A4 board caused informants to prioritise their disk placements, rather than placing them all at similar distances from the “self” circle. Informants were asked also to justify the position of their disk placement, which could be written down or recorded to gain qualitative understanding of the informant’s choices. Sensky and Buchi (Buchi et al, 1998, Buchi and Sensky, 1999) argue that the use of a visual metaphor enabled informants to elicit brief but focused responses, rather than lengthy narratives on their suffering associated with interviews or extended questionnaires. Sensky and Buchi (Buchi et al, 1998, Buchi and Sensky, 1999) also hypothesised that the angular position on the PRISM board may indicate the psychological state of the respondent, and specifically the respondent’s expectations for their future levels of suffering. In tests with patients, for depression and anxiety they (Buchi and Sensky, 2016) found a correlation between angular positions of the illness marker and the scores in these tests for levels of depression or anxiety as indicated in **Figure 3.2**. This was unexpected because at no point in explaining the PRISM exercise did they draw significance to angular position. They proposed that the link between angular position and the informant’s state of mind is that by placing a marker in the longer or more open-ended part of the board (sector B in **Figure 3.2**), the informant unconsciously represents the extent to which they hope

that their illness might become less important in future: a situation in which they would move the illness marker further away from the self-marker. In contrast, Sensky and Buchi interpret a placing of the illness marker closer to the shorter side of the board (sector A in **Figure 3.2**) as indicating an expectation on the part of the informant that their illness will always be important in their lives (causing suffering) and so they will never be able to move the illness marker away from the self-marker (Sensky 2013).

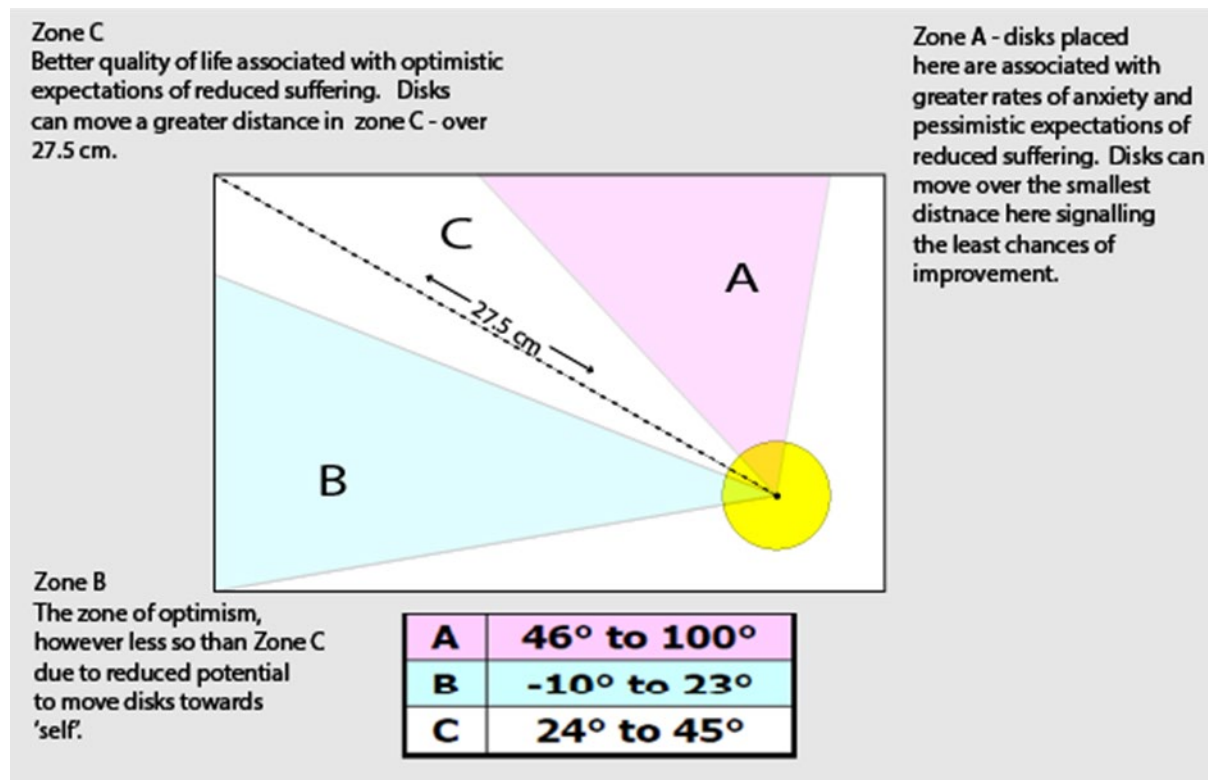


Figure 3. 2 Interpretation of angle measurement on the PRISM board (after Sensky, 2013).

Although not the focus of this study, by collecting angular data will allow further study of this hypothesis.

Although originally designed for adults, PRISM has been effectively used with children in the age ranges of 12-16 (Melbrandis and Jemec, 2011) and disability groups. Studies in Brazil and Latin America (Krikorian et al, 2013, Lima-Verde et al, 2013) show the success of applying this visual method in other languages to assess suffering, transcending language barriers. Several studies have shown that the method is understood by most of its users via relatively brief instructions (Buchi et al, 1998, Buchi and Sensky, 1999, Higginson and Carr, 2001, Reinhardt et al, 2006, Kils et al, 2008, Kassardjian et al, 2008, Streffer et al, 2009, Melbrandis and Jemec, 2011, Sensky, 2013, Krikorian et al, 2013, Lima-Verde et al, 2013, Gielissen et al, 2013, Krikorian et al, 2013, Sensky and Buchi, 2016). This study represents an opportunity to understand the long-term repeated use of the technique

led to adaptations prior to visiting students in Dominica. The use of PRISM was further tested in the field, as mentioned in **section 3.2.1** to understand the differences between questionnaire and PRISM. Using the same student groups (small samples of up to 15-20 students per school) found greater consistency in the placement of disks using PRISM compared to Likert scaling on questionnaires. Students commented on difficulties in question interpretation as one reason for these inconsistencies. Therefore, we were content to continue using PRISM beyond 2014.

Before each PRISM exercise, the students in Dominica were informed about the workings of the survey tool and read the instructions in **Figure 3.4**. These instructions were delivered to the students and words such as 'perceive' or 'relative' were explained to help students understand meaning.

Instructions for PRISM exercise 1

- i) I want you to imagine that this board represents your life, and the yellow circle represents you.
- ii) I am going to give you a series of disks which represent the threat of a hazard in your life.
- iii) I would like you to place them relative to yourself to show how you perceive the risks.
- iv) The closer you place them to the yellow circle the greater the perceived risk.
- v) If you place them off the board, this means that they do not affect you at all.
- vi) If you place them over / within the yellow circle this means the risk has a direct influence on you.
- vii) Each disk needs to be placed relative to the other.
- viii) You may change position of the disks as you go along.
- ix) I may ask you why you chose to place the disk in the chosen position so think about why it is placed where you have positioned it.

Figure 3. 4 Example of instructions given to introduce the PRISM activity to a new respondent.

Students were asked to place coloured magnetic disks on the board to indicate the perceived hazard risk associated with that disk (the meaning of the disk was different for different exercises, see **section 3.3.3**). During each exercise, successive markers were left on the board so that students could see their relative positions, but in all cases, they were asked to place each new marker in relation to the self-marker. Placement of disks off the board were considered of no importance to that student and scored with the maximum SHS distance of 27.5cm. After placement, a photograph of the board was taken, with rulers placed along the side so that the radial distance and angular

position from self could be calculated (**Figure 3.5**). Students were invited to evaluate and explain the positions of the disks that they had placed on the board to reflect their relative positions. Student explanations, justifying disk placement were recorded using a Dictaphone for later transcription. Photographic evidence of the final position of participant disk placement were taken, again with rulers placed alongside the board to measure SHS measurement from self (**see Figure 3.5**).



Figure 3. 5 Original PRISM set up pre-2015.

Following the PRISM exercises, participant was given a short survey of closed questions to determine their family wealth, location, age and gender to understanding socio-economic influences on the survey results (**Appendix J**). These variables would help analyse the PRISM perception data to determine the extent to which students living in different locations, of differing gender or with different socioeconomic backgrounds showed variance in their perceptions of risk perception. The use of the questionnaire was important in making this a semi-structured survey. It was important to collect student reasons for their disk placement and contextualise these in socio-economic data. This allows for both an analysis of quantitative disk placement as well as sub-dividing these results by location type and by gender. Watt and Lil (2018) outline the importance of perception studies adopting a semi-structured approach. The methodology of this study allows for this and allows relative comparison between the views of the students in each location and those of the experts to understand relative difference. This therefore provides a focus for future educational measures to reduce gaps in disaster risk perceptions on a small-scale approach, rather than at a national scale, thereby accounting for local differences (Borque et al 1997, Douglas,2001,).

3.3.3 Planned PRISM exercises

To help understand the longitudinal changes in risk perception and learning sources for DRR a series of exercises were undertaken with each student. Therefore, each PRISM data collection had three parts called exercises. Each exercise was set up to answer a particular question. These are outlined below:

Exercise 1 - How important is the threat of hazard xx to you in your life?

Exercise 2 - How important are different methods of learning about hazards to you in your life?

Exercise 3 - How important are different groups, in the event of a future hazard, to you in your life?

The purpose of exercise 1 was the principal component of the exercise. This established the hazard risk perception at that time. This exercise helps understand longitudinal student risk perception which is important to understand the change in relationship in perception change between hazards in a multi-hazard environment. This also helped understand the impact of a disaster event on the relative perceptions of each risk. This has not been achieved by other studies before and therefore serves as an important benchmark. The verbal justifications given by the students contextualised the disk placements but also helped analyse how the justifications for disk placement (i.e., perception) were different post disaster and inter-disaster periods.

At the start of each visit or teaching session students were asked to complete exercise 1 to benchmark their perceptions. They were again asked to complete this at the end of the sessions to show variations in hazard risk perceptions based on a taught session. Exercise 1 was analysed to show how students of different gender perceived hazards in each school, and how hazard perception varied by student home location. During each exercise 1 students placed disks to represent the following hazards: Hurricane, Flood, Earthquake, Volcanic Eruption, Landslide and Tsunami as these were judged to be most relevant risks at each location (chapter 4). Students also placed a disk to represent the risk of car accidents which is a prominent ubiquitous risk across the island, which is something that all students would be familiar with; this acted as a benchmark for the relative perceptions of the other disks and was felt that this value would not change much during the study period. Exercise 1 formed the key focus in the understanding of relative disaster risk over time and how this changed in response to disaster events and as students got older. As part of the analysis, it was also important to understand spatial changes in relative risk to determine whether national efforts to reduce disaster risk were relevant to different groups of local people.

Exercise 2 showed how students perceived their learning about hazards. This information is important to understand the origins of student risk perceptions. Within each community it helped determine the extent to which school education was the main source of information or how students prioritised other learning methods. This is particularly important when preparing DRR teaching resources to increase the likelihood of student engagement. Students were given the options of TV, Radio, Internet, Family, Church, School, Red Cross or the Office of Disaster Management for learning.

Exercise 3 was an attempt to understand how they would react in the face of a hazard. This also determines the extent to which government messages or actions are followed by the students. It also attempts to understand whether authorities play a greater role in safety compared to the role of the family. Students were given the options of (Immediate) family, relatives, Church, Community, School, Emergency services, Red Cross or Office of Disaster management. The original intention was to collect this data but owing to data loss and time pressures this exercise was not analysed throughout the longitudinal study and therefore will not be reported on (**section 3.5**).

For exercise 2 and 3 the Red Cross and the Office of Disaster Management were included as organisations as these represented the main known DRR organisations in Dominica.

3.3.4. An alternative version of PRISM – Paper PRISM

As suggested in **section 3.2.1 and 3.3.2** pilot testing in of PRISM presented disadvantages, namely concerns about timing. During these visits one interview could range between 15-20 minutes per respondent, plus additional time for the questionnaire, thus providing a challenge with student groups of 20-30 students and only one interviewer. Pilot testing and initial use of the method in the study area showed that interviewing 30 participants would take more than 6 continuous hours of face-to-face surveying with one interviewer. The school day was 5 hours (8am-1pm) in most schools therefore, limiting the number of student surveys. Therefore, a revised version of PRISM was employed after this between 2015-2018 to overcome the issues faced in 2013-14 and allow for teaching educational sessions in later years. To collect data from class groups an adapted PRISM survey (Paper PRISM) was developed. Fundamentally this approach allowed for mass testing of students, significantly reducing the time taken to conduct the study. This was important for maximising the use of time with the students but had the limitation of not being able to interview the students one-to-one, therefore increasing their need to express their views in written format.

This therefore has potential problems for students who have learning difficulties or felt unable to express their views concisely within the time given.

Since the original PRISM method had already been tested on the cohort of school students being investigated in this study, the new adaptation of the PRISM method was kept as close to the original as possible to maintain comparable data sets over the study period, accepting that the difference in approach was not entirely consistent with the original. After further pilot testing with UK secondary students changes to the colours and sizes of the disks were made in line with other studies (Higginson and Carr 2001). The new method (Paper PRISM) differed from the original approach as instead of a magnetic board with disks (**outlined in section 3.3.1**) an A4 piece of paper with the same dimensions as the PRISM board and the same positioned “*self*” marker was used, with circular-coloured stickers (1cm in diameter) instead of the original 5cm disks. The colours of the disks were kept the same, where possible, as colours as used in the earlier tests.

Each student in a group was issued with the A4 piece of paper and a set of stickers (in place of disks) for each exercise (**Figure 3.6**). Class groups undertook the exercises simultaneously but individually thereby avoiding instructional bias, variation or to stop collaboration. As it was no longer possible to record disk placement justification, participants were encouraged to annotate their PRISM board to justify their placements. Participants were able to reconsider the positions in which they had placed their stickers by drawing an arrow to a new position on the board. This was important after educational sessions as students could change the placement of stickers without having to complete another Paper PRISM exercise. Students were encouraged to further annotate and was also possible on the front and reverse side of the paper. While this change in method allowed for the original principle of the PRISM exercise to be conducted, the reliance on written explanations was a limitation as students' different learning needs limited the explanation of all hazards. This concentrated student responses on the disk (sticker) positions placed ‘most’ or ‘least’ distance from “*self*”. After Paper PRISM exercises were collected, student names were anonymised to conform with the ethical considerations of the study. Therefore, all student references in the data appear as code. All PRISM data is found in supplementary files shared here: [PRISM data](#). Guidance to these files is found in Appendix E.

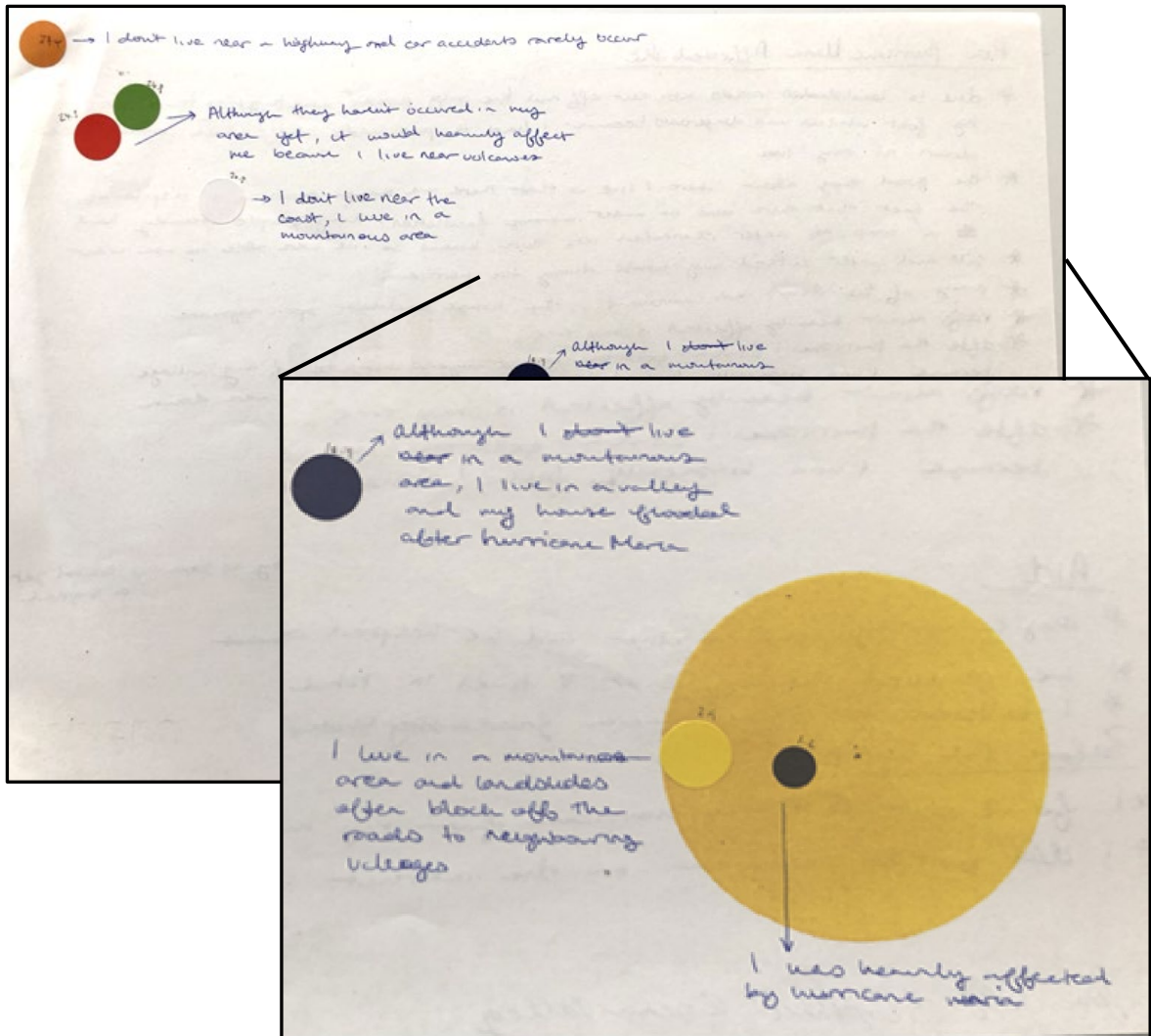


Figure 3. 6 An example of the 'paper' PRISM activity used post-2015.

3.3.5 Qualitative PRISM perceptions

This section will briefly cover the detail of collecting the qualitative element of the PRISM study. Between 2013-2014 student's justification for disk placement was made using a Dictaphone / smart-phone recording. Students justified reasons for their disk placement and explained the relative placement of disks for exercise 1. This helped understand the extent to which they understood the hazard and allowed them to explain why they chose the placement of the disk, often closest or furthest from self. A more systematic approach to assess each disk placement would have been preferable, however, time constraints in completing each exercise and a lack of familiarity or willingness to share information may have contributed to short answers from some students. After 2014 students used the Paper PRISM method, requiring students to write their justifications of disk

(sticker) placement. This inevitably led to students giving reduced detail in their comments but enabled students to express their views more personally and anonymously, as some found the one-to-one interviews intimidating. Comments are found in the supplementary files: [PRISM data](#).

This method enabled quicker collation of results but lost the depth of information gained from personal one-to-one interviews. The postproduction measurement of SHS values and angle was quicker per participant. Despite concerns about altering approach after 2014, comparative results show little variation in disk placement of ‘paper PRISM’ values, relative to that of the board PRISM values (**Table 3.2**). Students adapted to the new method with limited need for explanation. The use of annotations on the board helped express participant views, however, there was concern about the ability of some individuals to express themselves and re-evaluate their disk position.

Table 3. 2 A comparison of the two PRISM methods

	Response rate	Board dimension/ disks	Recording information	Process timing	Consistency
Original PRISM	Current rate of 1 respondent per 20-25 mins, so very small samples sizes	A4 board with 5cm diameter disks	Use of voice recording to capture interview	20 minutes per interview and 1-2 hours of data processing	Followed the same procedure as Sensky and Buchi.
Paper PRISM	Can sample multiple respondents simultaneously	A4 board with 1cm disks	Written annotation on paper board	15 minutes per PRISM board and 2 hours of data processing	Disk size may alter perception of distance on the PRISM board; but limited evidence of this in our testing.

Section 3.2.6 outlines the details of the visits to collect the data. Owing to time constraints with each group of students allowed outside of their normal class time, placed upon us by the principals of the school, different sample sizes were collected on each visit. In some cases, an inability to visit on consecutive days also meant that some students were absent from visits. This was more of an issue after Tropical storm Erika (2015) and Hurricane Maria (2017).

3.2.5 Using PRISM to address the criticisms of perception data collection.

The choice of the PRISM method was made to address some of the challenges with conventional perception data methods, notably questionnaire and interview (**section 2.9**) . This section outlines how this study attempted to address some of these issues. **Table 3.3** summarises some of these issues and gives information on how the use in this study addresses them.

Table 3. 3 A summary of how PRISM addresses issues from risk perception studies

Issue	How PRISM addresses issue	Reference
<p>Bias</p> <p>Use of quantitative measures perceiving risk are subject to bias through assigning risk values.</p>	<p>Students conduct the PRISM exercise alone and are subject to their own heuristics and biases but not from copying others. Students are informed there is no correct answer, and they are free to express their perceptions.</p>	<p>Shreve and Kelman, (2014)</p>
<p>Likert scale modelling</p> <p>Likert scales do not allow for absolute risk values – they represent categorical data.</p>	<p>Use of a scaled approach between defined parameters (0-27.5cm) allows for relative quantification. However, PRISM does not allow for expansion beyond the maximum of 27.5. Is there a question regarding the validity of relative magnitudes associated with disk placement?</p>	<p>(Sjoberg, 2000)</p>
<p>Framing</p> <p>Face-to-face interviews are subject to interviewer framing or prompting.</p>	<p>PRISM is undertaken by the participant at their pace. The interviewer only asks questions to prompt explanation of the disk placement, limiting the opportunity for framing or prompting.</p>	<p>Kahneman, (2011) Sjoberg, (2000)</p>
<p>Use of appropriate language.</p> <p>Use of language unsuitable for intended audiences e.g., technical terms / assumed understanding</p>	<p>PRISM concept is not based on language, other than instructions. These need to be explained clearly from outset explaining the meaning of words. Children have successfully used the PRISM method down to the age of 11 without misinterpretation.</p>	<p>Bird, (2009), Johnson et al, (2014)</p>

While the PRISM method lacks the ability to ask a range of questions like conventional interviews and questionnaires, its construction is designed to allow for targeted data collection of perception by allowing collection of quantitative data on a continuous scale. It therefore avoids the pitfalls of

Likert scale data (Knapp, 1990, Jamison, 2004, Carifio and Perla, 2008, Bishop and Herron, 2015, Farinella et al, 2016) in understanding the use of scaling between data collection points. It also allows an approach for students without complex language which is participatory and therefore engaging. While all questioning is subject to some bias, it allows for limited input from the interviewer therefore limiting the potential for bias.

3.2.6. Sampling using PRISM.

As outlined in **section 3.2.3** permission was given by the Ministry of Education and principals to complete this study with Dominican students. This section outlines the breakdown of the students who agreed to participate in the study. **Table 3.4** shows the sample for each school. Student numbers are given for each visit and participation among the sample varies based on absence, sport fixtures, independence celebration preparation (in October visits) and the impact of Tropical Storm Erika and Hurricane Maria.

Table 3. 4 Numbers of students sampled for PRISM in each visit.

School	Students sampled							Total Prism sample
	Sample size	2013	2014	2016	2016 (Oct)	2017	2018	
1	32	3	23	26 (26)	25	30 (30)	26 (26)	215
2	20	3	15	16 (16)	18	18 (18)	20 (20)	144
3	24	6	12	24 (24)	22	24 (24)	17 (17)	170
4	30	3	13	30 (30)	29	28 (28)	19 (6)*	186

* Values for school 4 (CBS) show 19 students – however only 6 of these students were able to complete the teaching session and fieldwork therefore we have not included these results in Chapter 6 when analysing impact of educational methods.

In each school, student representation varied for a given cohort dependent on school size. The school 1 sample of 30 selected students represented 46% of the student cohort, while in School 2 the 20 students represented 100% of that cohort. In school 3 the student sample represented 36% of the cohort, while the 30 students in school 4 represented 38% of the students. School 1 had a 100% female student group, but the other schools were mixed gender. School 2 and school 4 had a 50% gender split, while school 3 had 46% males. This was an attempt to be representative of the gender split in each school as school three had slightly more females (52% in the school population). School 2 included the entire cohort, but males were more dominant in other year groups (61%

males) while in school 4 the split in this study was reflective of the overall split, with 53% girls at the school. It was more difficult to accurately represent the school population in terms of student home location. While most of the sample in school 1 came from the immediate Roseau area this was chance, based on the parental agreement. In school 4 there was some reluctance of students from Kalinago backgrounds to join the study. The school has a Kalinago population of approximately 32% but in this study only 23% of the sample group were from the reserve. In school 2 many of the students come from expat communities, residing in more affluent upland areas or in more expensive Roseau suburbs. This represents over 70% of the school population yet for this study 65% of the group came from these areas. In school 3 there is an equal split between those local and those from outside villages (40/60%). In this study only 33% of the students were from the local area. Attempts were made to make the sample representative of the local school population, but it was ultimately dependent on student and parental willingness.

Reduced sample sizes in 2013-2014 reflected the time constraints of the one-to-one interviewing. However, during the 2013 data collection period 5th form students were interviewed (intended as a control) to allow for comparison with the sample group after their 5th form. Due to the reduced sample sizes, the 2013 values are omitted from the analysis.

While the constraints of small sample sizes are documented (Kahneman, 2011) this study sought to collect successive samples from the same individuals longitudinally. This approach is not well documented in other DRR studies, and not at all for multi-hazard studies. The Dominican Ministry of Education gave permission for one group per school to be part of the research; while it would have been advantageous to target a wider range of schools, it was not feasible within the time constraints of each visit, as each visit was conducted within UK school holiday periods outside of the school holiday schedule for Dominica. This study, therefore, unlike no other child perception study, allows us to understand relative changes in perception over time through repeated data collections.

The original intention of the study was to conduct a parallel control group in each school to determine the effectiveness of educational measures employed between 2015-2018. As the Ministry of Education and school principals only allowed one sample group per school to limit impact on student education. The original intention was to compare perceptions of school leavers (5th form) in 2013 with the 5th form perceptions of the sample group. It was also the intention to compare 1st form data (from 2013) with new 1st form students in 2018. This would allow for comparison groups in each school who were not part of the study. The control group was limited by two factors; i) issues with PRISM data collection time resulted in relatively small numbers of 5th form students were collected in 2013; ii) the first form values in collected 2018 were influenced by the

event of both Tropical Storm Erika and more likely by Hurricane Maria which therefore does not allow for like for like comparisons between 1st and 5th form groups. While the comparison with control groups is made in Chapter 6 there is recognition of the limited validity of these comparisons between the sample and control groups.

One other intention was to compare the perceptions within sample groups of these students who had opted for geography and those who had not. However, as the same student sample was used through the study, it was not possible to get reflective numbers within the sample who opted for Geography from the outset. It would be advantageous to make comparisons between students' risk perceptions of those who had studied Geography at CSEC compared to those who had not, to see if the existing Geography CSEC content altered perceptions of disaster risk.

3.2.7 The novelty of the PRISM method

Using PRISM is an alternative to traditional questionnaires and offers many positives. This section summarises these and identifies the differences from standard methods of survey techniques.

The use of the method is straight forward and like other studies outlined in **section 3.3.1** it is quick to understand and limits the need for understanding terminology and communicating in written form. This is particularly beneficial for people of different socio-economic status and for children who may not have the education to fully understand questionnaires. The placement of disks on the board allows for a bespoke representation of importance (perception). Unlike Likert scaling, it allows for a relative comparison of scoring, relative to self. The inclusion of the “self” circle allows the participant to show the extent to which, for disaster risk, whether they have been personally affected. This is significant in understanding the context of a disk placement and perception score.

The placement of disks allows a potential scale from 0-27.5cm from “self” thereby offering a much larger scale, than Likert. The spatial nature of disk placement may also infer the level of optimism regarding how an individual feels about their placement. Including the angular nature of the disk placement gives this information and therefore makes the quantitative data more than just a 2-D sliding scale, like the Likert data.

The repeated use of the method allows for consistency in approach. This consistency breeds familiarity with the participant which, over time, reduces the need for extensive exemplification as users quickly remember the concept. Using the disk placements from each time series allows for visual snapshots of perceived risk. This has allowed for a longitudinal picture of an individual's

perception and can be compared with fellow users or experts. As the nature of risk is not fixed, the use of this longitudinal approach allows for a constant reassessment of the relative understanding of risk, which is important in a multi-hazard environment. This study used this approach to understand the relationships between high and low frequency hazards to determine the impact of change of one on the others.

The use of interview or written justifications should be considered based on the age of the user. While this method has shown its use for younger students, the Paper PRISM method worked because of the relative age of the students, able to convey their thoughts in a written manner. When interviewing individuals, for example experts or other DRR stakeholders, an interview approach recording is preferable. This study showed that PRISM interview had the ability to elicit detailed personal responses, especially among those in governmental / leadership positions in DRR organisations. PRISM can do this because the interview asks the individual to comment on their personal reflection shown in their disk placement on the board. Such accounts were often candid and detailed and allowed the individual to talk beyond the official line of the organisation they represented. This allowed for a significant insight into how high-level officials in Dominica dealt and coped with the disastrous events. In multiple examples, when speaking to one of the directorates of DRR organisations the use of questionnaires led to responses which referred to the official response of the organisation. However, when subsequently questioned using PRISM responses became far more personalised and fed into some of the inner workings of the organisation not offered with the questionnaire style surveying. PRISM elicits a personalised approach. This is important in understanding beyond the facts of a situation, as this allowed for an insight into decision making based on both fact and emotion. This therefore is a powerful tool for researchers in DRR.

3.4.8 Fieldwork methods

This section outlines the fieldwork approaches used to understand the nature of disaster risk across Dominica. Fieldwork served three purposes for this study. Firstly, to understand the nature of multi-hazard risk in Dominica, both nationally and locally. Secondly to understand impacts of Tropical Storm Erika and Hurricane Maria. Thirdly to prepare sites for the fieldwork education sessions undertaken in 2018.

To understand the nature of the multi-hazard risk, initial secondary research was completed in 2013 to gain understanding of hazards affecting Dominica (Honeychurch, 1995, Clay and Benson, 2001, Lindsay et al, 2005, Smith and Kirkley, 2004, Smith et al, 2013). Through qualitative interviews with

local DRR excerpts, including ODM Dominica, local historians, the Red Cross further detail was collected to understand their perception of the risk linked to different hazards. During the October 2013 visit, with the assistance of Dr Simon Day, sites were identified to give evidence of past volcanic, flood and landslide events. These sites (**see chapter 4**) were local to the selected study sites of Roseau, Portsmouth and Castle Bruce. However, additional sites were conducted along the coastline between Roseau and Portsmouth, in Coulibistree, Dublanc, Layou and Jimmit where it was possible to see geological exposures and deposits. Further visits were made north of Portsmouth between Portsmouth and Capuchin and sites along the main road network between Portsmouth and Castle Bruce. During the 2013 visit a similar process was undertaken at each site. Field notes were recorded into a field notebook, annotated sketches were taken to describe features and photographs were taken. The key focus of recording data included geological structures, sedimentary logs of exposures to understand past events, and field relationships. A summary of approaches followed are detailed in Coe et al., (2011) and Barnes and Lisle (2008). Subsequent visits allowed repeat visits to sites. During the April 2016 visit further visits were made along the central road network from Atkinson to Ponte Casse, at sites along the west coast between Roseau and Portsmouth and along the road from Loubiere (south of Roseau) to just outside Petite Savanne to assess evidence for damage created by Tropical Storm Erika. During the 2016 visits photographic evidence of Tropical Storm Erika impacts were collected near roadside locations to understand the impact on infrastructure and local settlements. Some parts of the southern side of the island, particularly Petite Savanne, were inaccessible despite being one of the most damaged areas. Secondary evidence was collected from local recollections.

Hurricane Maria impacted Dominica in September 2017. As part of a NERC grant (*NE/RO106968/1*) to assess the geomorphological change Dominica, the University of Portsmouth sent a team of researchers to the island in February 2018. Illness prevented my participation in this trip, however, two further visits in April 2018 and October 2018 helped participation in the re-assessment of damaged areas post hurricane. The assessment was two-fold, firstly to conduct questionnaires amongst local people in the locations of the school study and secondly to conduct ground-truthing assessments to verify geomorphological changes represented by drone and remote sensing data. This was largely conducted in Portsmouth, Roseau, Bellevue Chopin, Grand Bay and along the west coastal road near Canefield and Coulibistree under the guidance of local volcanologist Robert Watt and Dr Carmen Solana. While this was not directly relevant to this study, information collected during these visits helped develop the impact of disaster risk at locations across the island. To allow completion of the fieldwork booklets used for the educational session's fieldwork was conducted locally within Portsmouth, Castle Bruce and Roseau to formulate relevant sites. Data for these

education booklets were conducted based on initial visits and with the help of Dr Simon Day during his part of the February 2018 visit. The field guides were written initially by Dr Simon Day and then amended for use with students by the author (Appendices B -D). The routes were all verified and checked for logistical purposes before use with school leaders.

3.4 Qualitative methods.

In this section details are given of the other qualitative methods used to collect data from DRR professionals and a summary of the educational methods. Interviews were conducted with DRR professionals to understand the provision of DRR and DRE in the local communities (**section 3.4.1**). Assessment of existing DRE materials and provision were made as a benchmark of understanding from which the taught sessions could be planned (**section 3.4.2**). The

3.4.1 Interviews with DRR professionals

To understand how organisations and professionals involved in DRR worked to improve disaster risk awareness on Dominica interviews were conducted with the officials and ‘experts’ who worked in disaster risk reduction or within education. The schedule of these interviews is shown in **Table 3.1**. All interviews were either recorded by phone or notes were taken to summarise the key ideas. These notes were subsequently paraphrased or transcribed. Although the intention was to interview the same representatives from the Office of Disaster Management, Red Cross, school representatives and local experts each visit, it was not always possible. Therefore, meetings were conducted with these individuals during each visit subject to availability, resulting in an ad hoc approach to sampling experts. For each meeting, a similar interview methodology was adopted. The sessions were designed to give open ended responses rather than structured questions, allowing respondents the opportunity to elect detail. Interviews lasted between 45-90 minutes dependent on the extent of feedback individuals were willing to give. The interviews (Appendix F) followed a similar structure each time, detailed below:

- What events have happened in location x since the last visit and how has this changed your perception?
- An update on disaster risk reduction programmes / work undertaken by the individual since the last meeting.
- An opportunity to evaluate programmes / risk reduction methods.
- A PRISM activity.

Interviewing the same groups of people over the period of the study allowed for personal associations to be made between the interviewer and the interviewee. This was important to build trust and develop a willingness to speak openly, which is not always possible with one-off visits. This approach allowed for a consistent reflection on the changing nature of DRR on Dominica since the previous visit. It also allowed for a PRISM activity as the DRR professionals were considered local experts, despite their varied experiences. PRISM values were collected during only some interviews it was not possible to gain longitudinal changes in their views of individual DRR professionals. Therefore, individuals working in DRR from each location were collated for given time periods to represent the views of collective 'experts' working in DRR in Dominica in each location. As there are few working in DRR in Dominica these samples were small, underlining the problem of collecting perception values from professional experts.

3.4.2 Educational methods for DRE

To understand the impact of different educational approaches based on the pedagogies outlined in **section 2.82** and the UNESCO report recommended teaching approaches for DRR (**table 2.3**) it was necessary to design educational resources and adopt different educational approaches to assess which were more effective at improving understanding of different disaster risks. This would help understand one of the key objectives, to understand the impact of educational methods on student perception in a disaster risk context. The UNESCO (Kagawa and Selby, 2012) report outlines recommendations for educational approaches in DRR:

- I. Involve decision making and participation.
- II. the use of large sample groups.
- III. use of child focused resources.
- IV. include learning opportunities for resilience and recovery.
- V. establish links with local NGOs.
- VI. develop long term research.
- VII. incorporate different learning styles.
- VIII. develop focus in less developed countries.

In testing the effectiveness of educational approaches for DRR the aim of this study was to incorporate as many of these recommendations.

As the longitudinal study was planned over 5 years the teaching component was planned to take place during the period 2015-2018. To inform this teaching familiarity with the class students and styles of teaching were undertaken during 2013-2014. During each visit to school lessons were

observed and notes were included with focus on lesson structure, student / teacher interaction, lesson resourcing and delivery. During these observations, the author was able to interact with students in the role of a teaching assistant and build trust in the student group. This was important for taking over and delivering lessons in the latter part of the study as one element of student engagement is based on familiarity (Roberts, 2011)

Table 3.5 shows the provision of DRR education received by students in each school based on information observed. It was important to gain this context to understand likely student school input to DRR prior to their first DRR session in 2015/2016 (3rd form).

Table 3. 5 A summary of student DRR education in the sample schools.

School	DRR provision
1	<p>Students taught about earthquakes and volcanoes in Form 2-3 (2nd/3rd year). Students learn about the impact of hurricanes in the Caribbean in Form 2/3.</p> <p>Students selecting CSEC in Geography learn a term unit on natural hazards in Caribbean.</p> <p>Whole school – students may have outside speakers from Fire Brigade about local hazards</p>
2	<p>Students learn about hurricanes in Caribbean in Y1 or 2. Form 1-3 students learn geography but have only limited introduction to geophysical hazards in Caribbean, including a practical project on exploding volcanoes. Students in Form 4 or 5 opting for CSEC geography learn about natural hazards in the Caribbean for one term. No outside speakers.</p>
3	<p>Students in Y1-3 study social studies and do not formally learn about natural hazards except for hurricane preparation in September. Students who study Geography CSEC study natural hazards for one term. Students have biannual whole school assemblies with the fire brigade about safety. Between 2014-2015 the school students were included in a government scheme to have outside teaching on tsunami alert (Tsunami Smart scheme).</p>
4	<p>Students study social studies in form 1-3 - not formal teaching of hazards. Students who opt for CXSC study natural hazards in Caribbean for one term. Students have whole school assemblies on hurricane impact, and few have taken part in CERT training methods.</p>

Between 2015-2018 the plan of teaching each group of students 3 sessions, equivalent to 1 - 1.5 days of teaching, focused on three teaching approaches which had seldom been studied, i) interactive, ii) surrogate and iii) field-based (Kagawa and Selby, 2012). The design of these sessions was to deliver DRR education in a regional or local context. As a qualified teacher the author was able to deliver each session in the same way to each student group, although all methods were

carefully discussed with local teachers first. This approach benefited from consistency in approach but was limited by time allowed in each school.

Three educational sessions were taught during April 2016, April 2017, and April 2018 using the same student groups in each school. Each session had a focus of improving student awareness of multi-hazard risk, contextualising local risk. Session 1 aimed to identify and compare local disaster risk with wider global trends using an interactive teaching approach. Session 2 aimed to develop an understanding of local and regional hazard risk with a focus on mitigative approaches, using a surrogate teaching method. Session 3, aimed to assess the local hazard risk and evaluate designated safe zones, using a field-based teaching approach. Before each educational session PRISM SHS scores were measured to quantify hazard risk. This was repeated directly after each session. This change was used as a measure of impact to show the perception values based on individual experience (Wachinger and Renn, 2010, Wachinger et al, 2013). This approach helped understand the short-term perception change in respect to each session, however, it did not quantify any further change in perception in the period following the teaching intervention. All references to students' names and schools were anonymised for the purpose of the study.

Specific details of teaching and resources for each session are given in Appendix A. Each session aimed to build on the recommendations set by past studies (Ronan and Johnson, 2010, Ronan et al, 2012, Kagawa and Selby, 2012, Johnson et al, 2014, Ronan, 2015, Ronan et al, 2016, Kagawa and Selby, 2015, Amri et al, 2017a, Amri et al, 2017b).

Session 1 (conducted in 2016) was based on the interactive learning style (Kagawa and Selby, 2012) to raise discussion about the perceived differences in the perception of local disaster risks and global trends. Students worked in teams to construct disaster profiles for different locations using existing data. These were presented back to the group and points were allocated to foster a competitive element to the session. Students were encouraged to challenge the views of each other and justify their choices of data selection for the disaster country profiles. While this was a class-based approach the format was different to the traditional teacher led session. The aim of the session was to evaluate disaster risk in Dominica through a global context of disaster risk. The session was student centred and incorporated the principles of Anderson and Krathwohl (2001) to synthesise, evaluate and create based on existing data. The discussion element of the session allowed development of student voice on disaster risk in each group.

Session 2 (conducted in 2017) was based on the surrogate learning style (Kagawa and Selby, 2012). The session aimed to raise the awareness of disaster risk in Dominica, and the wider Caribbean, through self-assessment and evaluation of resources. Students worked in pairs or small groups (up

to 4) and were given time to explore a range of resources which linked to DRR in Dominica or the wider Caribbean. These included:

- I. Top Trumps card game, including Caribbean volcanoes – students played the game and tested each other on the volcanic facts relating to each volcano.
- II. Storybooks, produced by CDEMA, designed to educate children on tsunami risk in the Caribbean – students considered the relevance to their lives.
- III. Disaster Risk maps – a series of maps of disaster risk in Dominica – students had to assess the maps and decide on relative risk in different areas.
- IV. Risk awareness leaflets – students used existing leaflets and posters from ODM and local NGOs to understand the messaging and determine the accessibility of information.
- V. 'Earth Girl App' – students played the app which required them to work through timed simulations to prepare a population for an impending tsunami based on a set budget. Tsunami simulations were run, and death rate data indicated the success of the plans.
- VI. Infographics of multi-hazard risk – students discussed the infographics and explored their messaging and made suggestions for improvements.
- VII. Disaster plans – students worked through disaster planning and discussed their personal approaches, identifying their own strengths and weaknesses.

At the end of the session each group was responsible for evaluation of a resource leading to class discussion. This was followed by an evaluation exercise where students gave qualitative comments on the resources based on i) their level of engagement; ii) the personal use in DRR mitigation and iii) community use for DRR. This student-centred approach was developed around Bandura's and Vygotsky's social learning approaches (Aubrey and Riley, 2019), whereby interaction with stimuli and opportunity to discuss, ask questions and build knowledge was based on social interactions.

Session 3 used a field-based approach to assess the student perception of safe locations locally, in the context of different disaster risk (Kagawa and Selby, 2012). This session encapsulated the principles of Kolb's experiential learning methods, through engagement with the environment to apply knowledge and understanding and aid decision-making (Kolb, 1984). Students were given the opportunity to engage with a local expert on hydro-meteorological and geophysical disaster risk in a local context. They recorded their perception of safe locations, in response to different disaster risks in their local area. A fieldwork tour of the local area followed, to assess evidence of the different hazards faced in the Roseau area, giving students the opportunity to ask questions and discuss observations. Following the trip, students re-evaluated their original estimations of perceived safe

zones based on their experiences of the trip and the discussions with the local experts. The author was responsible for the delivery of all the teaching sessions to eliminate inconsistencies, though material used was in collaboration with ODM, DRC and local staff. All sessions assumed limited DRR educational input prior to the sessions and were designed to differ from the observed traditional approaches to teaching in each school. The aim of these sessions was to address some of the recommendations made by the UNESCO report (Kagawa and Selby, 2012). **Table 3.6** outlines how our use of educational approaches to DRR attempt to address these recommendations.

Table 3. 6 Educational approaches for disaster risk reduction (after Kagawa and Selby, 2012)

Recommendations for	Links to our study programme
Involve decision making and participation	All sessions involved decision making and participation - students worked in self-led groups.
Use large sample groups	The nature of our longitudinal study and conditions from the MoE and school principals meant that sample sizes were still small.
Use child-focused language in all resources	All materials were pre-checked by secondary school teaching staff to ensure suitability for the age group
Include resilience and recovery as well as knowledge-based learning	Session 2 and 3 had decision making and evaluation which can be used to improve contextual understanding of risk in each location.
Work with NGOs to create links between top-down and bottom-up learning	Work was conducted with the assistance of the Dominica Red Cross and help from local experts.
Develop child centred approaches which are evident in wider community	Sessions were child-led, but with teacher facilitation.
Develop long term research	A 5-year longitudinal assessment of risk perception and teaching sessions conducted over 3-year period.
Incorporate different style of learning from multiple sources	Dynamic and varied teaching styles were chosen which differed from standard Dominican approach.
Develop a focus of study in less developed or emerging countries	This study was conducted in Dominica, classified as a middle-income country (MIC).

3.5. Adjustments to methodology

During the study period several changes impacted the schools within each study area. **Table 3.7** summarises the key changes and the impacts on the schools within each area and had an influence on the results.

Table 3. 7 A summary of impacts during study period.

Date	Impact	Impact on study areas
April / May 2013-2015	ODM tries to set up hazard awareness week. Stopped in 2015.	Increased radio broadcasts across the island which feedback to students across all schools.
2014-2015	ODM / CDEMA introduced the Tsunami Smart scheme with pilot scheme in the north of the island (Portsmouth). Students from select secondary schools are given talks from ODM officials and workbooks to improve their understanding of tsunami risk.	Potential impact on student understanding of tsunami risk in school 3. None of the other schools are included in the scheme.
September 2015	Tropical Storm Erika. An intense rainfall event occurring between midnight and 7am. Produced greatest impact on southern villages on island with notable landslides and flash flooding in Petite Savanne – leading to the collapse of properties and loss of 18-21 people.	Roseau schools affected by flooding adjacent to the river. The main routes into the city, and bridges suffered damage cutting access. Bailey bridges were installed along the main highway. Minimal impact on Portsmouth. Access south of Portsmouth was cut due to damaged bridges. Landslides in upland areas block access routes to schools.
November 2015 – April 2016	Change in the leadership of the ODM post Tropical Storm Erika. ODM leadership and staffing replaced. Head of Met. Department given role as acting leader of ODM with support from previous ODM leader. This change led to reduced contact with ODM.	Little impact on school provision as ODM until this point had not visited schools directly. Movement away from community-based policy towards top-down approaches.
October 2016	Seismic activity – 5.6M earthquake SW of Roseau. Minor structural damage across the island mainly felt in the southern part of the island.	Students in Roseau and Castle Bruce would have felt light shaking to their properties.

March 2017	5.8M earthquake in March 2017 SE of island between Dominica and Martinique.	Seismic activity noted along the east coast with some locations across the island experiencing shaking.
Hurricane Maria	<p>100% impact across the island. Island largely inaccessible between September 2017 and February 2018 as flight services were cut.</p> <p>Chief Education officer steps down from their role in early 2018.</p>	<p>Damage to communities across the island. All schools shut between September and April to the whole school community.</p> <p>School 1 – suffered structural damage rendering part of the ‘old building’ out of use. 5th form students invited back from early November. Staggered return with focus on exam groups until the whole school opening in April 2018.</p> <p>School 2 – lost part of the building – losing staff room, one classroom, kitchen and store area. School reopened in late November / December to exam groups. Full school return by March.</p> <p>School 3 – Loss of temporary classrooms in the courtyard – replaced with tents. Students invited back from late November / December with focus on exam groups.</p> <p>School 4 – little damage to school building – but school used as a shelter. Last families left shelter in March 2018 which meant partial reopening of school after cleaning up. 4th & 5th form students invited back in January – but access for students using school transport (from indigenous areas) was limited until March/April 2018.</p> <p>All schools were offered psycho-social support and training for staff and students starting from February 2018.</p>

The impact of the events in **Table 3.7** had some influence on the methods undertaken. By the April 2016 visit, most of the main routeways had been reopened with ‘Bailey bridges’ meaning that access to the schools was possible. Students missing from the sample groups between 2014-2017 were a

result of absence on the days of visit. Although data was collected from students in April 2016 much of the trip was given to visiting sites of damage across the island. This restricted meetings during this visit.

Hurricane Maria caused widespread damage across the island and therefore cancelled the proposed visit in October 2017. However, an opportunity to visit the Caribbean was still possible to meet with CDEMA to understand the response to Hurricane Irma and Maria. A planned visit in February 2018 was cancelled due to the author suffering from flu and being ordered not to travel by medical staff, delaying the visit until April 2018. Hurricane Maria caused students to leave the island, and some did not return to school. This caused a reduction in sample sizes of groups at almost all schools. Some of the principals also could not gain permission from students to conduct the fieldwork and practical activity session in 2018 therefore these trips were conducted with the full sample in school 1 and 2 and a small number of students from school 4. None of the students from school 3 were able to attend the trip. Fieldwork sessions were further complicated in schools 3 and 4 by staff reluctant to allow students away from classes owing to study time missed prior to their final CSEC exams in May 2018. The impact of Hurricane Maria meant that some of the planned itineraries for the fieldwork visit were no longer possible due to restricted access or damage. Therefore, with the help of Dr. Simon Day (visiting in February 2018) new planned sites were made around the study location areas, which were adapted for the field guides for each trip (these are detailed in **Appendices B-D**).

Other key changes to methodology included the change in the PRISM approach used between 2014 and 2016 visits as previously outlined (**section 3.3.4**). This change did not cause significant change in outcomes during this time as the principles of the board remained the same. Most notably was the change in disk sizes from 4cm to 1cm.

Due to the time constraints in undertaking each PRISM exercise beyond 2014 (post Tropical Storm Erika), all results from exercise 2 were conducted using a ranking method rather than PRISM. While this approach gave relevant results to understand about how students learnt about hazards the approach was not consistent. Despite this the information for the ranking was valuable and helped understand student preferences to learning which helps understand how to best communicate messaging around DRR. The results collected do form part of the analysis and give insight into how DRR messaging should be conducted for a student audience.

The result of time constraints noted above also resulted in Exercise 3 not being completed after 2014. Information collected during 2013 and 2014 meant that this exercise was often the one which was incomplete. As a result, initially of Tropical Storm Erika, the focus of PRISM exercise 3 was no longer valid as intended. The intention of this exercise was to understand who student perceived as

important in a potential disaster scenario. The events of Tropical Storm Erika followed by Hurricane Maria meant that students could comment on the impact of these events rather than giving their perceptions of it. Early results from the 2013-2014 samples showed that family and local community were the most important perceived sources of help after a hazard. This proved to be true after the events in 2015 and 2017 based on comments made by the students. This provides an important contrast between local support and national support after a disaster event. These initial results could provide an important pilot for future studies to determine the importance of community vs. national support systems pre and post disasters.

As a result of the two disasters impacting the island during the study period (Tropical Storm Erika in 2015 and Hurricane Maria in 2017) DRR agencies were put under stress. Therefore, changes were made to the management of both the major DRR organisations on the island (the ODM in 2015 and the Red Cross in 2017). Since the initial visit in late 2012 relationships had been made with each team. New management in each organisation changed the dynamic of the working relationship. After Tropical Storm Erika, new management at the ODM were difficult to contact as they sought to establish themselves in their new roles. Therefore, although it was possible to gain an initial interview with the new ODM staff in 2016, they were unavailable on subsequent visits. Similar changes occurred to the Red Cross after 2017, however, interim management between 2017-2018 and new management from 2018 onwards were open and content to continue the existing working relationships. This left a lack of balance in understanding the operations of both organisations which made it more challenging to triangulate information on national approaches to DRR on Dominica.

The result of Hurricane Maria, and to an extent Tropical Storm Erika, meant that the perception of students was potentially influenced in a way not anticipated from the outset of the study. While this provides data to show how such events have an impact on perception, they do not represent the intended impact of perception over time under 'normal' conditions. The impact of both events, but notably Hurricane Maria led to greater exposure to hydro-meteorological hazard impact compared to a period without. Therefore, this impact will have influenced perceptions. It was not possible to determine this effect because all students were impacted therefore it was not possible to conduct a study with control not affected. As Maria had such an impact on the social and economic status of Dominica it is also difficult to compare the differences between those who studied geography and those who did not – as all students will have been exposed to the impact. Therefore, this study will not assess this difference but will compare the impact on gender and location to assess differences there and look at the impact of disastrous events in a longitudinal sequence of perception of multi-hazard.

The creation of educational material was influenced by the impact of Tropical Storm Erika and Hurricane Maria. These events needed to be acknowledged in both sessions 2 and 3 respectively, while trying to maintain the original plan of teaching; a comparison of global hazard trends with Caribbean (session 1), multi-hazards affecting Dominica (session 2) and multi-hazards at each school location (session 3). The influence of these events will inevitably have altered the benchmark perceptions of students especially in 2016 and in 2018. However, without a control group it was difficult to compare the impact of events in locations affected versus those not. Therefore, this study compares the inter hazard relationships as a result of the disaster events and also compares perception levels across the study period to understand the extent of change caused in perception as a result of the events.

After Hurricane Maria (from June 2018) Israelaid started working with the Ministry of Education to initiate a whole school training and assessment of Disaster Risk Reduction in schools. The results of these changes would not be evident in the data collected from the sample group, however, will have influenced the 1st form students (data collected in October 2018) therefore creating further problems of control comparison with those of the sample group. The results of October 2018 students were included for control purposes, but the validity of these results is commented on in the analysis chapter.

3.6 Unused data from this study.

This section aims to summarise some of the data collected which will not appear in this thesis but is intended to give the reader an understanding of the work undertaken during the study and the potential use of this research data for future study. This data is divided into the themes, i) field data, ii) PRISM data, iii) qualitative data iv) data collected in response to disaster events.

3.6.1 Field data

This study set out to understand the risk associated with multi-hazards in different locations across Dominica. Initially this data was collected using secondary sources, which are summarised in **section 4.5**. To ground truth this evidence field studies were conducted to find geological evidence of deposits or structures, or evidence of damage or management linked to past events (the methods for these are outlined in **section 3.4.8**). Much of the field evidence is not presented in this study as the focus of this thesis is largely an understanding of longitudinal perceived risk of student populations in different locations. However, many of the field notes could be used for future study. They could be used as a composite information to show evidence of multi-hazard risk in each

location. This could be used to create or present a field guide to the nature of risk in each location. This information could also be used in educational resources for students or communities to increase awareness of local multi-hazards, in the same way that teaching session 3 sought to improve the awareness of students. It is the intention to use this data to create local bespoke guides for communities in Dominica, or for use in the disaster councils, to further understand the nature of the local risk and understand their local environment. The aim of this is to further improve community understanding of local hazards so they can make appropriate preparatory action.

3.6.2 PRISM data

The main PRISM data presented in this thesis seeks to understand the longitudinal changes in perception of students. However, angular data linked to disk position was collected for each student disk placement. This extensive data set could seek to provide evidence to understand the relationship between angular position on the board and distance from “self” as suggested by Buchi and Sensky (2016). This data will be presented in a future paper to assess this relationship to analyse the extent to which angular position and distance from “self” correlate. Do students who place along the long axis of the PRISM board show greater rates of change than those on the shorter board axes? This can be combined with the student comments to understand the extent that students felt optimism or pessimism in their placement of the disk.

The data for PRISM Exercise 3, collected in 2013 and 2014 was not presented in this study for the reasons mentioned in **section 3.5**. This data gave early indications of how students may respond to seek help in the event of a future disaster (type not specified). Indications from the data collected suggested that students would preferentially seek help from immediate family if nearby, or alternatively relatives or community member (though this was dependent on community). Disaster risk agencies and national services such as the police / fire brigade did not gain favourable support. A study to assess the differences between perceived sources of help and recommended sources of help could be made, as well as comparing the perceived sources of help with the actual sources taken after Tropical Storm Erika or Hurricane Maria.

3.6.3 Qualitative data

The qualitative data included in this study focuses mainly on the actions of DRR organisations in response to both Tropical Storm Erika and Hurricane Maria. The purpose of this was to understand how these organisations dealt with the challenges presented by each event and to evaluate their performance. However, the original intention was to understand the perspective of DRR practices

from a range of DRR professionals including teachers, government officials, local disaster council members and community leaders. As a result, there are a series of interviews which were collected and not used in the presentation of results. These interviews followed the same methodology as set out in **section 3.4.1**. The data collected from these interviews would help understand the different perspectives of DRR in each community and allow comparison with the national picture created by the larger organisations, the ODM and the Red Cross.

3.6.4 Post disaster data

After both Tropical Storm Erika and Hurricane Maria data was collected to focus on specific impacts of each event. As Tropical Storm Erika was largely a rainfall event (**section 4.5.5**) it had specific impacts roads and river valleys. During the visit in 2016, GPS data was collected to show the sites of landslides which had affected the road network. At each site photographic evidence was taken and field notes were gathered to describe the damage. The routes covered included the main route from the airport to Roseau via Pointe Casse, the west coast route between Scott's Head and Portsmouth and the route from Portsmouth to Castle Bruce. Additionally, along the southern part of the island from Roseau to Petite Savanne stops were made at Loubiere, Bellevue Chopin and Grand Bay to assess the damage at each settlement. Petite Savanne was inaccessible as it had suffered the greatest amount of damage. However, secondary photographic data collected by school students who lived locally gave a perspective of the damage. Other sites such as Coulibistree and Dublanc were also visited to understand the impact of the event on settlements in confined river valley locations. This data could be used to assess the extent of damage from this event on the road network which would add to the work by Barclay et al (2019).

During the April 2018 visit to Dominica, a situational study of each school location was undertaken to understand the effects, 7 months after the event. For each study photographic evidence and field notes were combined to create a summary of the spatial variation in damage in each location. Data was collected with the help of locals who gave guided tours and highlighted areas of damage. Observations made could be triangulated with interviews from local community members taken to understand the extent of the damage. This data could be used to provide a visual representation comparing before and 7 months after to understand the variation in speed of recovery spatially across the island and within each location.

3.7 Processing data methods and analysis

This section outlines the methods employed in analysing the data collected in **sections 3.3 and 3.4** and will be broken down into three themes; i) analysis to understand the longitudinal changes in perception based on PRISM data, ii) qualitative data analysis to detail how the interviews conducted with DRR professionals were analysed for use to understand the actions around each of the disaster events, and iii) educational data to understand the effectiveness of different methods to improve student DRE awareness through contrasting pedagogic style.

3.7.1 Quantative data

To understand the longitudinal perception of students it was necessary to calculate the angular scores and distance from “self”; achieved with ruler and protractor. Recordings for each hazard were made for each PRISM exercise undertaken and the data was collated in Excel. Students in each school were assigned numbers (not in alphabetical order), and SHS values for each hazard and angular data was ascribed to each student for each session. Values for PRISM exercise 1 were averaged by class, for each hazard disk from each session. This allowed a class comparison over time to compare the differences in average perception values. Student values were then entered into SPSS and exercise 1 values were collated for each hazard in each session for each student. Additional columns were entered for gender and location to allow for comparative analysis. The rest of this section outlines how data collected in this study was analysed using SPSS version 27 using different statistical techniques:

1. Cronbach Alpha to understand the reliability of class mean of SHS values.

As the longitudinal analysis required the use of mean values (of SHS value) for each hazard it was necessary to understand the extent to which the data was valid for this purpose. The standard for assessing qualitative data is to test whether it fits a Gaussian distribution. However, Taleb, (2007) warns about the inappropriate application of Gaussian statistics with data that has “degrees of magnitude” whereby large changes are possible, for example risk perception data. Is PRISM data traditionally Gaussian? The nature of PRISM values suggests a tendency towards skewness or kurtosis (Mandelbrot and Hudson, 2004). Therefore, use of mean values in assessment of this data should be treated with caution. However, standard practice in academia and particularly risk perception is to apply standard Gaussian tools. Therefore, to understand the reliability of the mean the Cronbach Alpha test was applied to each of the SHS values, for each hazard, in each school.

Cronbach Alpha is a reliability analysis for mean values which looks at the spread of values to determine a reliability index. Nunally (1978) suggested a score of 0.7 for reliability of data use, however George and Mallery, (2003) suggest a tiered approach consisting of the following: “ $\geq .9$ – Excellent, $\geq .8$ – Good, $\geq .7$ – Acceptable, $\geq .6$ – Questionable, $\geq .5$ – Poor, and $\leq .5$ – Unacceptable”. This study will use the approach suggested by George and Mallery because of the small range of values used to generate the mean scores. Cronbach Alpha scores showed that all data for schools 1-3 had acceptable or better mean values. However, this was not the case for the values given for ‘Car’ which show low reliability scores (0.340) therefore these values have been omitted from the results and only the results for the named hazards are given.

II. Shapiro-Wilk test (SWT) – to assess whether the SHS data shows the characteristics of a normal distribution.

As this study uses mean values to assess the class averages for each hazard in exercise 1, it is important to understand the nature of the data used. Normalised data is more appropriate to use with mean values as the mean represents the central tendency of the data. The SWT is used to characterise the extent of normalisation of the data. This is important because other statistical tests which look for differences assume normalised data sets, such as t-tests. The SWT shows that if a data set has a $p = >0.05$ that this set score is not normalised (Van den Berg 2020). Van den Berg (2020) indicates that sample sizes >20 , because of the ‘central limit theorem’, will be normally distributed. This test will be applied to exercise 1 PRISM data to determine the extent of sample scores during different data collection periods.

III. Descriptive statistics to show the mean SHS values for groups in each period; the standard error of the mean to show estimated deviation within the population of the sample; standard deviation (sigma) to show dispersion of values around the mean.

Descriptive statistics allow for an understanding of the mean value. This is important when using a sample to understand how values fall around central tendency. Such statistics may show outliers in the data or information about the distribution. In this study the standard error of the mean and the standard deviation will be used. The standard error of the mean (SEM) refers to the estimated deviation of the sample mean within a population. Therefore, a larger SEM gives us less confidence in the sample mean. The standard deviation represents the dispersion of the values around the mean. Therefore, an increased standard deviation represents a wider spread of values around the

data. In the context of perception values, larger standard deviations represent a wider range of opinion around the mean value, which will take for this study as meaning less certainty of the likely risk of that hazard. Smaller SEM values reflect the variation of our sample mean compared to a likely mean in a wider population. Therefore, smaller values will give greater confidence in our mean. In this section we will comment on the confidence of hazard mean values before we analyse the change in longitudinal change in SHS values.

IV. Independent t-test (2 tailed test) to assess differences between groups within a sample population – to analyse the difference in perceptions based on gender or location.

After calculating the SWT to show extent of normalised data independent T-tests will be used to understand the extent to which there are differences between groups or sample populations. Significant differences in SHS values will allow for an understanding of difference in perception between two groups of people or people in different locations. In this study the significant differences assessed include the difference between male and female students within a location to meet the needs of the research objective to see if gender plays a significant role in student perception. The home location of students will also be compared for each school, focusing on students from a coastal location, those who live in the area nearby the school and those who live in river or upland areas. This will help determine whether all students perceive the different risks the same or whether where they live is a relevant factor on their perception.

When conducting the t-test in SPSS to determine if there are differences in perception between a given factor e.g., location, results should indicate this. The t-test gives a p-value score to determine significance. T-test scores are available in SPSS for one or two tailed t-tests, however one-tailed tests are not used for significance testing therefore in this study only the two-tailed results are presented. Two-tailed tests are more stringent and use the entire data distribution (UCLA, 2020). For this study, a significant difference is identified where the result is $p < 0.10$. As the sample sizes for each group are small relatively the true nature of significant difference may not be evident in the t-test result. Therefore, a calculation of the Cohen's d effect score is included to indicate which determines the extent to which a result (significant or not) might reflect a realistic difference in real life (van den Berg 2020). For this comparison effect scores are interpreted as: 0.2 - small effect, 0.5 – medium effect and 0.8 - large effect (van den Berg, 2020). for this study large effect scores > 0.700 are considered due to the small data set used. SPSS was used to calculate independent t-test and effect scores.

- V. *Two-tiered Pearson correlations to look for correlations between SHS values at each school and in each period to analyse the relationship in hazards risk perception between each hazard with each student group. Correlations were also calculated to show relationships between measures of student preparedness and student socioeconomic background to assess whether wealth motivates preparation.*

For this study Pearson Product correlations were chosen to look for the correlations between data because this method is used for parametric data, which is linear, which is what we are testing with the SHS data. We are testing the null hypothesis that there is no statistically significant relationship between each data set. A statistically significant result will enable the alternative hypothesis to be considered. Correlation values are given between -1 (perfect negative) and +1 (perfect positive) with values of 0 considered to be no correlation. As each correlated data set is different the calculated correlation is compared to a reference table which compares the sample size and the result to a given p-value. This will determine the strength of the correlation. For this study only correlated values which meet $p=0.05$ are statistically significant. Correlation testing was used to understand the relationships between SHS values by hazard. For example, does a high perception of a hurricane hazard have a lower perception of an earthquake. From this analysis can be gathered to determine the student understanding of different hazard types and their perceived likelihood. Correlation was tested to identify the relationship of SHS scores between sample periods. This would help understand the extent to which perceived relationships were understood temporally.

The study also analyses mean SHS values to compare the differences between expert and student populations for each school and to assess the differences between control group and sample group populations. This will help understand the gap in understanding, with high correlations showing agreement between the two groups.

Correlate data was tested to understand the relationship between socio economic group (of student) based on parental education levels, and the level of preparation made by individual student families. The notion was to test whether students with higher level educated parents had made more attempts to prepare for hazards in their location. Parental education was scored on a scale of 0-8. With 0 = no education, 1 = one parent completed primary, 2 = 2 parents completed primary, 3 = one parent completed senior school, 4 = two parents completing senior school, 5 = one parent completing undergraduate, 6 = two parents completing undergraduate, 7 = one parent completing post grad and 8 = both parents completing post graduate course. This was correlated with the number of items students had in their home (from a pre-prepared list) and any other not on the list.

Statistically significant positive correlations would show increased education was equal to greater preparation while negative correlations would indicate the opposite.

VI. Testing non-parametric data from PRISM exercise 2, using Independent Mean Samples test and Kruskal Wallis test for difference.

Data from PRISM exercise 2 was collected to understand the rank preference to learning about DRR from different sources. The 7 options for learning were ranked and these were calculated into mean values for each data collection period (during 2014-2017 as this data was not collected due to time restrictions in 2013 and was not possible to collect after Hurricane Maria in April 2018). To understand whether the mean values have changed between data collection periods, for a given learning source, the Independent Means Samples Test (IMST) can be conducted because the data is ranked and therefore non-parametric. The IMST test can determine for each learning option whether there were significant differences between each school. If so, then this means that students value the learning options differently, for example if learning by internet was preferential in 2 schools but not in others it would show a significant difference. If all students across the island had similar learning preferences, there would not be significant differences. Significant differences in mean will be shown by a p-value <0.05 . Similarly, the Kruskal Wallis test conducted using SPSS can determine the extent to which the distribution of ranked choices was similar between school locations. This principal works the same as ISMT but looks at the entire data set rather than the mean. Again, a significant difference would give a score of $p < 0.05$, while scores above this would show there were not significant differences, suggesting that student rank distributions were similar across each of the schools. This is useful for determining the extent to which learning preference is similar among contrasting socio-economic groups and could also help DRR agencies to target student learning styles specifically.

This study also sought to understand the gender differences in the learning preferences. As this required a comparison of choices made by two difference groups, the Mann-Whitney U Test was used to determine significant differences across these populations, as this test deals with only two groups of non-parametric data, rather than multiple groups as with the Kruskal Wallis Test. Significant differences were again shown by a p-value score of <0.05 for each data collection point, for each learning option. These results will enable an understanding of variance in the learning preferences between gender during each visit, for each learning option. Values of $p > 0.05$ show a non-significant difference, i.e., that students in each gender group had similar views.

3.7.2 Qualitative data

Interviews were conducted with selected DRR professionals in locations across Dominica to understand how DRR was managed through the study period to see if this had any impact on student perception. All recordings taken from interviews and from students were firstly transcribed by the author. These were then coded using principles outlined in Bryman (2016). A deductive method was used with the DRR experts to code the transcribed interviews (Sayer, 1992). Analysis of DRR experts were divided up into 3 areas: i) key activities between 2013-2015, ii) Tropical Storm Erika and iii) Hurricane Maria. For the activities between 2013-2015 only key events were coded to gain an understanding of change over time in the major DRR organisations. For both Tropical Storm Erika and Hurricane Maria thematic codes were applied to transcriptions. For Tropical Storm Erika text was coded based on i) warnings prior to the event, ii) the impacts of the event, the operation of the Emergency Operating Centre, iv) post Erika support and v) reflective comments. Using these themes helped break down the text into a timeline of events and actions to help analyse the role of the DRR organisations. The analysis of transcriptions relating to Hurricane Maria were similarly based on i) warning, ii) short-term impacts, iii) reflecting on approaches used, iv) developing resilience in Dominica. These themes helped grasp the role of DRR organisations to meet the objective of analysing their actions around these events.

The coding was completed after each visit to the island, soon after the visit. Similar approaches to coding the DRR professionals' transcripts were applied to reduce the impact of intra-rater reliability (Bryman, 2016). The methods for coding involved reading through the text repeatedly and highlighting relevant information, before reviewing the codes set to ensure their applicability to the transcripts and then deciding on the themes (Fox, 2004, Edwards and Lampert, 2014)).

Coding of student comments was conducted differently compared to the method taken by the DRR professionals' transcripts. Student data recorded in 2013 was not coded due to the corruption of the data from Dictaphone. The 2014 data was recorded using a smartphone and this method was more reliable for reviewing, despite brief comments made. The Paper PRISM approach was easier to transcribe because all comments were written onto the 'paper' PRISM board. Again, principles of thematic coding (Bryman, 2016) were applied. PRISM copies were read and from repeated reviews themes were decided. All transcriptions were made into excel spreadsheets alongside the qualitative PRISM data. The codes used for student comments included:

- i) comments about a specific event.
- ii) direct experiences of disaster risk events.

- iii) comments about a lack of experience influencing perception.
- iv) comments showing a linked understanding of different hazards.
- v) comments about family experiences.
- vi) emotions given in description of an experience or event.
- vii) references to locational context.
- viii) student perception of likelihood or probability of a future event.

While these codes are relevant for most student justifications, this approach does generalise reasons and omits unusual ideas. It does, however, allow for frequency analysis of reasoning to highlight important themes during periods of time. This allows for a thematic analysis of student perceptions through the study period.

3.7.3 Educational data analysis

To analyse the student response to the educational sessions different approaches were used depending on the task. Before all session's students exercise 1 PRISM SHS data was recorded and recorded after the session. Plotting the changing position of the disk plots for individuals enabled the production of vector diagrams. These diagrams showed the impact an educational session had on the SHS distance changed for each hazard. Mapped onto a PRISM board template enabled comparison of which hazard each session had the greatest impact on. Vector diagrams (changing positions on the PRISM board) can also be compared for each educational session, for the same hazard, to show which had the greatest impact on changing the perception. Using t-test analysis it was possible to calculate the differences in SHS value for each hazard and work out statistically significant differences.

Session 2 required students to use different teaching stations to learn about hazards. After the session students were asked to evaluate these methods to determine which was 'most engaging', 'useful for personal use' and 'useful for the community'. This data was categorised and presented as cumulative bar charts. Students comments on the evaluation form were also coded using an inductive method (Bryman, 2016). Comments were read and categories were suggested based on the responses given. These were then organised into frequencies to understand which methods were considered useful in each category.

Session 3 included a mapping exercise. This mapping exercise took place in two parts. The first identified how well students understood the location of current DRR respondents, e.g., police, fire brigade or shelters. The second exercise involved making decisions over areas vulnerable to

different hazards within the local area. Students then decided (post fieldwork) which areas would be best to locate away from the threat of each hazard. Hotspot maps were created to show where students placed locators on the map to show the differences in pre- and post-fieldwork perceptions of DRR facilities and safe zones. These were compiled to show a cumulative map for each group completing the task.

3.8 Summary

The longitudinal nature of this study meant that there were challenges in the completion of it. This section briefly builds on comments made from section 3.5 and 3.6 to outline the key challenges.

Use of PRISM – the use of this method was work in progress as the method had not, at the start of this study, been used beyond the clinical world. Therefore, adapting it for perception study while trying to remain faithful to the original use was important. Discussions with the creator of the method, Tom Sensky, helped with this. Adaptions made, moving from the traditional board approach have their limitations in reducing the ability to record individual student comments and therefore increasing the need for them to write were taken to enable data collection in the allocated study period. Building the use of PRISM into class time meant that it was a challenge to complete all exercises. This did not affect the main aspect of the study, and alternatives for exercise 2 were found, however future management of the method would be improved with a computer-based adaptation of the method, currently being written.

Disaster events – the events of Tropical Storm Erika and Hurricane Maria changed the focus of the study. These events could not be ignored, as one had an impact on half the study sample and the other affected the entire island. Therefore, elements of the study had to be managed. Instead of focusing on just longitudinal perception, it was possible to compare the change in perception because of the events, focusing on the inter-relationships between the hazards. The key change was the focus with the DRR professionals. Both Tropical Storm Erika and Hurricane Maria caused change in leadership in the DRR agencies. This led to a change in the working relationship with some of these organisations and in one case led to their unwillingness to collaborate. Therefore, the focus of the study of DRR professionals became more about the record of events leading up to and the immediate aftermath, to understand how these organisations coped at the time and their main focuses. As information about these events is both organisationally and politically sensitive it was not possible to use the names of individuals in the analysis of their comments. However, comments are taken from leaders within each DRR agency, but the study recognises the potential source of bias

for these. Trying to understand the true nature of events is therefore based on a range of contributors as data was triangulated to attempt to understand the perspectives of individuals.

Teaching allowance. Some of the school students were not allowed to participate in the fieldwork element of the study after Hurricane Maria. Accepting this missed opportunity mean that one aspect of the educational analysis could not be complete, but as the school were still willing to allow some PRISM data collection the longitudinal element of the study was able to extend through difficult circumstances. The key to working with schools in a post disaster environment is to be flexible with them and understand that your research objectives are not important in the context of the situation.

Data collation – As this study is interdisciplinary one challenge was to organise the breadth of work into an accessible means. One challenge was linking the PRISM data and the qualitative data. The most effective method to achieve this would be to look at an individual's responses to PRISM and combine these with the qualitative data. However, to collate this information and draw analysis from them the PRISM data was combined into groups, e.g., schools, gender or locations and qualitative data was coded into general themes. The attempt was then to link the themes with the groups to come up with general views. Larger samples would give a greater insight into the conclusions drawn; however, the study was restricted by the guidance outlined by the Ministry of Education and the schools which therefore limited the number of students who were to be included over the 5-year period of data collection.

The longitudinal nature – this was a study conducted by a part-time student, self-funded, while working full time in education. The limitation of funding was alleviated in part by small grants awarded by the Geographical Association and the Royal Geographical Society, however it was only with the support of the school that allowed for some freedom to change working patterns to ensure the data could be collected, particularly in periods of difficulty e.g., after disaster events. The nature of a longitudinal study needs to be carried out over a period beyond the norm given by grant funding, but greater contact with students would give a more nuanced understanding of changes in perception. It is with thanks that the local schools were so generous in the time afforded to this study and this was a product of building working relationships within each community before starting the teaching element.

Chapter 4 – Context case study - Dominica

4.1 Overview of risk in SIDS

Many studies into risk perception are conducted on areas which have been subject to one-off disastrous events, or regions with established researched programs. In recognition of the need to study disaster risk perception and resilience in developing states (UNISDR, 2005) this study will investigate longitudinal change in secondary school student disaster risk perceptions in a multi-hazard environment, on a Small Island Developing States (SIDs). This study is based in the Caribbean SIDS focusing on the island of Dominica. The UNCED (1992) defined SIDs as *“...ecologically fragile and vulnerable. Their small size, limited resources, geographic dispersion and isolation from markets, place them at a disadvantage economically and prevent economies of scale”*. The Caribbean SIDs epitomise this vulnerability, because of post-colonial political separation, spatially distributed natural resources and exposure to a range of natural hazards (Honeychurch 1995). The Caribbean islands are subdivided into two sets of islands, the Lesser and Greater Antilles (**Figure 4.1**). The Lesser Antilles, a group of 24 islands in the Caribbean Sea, form a curved chain of volcanic islands, marking the westward subduction of the Atlantic Ocean crust beneath the Caribbean Plate (Lindsay et al, 2005b).



Figure 4. 1 Political map of the Caribbean (<https://www.nationsonline.org>).

They are further subdivided into three sets of islands, the northern Leeward Islands, the larger Windward Islands, and the western Leeward Antilles.

4.2 Hazards in the Caribbean

The tectonic setting, topography and location of the Lesser Antilles islands expose them to a range of disaster risk, which are further exacerbated by a combination of poor land use, management practices and political will (UNDP, 2011). Consequently, in the past 30 years there has been an increasing loss of life and damage from hazards (**Figures 4.2-4.5**). The majority of this has come from hurricane damage, at a cost of US\$5.7 billion in between 1980 and 2010. Hurricane activity overshadows frequent secondary hazards, e.g., flooding and landslides which still contribute to a high death rate. EM-Dat (2021) shows that between 2010-2020 that 84.3% of all recorded disastrous events were hydrometeorological, of which 52% were disaster related to tropical storms. These tropical storms caused the death of 1,377 people in this period. However, isolated geophysical disasters have also inflicted significant loss of life, e.g., 23000 casualties from the Haiti earthquake 2010 or 10 deaths linked to the 1995 Montserrat volcanic eruption, leaving half the country uninhabitable (UNDP, 2011). Yet between 2011 and 2020 geophysical events only resulted in the deaths of 21 people in the Caribbean (EM-Data, 2021). **Figure 4.5** shows that as well as dealing with the impact of flood and hurricane hazards, the Caribbean islands still have the daily threat of traffic accidents.

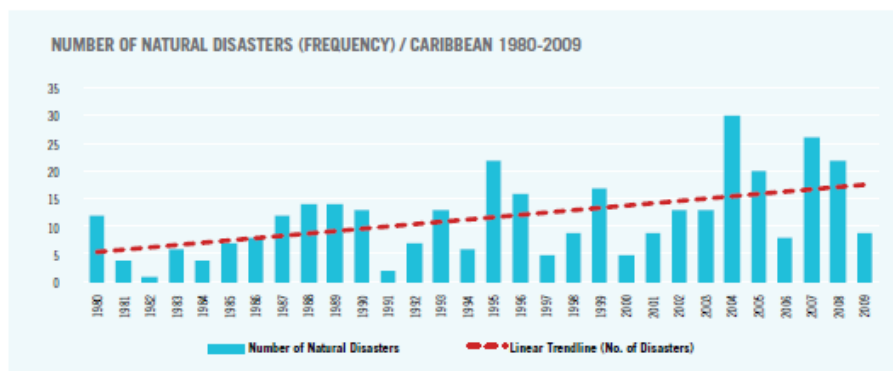


Figure 4. 2 Number of people affected by Caribbean disasters 1980-2009 (UNISDR, 2011)

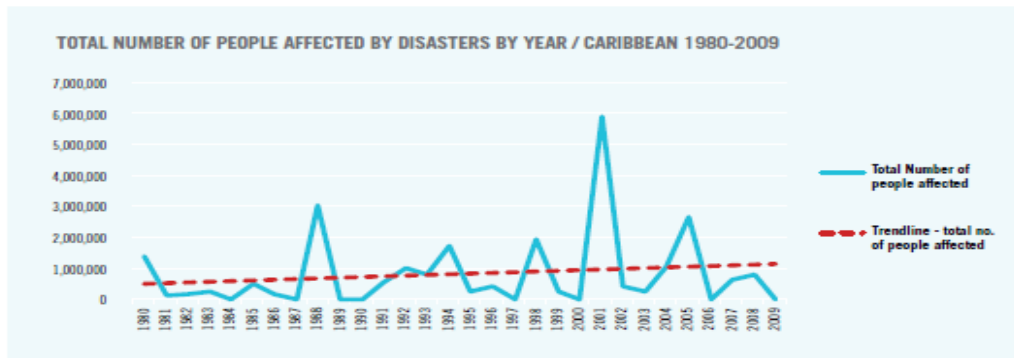


Figure 4. 3 Number of people affected by disasters in the Caribbean 1980-2009 (UNISDR, 2011)

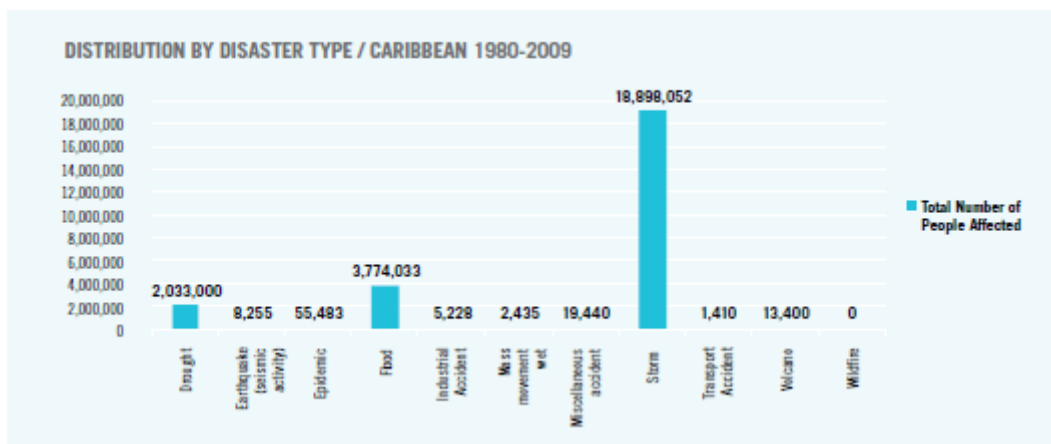


Figure 4. 4 Number of Caribbean people affected by different hazard types, 1980-2009 (UNISDR, 2011)

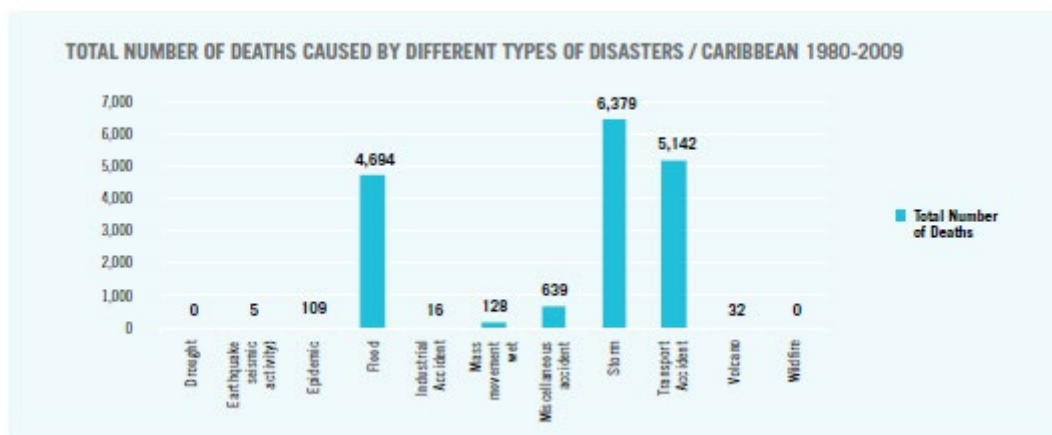


Figure 4. 5 Number of deaths caused by hazard type in Caribbean, 1980-2009 (UNISDR, 2011)

It is the role of CDEMA (Caribbean Disaster Emergency Management Agency) to provide regional disaster risk reduction strategy and support to member countries. However, within each island outside support is provided by agencies linked to colonial legacies, meaning that each SIDS can adopt a different approach to disaster risk reduction, resulting in a varying level of vulnerability.

The Caribbean Island states have the problem of dealing, not only with the annual threat of tropical storms, geophysical activity linked to the tectonic setting and hazards linked to the steep relief, but with the continued threat of climate change which could intensify and increase the frequency of hazards on the islands. A World Bank report *“Turn Down the Heat”* (2014) highlighted the potential impact of future changes in climate in the Caribbean region. Changes because of 2°-4°C temperature change could result in a 20-40% reduction in precipitation, increasing drought, yet increasing rainfall intensity. Drought events will likely increase the risk of forest fires and ecosystem degradation. Intense rainfall events could lead to greater risk of landslides, particularly in areas of high-angle slopes, a feature of many Windward islands. Such climatic change could lead to a reduction in agricultural productivity, limiting local food security. Marine environments would be threatened by ocean acidification and coral bleaching, resulting in a reduction in fish populations between 5-50%, impacting local fisherfolk. Most significantly, climate change could lead to an increase of 40%-80% in frequency of the strongest north Atlantic tropical cyclones, exacerbating the problems for coastal populations and the ability of government to function with a sustainable economy. These future scenarios make the Lesser Antilles a vulnerable location, with rates of urbanisation projected to reach up to 75% (UNEP, 2106), and rising temperatures despite only a 5% contribution to greenhouse gas emissions. This underlines the importance for Caribbean states to follow the principles of the HFA and SFA to increase resilience to future climate emergencies.

4.3 The vulnerability of Dominica

Dominica, the focus for this study, is an island in the Lesser Antilles (15°N and 61°W). With a population of 71,625 in 2018 (World Bank, 2018), it is classified an Upper Middle-Income Country (World Bank, 2016). It is the largest and most northerly of the Windward Islands, extending 47km in length and 35 km in width. The island's volcanic origin links to the Lesser Antilles Trench where the North American Plate subducts the Caribbean Plate. It has 4 mountains over 1200m with the highest point Morne Diablotins at 1447m and Morne Trois Piton at 1424m (Clay and Benson, 2001).

Economically it is reliant on tourism and has seen slow growth in GNI (**Table 4.1**). Limiting external debt has slowed social development on the island. Its limited resource base has increased its inability to develop (Ketilsson, 2009).

Table 4. 1 World Bank country indicators profiling Dominica (World Bank, 2018)

Indicator	2000	2010	2015	2016	2017	2018
Population	69650	70878	71183	71307	71458	71625
Pop. growth rate (%)	-0.3	0.0	0.1	0.2	0.2	0.2
GNI PPP per capita	5770	9870	10470	10990	10140	10680
Mortality rate – under 5s (per 1000 live births)	15.4	20.8	31.2	32.9	34.0	n/a
External debt stocks (US\$ millions)	90	271	314	297	295	296
Immunization's measles (%) children aged 12-23 months)	99	99	94	96	96	77

The tropical climate, with 365 rivers radiating from the volcanic peaks has led to deeply incised valleys (Lindsay et al, 2005). The dominant andesitic-dacite deposits contribute to some of the highest known chemical weathering rates (Goldsmith et al, 2010) and slopes of 30° or more are common and are found across 60% of the island.

The island is covered with dense tropical vegetation and has a tropical climate which supplies between 1800mm per year on the west coast to 7500mm in the mountainous central area. The island is home to over 1000 tropical flowering plants with over 80% of vegetation receiving more than 2500mm of precipitation (Clay and Benson, 2001). High rainfall levels lead to frequent local flooding and landslides. Dominica is a multi-hazard environment and is vulnerable to a range of natural hazards but notably tropical cyclones in the 'hurricane season' between August and November. The steep physical topography extending from the central uplands has forced much of the population to live along the coast within river valleys or alluvial fans. This creates increased vulnerability from river flooding, storm surges and wind damage. The island's situation close to the LAT exposes the island to annual seismic events and the potential for tsunami and volcanic activity, from one of the 9 active centres (Lindsay et al, 2005) Topographic and climatic factors also make landslides, bush fires, flooding and storm surges a regular occurrence. It is ranked 5th on the World

Bank Disaster hotspot list (2005) of countries with a relatively high mortality risk from multiple hazards. In a recent report it is classified as 4th most vulnerable of Caribbean states to climate hazards (CRRP - Dominica government, 2020).

Between 1886 and 1996 Dominica was affected on 61 occasions. On average the suggested interval time for a Tropical Storm is 2.9 years, with Category 1 hurricanes averaging impact every 5.8 years while category 3 hurricanes every 23.8 years (Honeychurch, 1995). The island has had 13 years with multiple storms. The two most significant events are the 1979 Category 4 Hurricane David and the 2017 Category 5 Hurricane Maria (Barclay et al, 2019).

Globally, Dominica is ranked 12th of 33 selected global SIDS assessing all physical and socio-economic variables (Scandurra et al 2018). Despite this the UNDP (2011) show that Dominica has not implemented specific Disaster Risk Management legislation from 2011. It has no ongoing hazard mapping programme or real time forecasting or warning systems, and only has 5 full-time staff in its Office of Disaster Management (ODM). Despite the countries need to implement the principles of the HFA and SFA, a UNDP report (2011) outlined a series of constraints faced by Dominica in its response to Disaster Risk Reduction (**Figure 4.6**).

- Lack of necessary legislative framework
- Insufficient central government support
- Insufficient support for capacity building (pre-Maria)
- Insufficient coordination and cooperation among sectors, including government, private and civil society to inform the development process.
- Lack of communication and a communication platform which is common to the strategies of the HFA framework.
- No champion to promote the adoption and implementation of the framework in Dominica.
- An inconsistent approach with education and simulation programmes.

Figure 4. 6 Recognised constraints to disaster risk management in Dominica for ODM (UNDP, 2011)

Consequently, Dominica is an ideal focal area for this study. Its lack of identifiable attempts to manage DRR, its vulnerable population, including the indigenous Kalinago population (Honeychurch, 1995) and the potential threat of multiple hazards highlight the need for an assessment of hazard perception.

4.4 Dominican disasters: a historical context

Dominica's history has made it vulnerable to natural hazards. The country has created a dependence on monoculture, notably coffee, sugar, cocoa, limes and bananas, which have each, at one point in time, dominated as the main export crop (Barclay et al, 2019). Production of successive crops led to a rise in exports followed by an inevitable demise caused by either disease, hazards or economic circumstances. Attempts to diversify were often "*superseded by capitalism and colonialism.*" This led to a weak economy (Honeychurch, 1995).

Dominica has been subject to colonial power struggles between the late 17th century to mid-19th century as well as being hit by a series of tropical storms or hurricanes in that period undermining exports (Honeychurch 1995). Indeed, Tropical Storm Erika 2015 caused damage to 40% of road and 50% of bridges, with significant damage along the coastal stretch from Portsmouth to Roseau, isolating coastal communities. (Govt. of Commonwealth of Dominica, 2015)

Constrained by its mountainous topography has prevented development of the internal road network, limiting agricultural production, and creating reliance on coastal or river valley locations, all increased in hazard vulnerability. The existing internal road system was developed in the 1950's and 1960's during a period of storm quiescence but these have been heavily affected by subsequent storms (Honeychurch, 1995).

Indigenous populations as far back as the 17th century have accepted the risk of tropical storms and hurricanes (Mulcahy, 2008), however knowledge of other hazards such as volcanic eruptions, earthquakes and tsunamis are uncommon. After emancipation from slavery poor black landless labourers were resisted access to land therefore forcing them to settle illegally in unoccupied land, such as the beachfront along the west coast of Dominica. Many of these areas, such as Pont Michel, Mero and Dublanc are subject to coastal hazards or sit at the mouth of streams originating from the mountainous interior. This increases the potential impact of flooding, landslides and hurricane damage (Honeychurch, 2017).

The historical approach to disaster response has varied from colonial loans or grants, to repair, rather than "*build back better*". Despite having a draft "*National Disaster Plan*" since 2001, there is continued reliance on support from international aid, or internal government budget reallocations, consultancy, leading to inefficiencies in response and recovery (Barclay et al 2019)

The history of Dominica has underlined the issues typifying a SIDS; a lack of diversification in economic policy, cultural and demographic segregation and disparity and a sense that governance lacks prioritisation to deal with the continued threat of natural hazards. All these factors add to the

vulnerability for islanders. It is important to understand the role the historical context plays in the fact that Dominica is often described locally as a country with the highest density of natural hazards on the planet per square kilometre.

4.5 Current hazards in Dominica

This section outlines the major geophysical and hydro meteorological hazards faced by Dominica based on a review of literature.

4.5.1 Tectonic setting

Dominica is a relatively young island at 7.5Ma old (Smith et al, 2013) and sits on the Lesser Antilles Island arc, consisting of 11 volcanic islands. The western edge of the North American plate subducts beneath the Caribbean plate at about 2cm/yr. The arc curvature is segmented into two segments near Dominica and the island sits on the southern end of the northern segment (Howe et al, 2015). The northern segment subducts at an angle of 50-60° which explains some of the larger magnitude earthquakes compared to the southern segment which has an absence of large earthquakes and subducts at a lower 40-50° (Smith et al, 2013) A detailed account of the geological evolution of Dominica is given by Smith et al, (2013). Dominica has 9 potentially active volcanic centres (Lindsay et al, 2005a) but 11 volcanic edifices. Early eruptions (between 1.7-2 Ma) originated from the northern part of Dominica, from the large stratovolcano Morne Diablotins and subsequently the smaller Morne aux Diables. More recently (0-1.1 Ma) six new centres towards the south of the island have erupted including Foundland, Morne Trois Pitons, Morne Anglais, Grand Soufriere Hills, Morne Micotrin, Plat Pays Volcanic Complex (PPVC). Of which two of these eruptions formed calderas at Wotten Waven and Morne Trois Piton (Smith et al, 2013). The PPVC, a lava dome complex, most recently erupted about 450-year BP (Boudin et al, 2017) Recently, a larger phreatic eruption occurred in the Valley of Desolation in 1880 covering a 4km area and a smaller phreatic eruption occurred in 1997. The island has encountered 17 seismic swarms (Lindsay et al, 2005) and these have become more frequent since 1994 in the southern part of the island and since 2000 in the north (Smith et al, 2013).

4.5.2 Volcanic hazards

The island has 11 potentially active volcanic centres, one of the world's highest concentrations per unit area, and is subject to associated geothermal and seismic activity. Southern Dominica is at risk from future magmatic eruptions from PPVC, Morne Anglais, Morne Plat Plays and Morne Micotrin which could all generate pyroclastic flows or surges, ash fall and lahars, affecting the southern coastal settlements, notably the capital city Roseau. Geothermal activity originates from four volcanic sources (Morne aux Diables, Wotten Waven, Morne Trois Pitons and PPVC) is linked to a range of areas most notably the Valley of Desolation, the Boiling Lake and Eastern and Western Hot Springs (SRC, 2000) Smith and Kirkley, (1994), important tourist destinations.

Dominica was affected by a major explosion about 30000-years BP, depositing the Roseau ash (tuff) (Carey and Sigurdsson, 1980), evident in an 8km long deposit, with an estimated volume of 3km³, on the west coast. The eruption consisted of a Plinian phase of airfall tephra, with an eruption column believed to be in order of 20km transporting material east of Dominica. This was followed by a series of pyroclastic, entering the sea to the southwest of Dominica, originating from the Microtrin volcano. Sparks et al, (1980) show that large scale block and ash debris flows have been located offshore, near Grand Savanne. This feature is 2-4km wide and 200-400m thick highlighting the potential of secondary hazards from large scale eruptions and the possible trigger of landslide-linked tsunami from edifice collapse. The event produced approximately 58km³ of tephra and is the largest eruption in the Lesser Antilles in the past 200000 years. Boudon et al, (2017) argue that this large eruption was more likely a series of events from two main volcanic centres, at Morne Diablotins between 76ka and 46ka and from Morne Trois Piton-Micotrin between 28ka and 5ka. The five largest eruptions occurred between 62ka and 25ka years ago. Boudon et al, (2017) argue the tectonic conditions are favourable for deep magma storage (16-20km), hence the infrequent but large eruptions. They also argue that Dominica is anomalous in its volume of eruption producing 5 eruptions of 2.5-4km³ within tens of thousands of years, compared to neighbouring Martinique and Guadeloupe which produce more frequent lower volumes due to the absence of shallow crustal reservoirs in Dominica. The most recent explosive eruption, not including the phreatic event at the Valley of Desolation in 1997, occurred 450-years BP, from Morne Patates, a 350m volcano in the PPVC consisting of block and ash-flow deposits. If the height of other nearby domes is characteristic (900-1100m asl) then Morne Patates has potential for a future eruption. **Figure 4.7** indicates the integrated volcanic risk zones from the 11 volcanic centres in Dominica. The collection of potentially active volcanoes in the southern part of the island puts Roseau and other southern towns at the greatest potential risk for a future eruption.

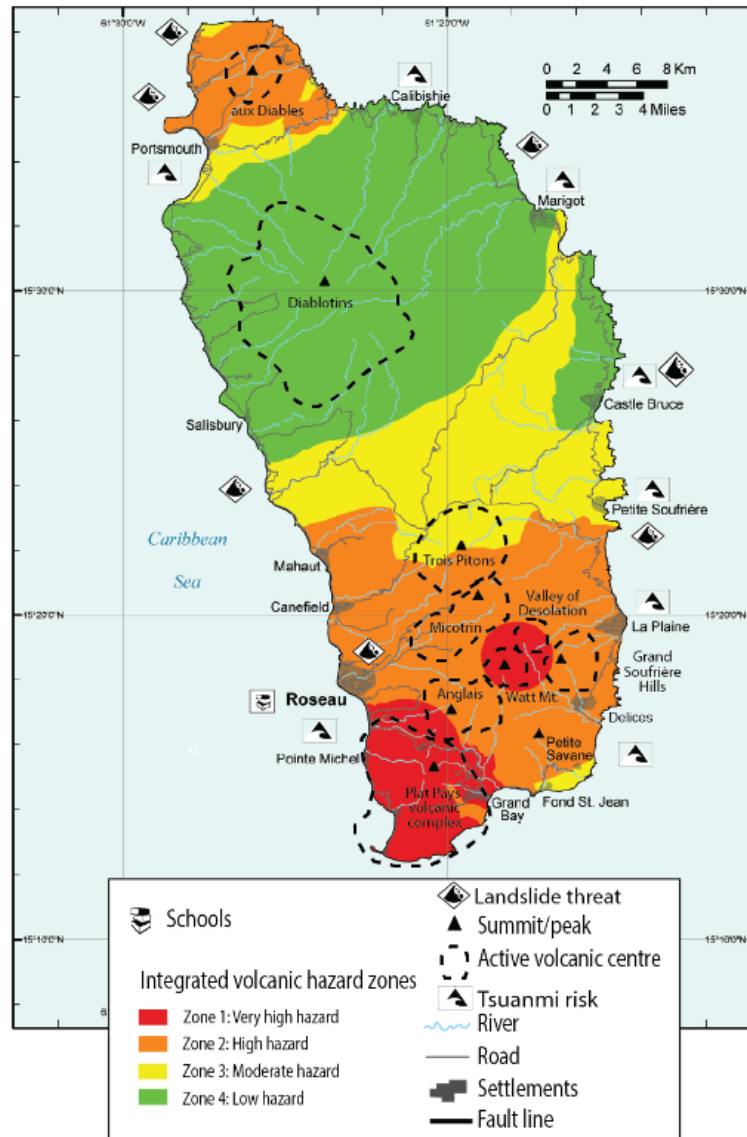


Figure 4. 7 Integrated volcanic risk zones in Dominica (after Lindsay et al, 2005)

4.5.3 Earthquakes

Majority of earthquakes felt from beneath Dominica are shallow and are associated with magmatic movements (Wadge, 1985). Recent earthquake swarms in 1974 and 1998 have been linked to magma at 3-6km depth linked to magmatic activity in the PPVC and a possible Morne Anglais potential eruption (Wadge, 1985). Ruiz et al, (2013) show that most regional offshore earthquakes occurring between Dominica and Martinique are linked to deep subduction events. Two significant events in 1906 a M7.5 event and November 29, 2007, a M7.4 event (@140km) occurred at depth greater than 100km. They note an absence of shallow seismic activity below 15km depth.

Feuillet et al, (2011) summarise the key seismic activity to impact the Lesser Antilles. They suggest that Dominica has been affected by 5 earthquakes greater than M_w 5.5 and intensities of VI. These include both January 1839 M_w 8 and February 1843 M_w 8.5 with intensities between VII and VIII, the 1851 M_w 6 event with VI intensities in the north, and the November 2004 M_w 6.3 event where the north of the island reached intensities of VII. In some cases, larger magnitude earthquakes are linked to volcanic eruptions in the Caribbean (1839 & 1841) however the recent 2004 earthquake did not follow this pattern. Recent earthquake activity has affected the southern parishes of Dominica, linked to a series of M_w 4-6 earthquakes occurring between Martinique and Dominica between 2014-2016 (USGS, 2020).

4.5.4 Tsunami

Dominica sits west of the LAT and the rate of subduction is about 2cm/yr. It is assumed that the rate of subduction increases with age of the subducted plate (Carlson and Rankin, 1983), however, the rate of subduction at the LAT is slow (2cm/yr.), while the age of the subducting crust is old (80-85 Ma) (Harbitz et al, 2012). Until the Sumatra 2004 earthquake it was believed that only young plates with faster subduction rates can create megathrust earthquakes, therefore the LAT could theoretically produce a tsunami forming earthquake. However, Stein and Okal (2007) show that no earthquakes greater than M_w 9.0 have occurred in subducting lithosphere older than 90Ma. Perhaps a more likely source is a tsunami generated from volcanic activity or flank collapse, either from one of the Dominican volcanoes or a neighbouring island. Harbitz et al, (2012) show that large flank failure deposits are found off the coast of Dominica, Martinique and Saint Lucia, with Dominica deposits covering the largest area (3500km²) and largest run out distances for debris flows (90km), signifying major collapse event capable of producing tsunami. They show that Dominica is likely to face up to 2-3m runup from Caribbean sourced tsunami, though, owing to the nature of the population distribution only 1-2% of the population would be directly affected. A trans-oceanic source, such as that from the Canary Islands (Ward and Day, 2001, Mader, 2001) could potentially cause greater runup distances affecting a greater proportion of the population. Yet Teeuw et al, (2009), show the possibility of 10m run ups associated with the destabilisation of a 1 million tonne block on the northern coast.

4.5.5 Atmospheric hazards

Tropical cyclones and drought are two common atmospheric hazards impacting the Caribbean. With an increase in global temperatures there is likely to be an increase in hurricanes, although Rojo-Garibaldi et al, (2016) show that long term trends indicate fewer but more intense hurricanes, associated with an inverse relationship between sunspot and hurricane activity in the Caribbean Sea. While increased global temperatures have led to more intense hurricanes the Caribbean has faced greater intensity droughts since the 1950s, with the most severe between 1974-77, 1997-98, 2009-10 and 2013-16 (Herrera and Ault, 2017). The two most recent events causing significant impact to GDP (CRRP, 2020) are Tropical Storm Erika, 2015, and Hurricane Maria, 2017.

4.4.5.1 Tropical Storm Erika

Tropical Storm Erika was a tropical storm which passed more than 150km north Dominica on August 27th, 2015 (**Figure 4.8**). The storm had no obvious central circulation but had embedded gyres within the broader circulation, one of which formed over Dominica. This led to high amount of rainfall forming over the island between 0800 – 1800 UTC (NOAA, 2015) leading to 300 – 750mm ppt in a four-hour period with peak runoff rates at 80% of peak rainfall (Ogden, 2016). Although the tropical storm track and formation was well anticipated by the US National Hurricane Centre, the high levels of rainfall, formed over Dominica were not (NOAA, 2015). The event cost the island US\$483million equivalent to 90% of Dominica's Gross Domestic Product (GDP) (World Bank, 2015) and killed 30 people (NOAA, 2016), leaving 574 homeless. The most significant damage was to the southern coastal parts of Dominica, with the worst impact to the village of Petite Savanne. The storm also had great impacts on villages located within steep riverine valleys on the west coast, such as Dublanc and Coulibistree and in some upland areas yet had minimal effects north of Portsmouth. The storm affected 271 houses and numerous roads and bridges around the island, isolating communities across the island (NOAA, 2015). The event had an immediate impact in reducing tourism due to the closure of the Melville Hall (now Douglas Charles) airport. The key issue for Dominica was the lack of warning from NOAA, largely due to the perceived lack of possible impacts associated with the track of the storm passing north of Guadeloupe (**Figure 4.8**) (NOAA, 2015).

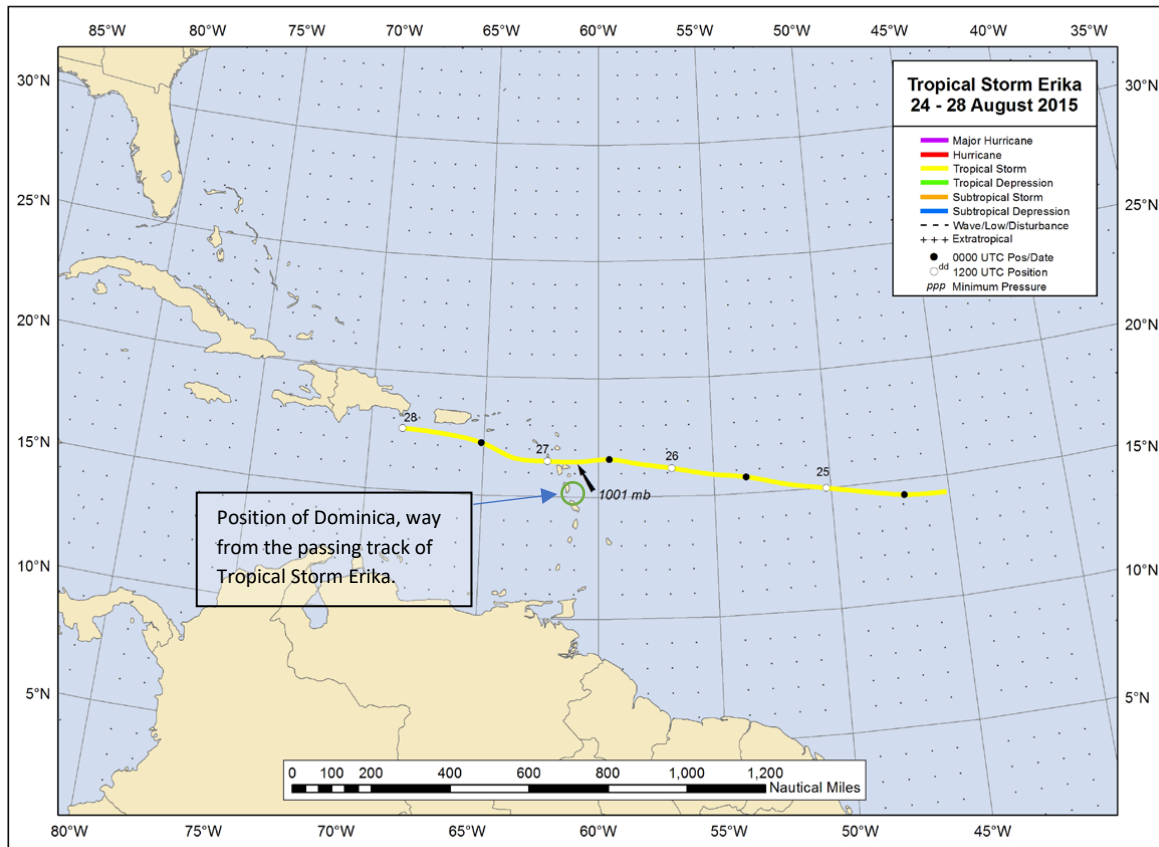


Figure 4. 8 Best track positions for Tropical Storm Erika, 24-28 August 2015 (NOAA, 2015)

4.4.5.2 Hurricane Maria

Hurricane Maria was one of the 5 costliest tropical hurricanes across the Caribbean – totalling 63000 million US\$, 30000 million in insured losses and 108 deaths, only second to the preceding Hurricane Irma (Wilkinson et al, 2018). It formed 580 miles east of Barbados on 16th September and tracked west until 17th September when it intensified rapidly. By 18th September it became a 1000-kt hurricane and as it neared Dominica it became a category 5 hurricane with 145-kt winds and an estimated central pressure of 922mb (NOAA, 2019). It is the strongest hurricane on record to make landfall in Dominica (**Figure 4.9**). The island received huge amounts of rainfall, with a maximum of 22.8 inches, resulting in serious flooding and mudslides. **Figure 4.10** shows the hurricane track which made landfall late on the 18th of September and headed in a SE-NW trajectory across the island. The storm impact 100% of the population with the greatest vulnerability for those in valley and coastal locations. Maria killed 31 people directly and left 34 missing, resulting in US\$1.31 billion total damages, felling large swathes of the tropical forest, and bringing the agricultural sector to a standstill (NOAA, 2019).

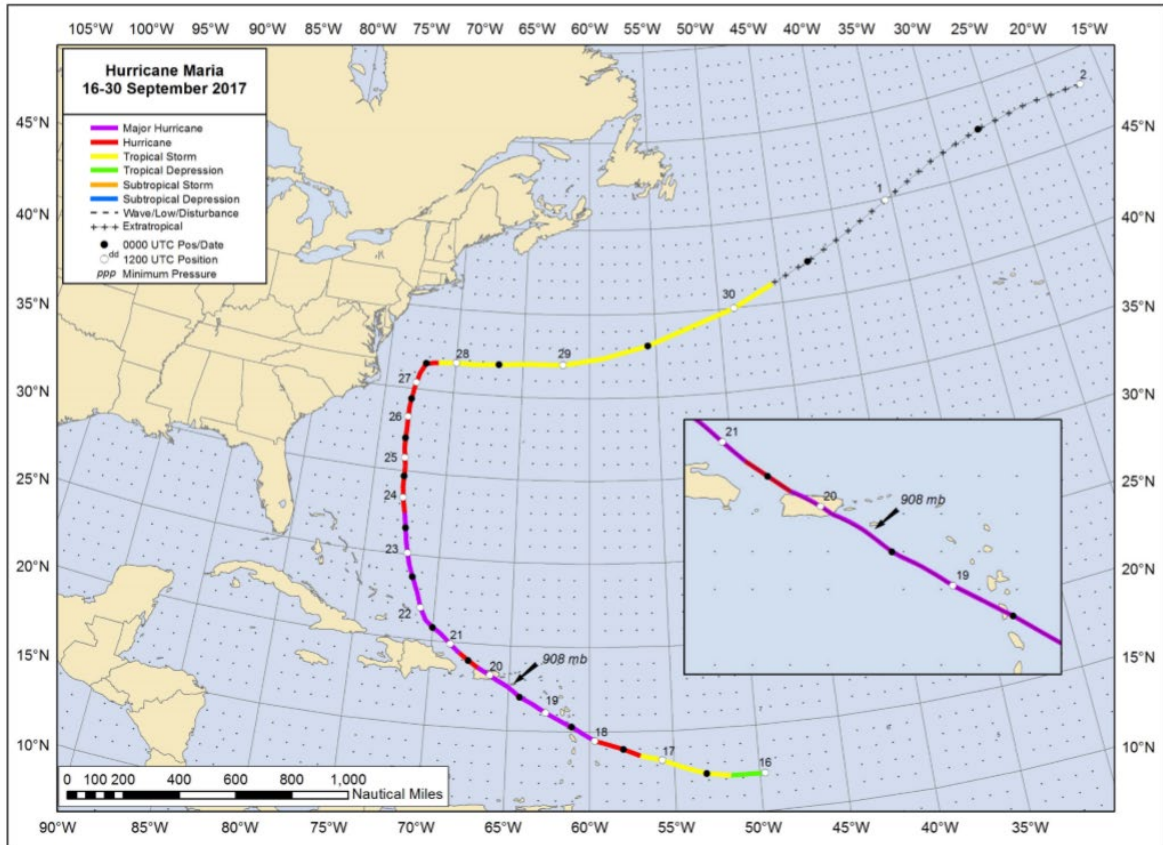


Figure 4. 9 Track positions for Hurricane Maria 16-30th September 2017. (NOAA, 2019)

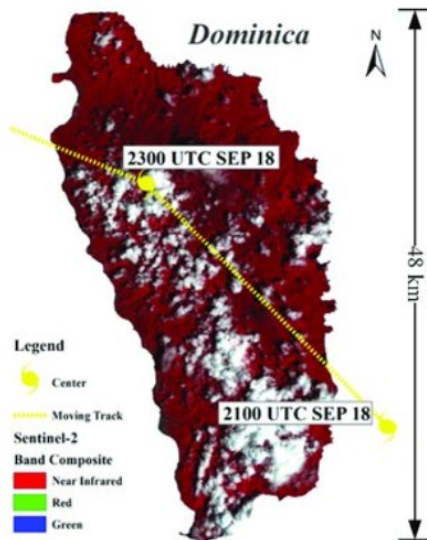


Figure 4. 10 Hurricane Maria track through Dominica (after Hu and Smith, 2018)

Hurricane Maria resulted in damages of US\$931 million and losses of US\$382million which amounts to 226 of the 2016 GDP. The identified amount to 'Build back better' is US\$1.37 billion (Govt. of

Dominica, 2017). With the greatest losses from the agricultural sector (US\$124.37 million) and tourism (US\$70.77million). 2800 individuals considered vulnerable prior to Maria will have fallen below the poverty line. Two months after Hurricane Maria more than 80% of houses lacked adequate roofing and over 90% had no electricity (UNOCHA, 2017).

4.5.6 Landslides

Landslides are a common hazard in Dominica and are associated with intense rainfall events and passing storms. Rouse (1990) shows that the tropical clay soils of Dominica are like the granular temperate soils allowing for higher water retention and capacity. However, prolonged rainfall events can induce landslides which may already hold vast amounts of water (Reading, 1991). Despite relative stability on slopes over 40°, prolonged rainfall can induce slides. Once initiated such slides can travel great distances across low-angle slopes as debris flows. Van Westen (2016) compiled a comprehensive landslide susceptibility report showing three levels of susceptibility in Dominica. The low zone, representing 391.7km² has had 137 landslides, medium zone 168.6km² with 356 landslides and the high-risk zone, covering 191.8km² with 3104 landslides. He surmises that 84% of buildings are in the low zone, 11.5% are in the medium zone and 4.5% in the high zone. Van Western (2016) shows that main roads represent 59.2% in the low zone, 18.7% in the moderate and 22.1% in the high-risk zone – all of which could potentially isolate settlements in the event of a hazard. The most notable landslide in recent time in Dominica was the landslide dam on the Matthieu river in July 2011. James and De Graff, (2012) summarise the events on Wednesday 27th July 2011, as the landslide dam collapsed releasing a major flood event into the Layou valley. The cost of the event was between 9-18million ECD\$ causing damage to property and infrastructure in the Layou valley. The cause of the event was the breach of two smaller landslide dams on the Layou river in 1997.

4.5.7 Flooding

Flooding is considered an indirect hazard in Dominica and is largely attributed to the coastal zone, with storm surging associated with storm activity, or with landslide dam collapses as already noted. Flooding in lower course catchments is most common in areas where valleys open towards the coast from narrow inland channels, e.g., in Coulibistree. High discharge events associated with excessive rainfall, mainly attributed to storm activity, lead to overbanking on alluvial plains, common on larger rivers such as Roseau or Layou rivers. Benson and Clay, (2001) attribute increased vulnerability to

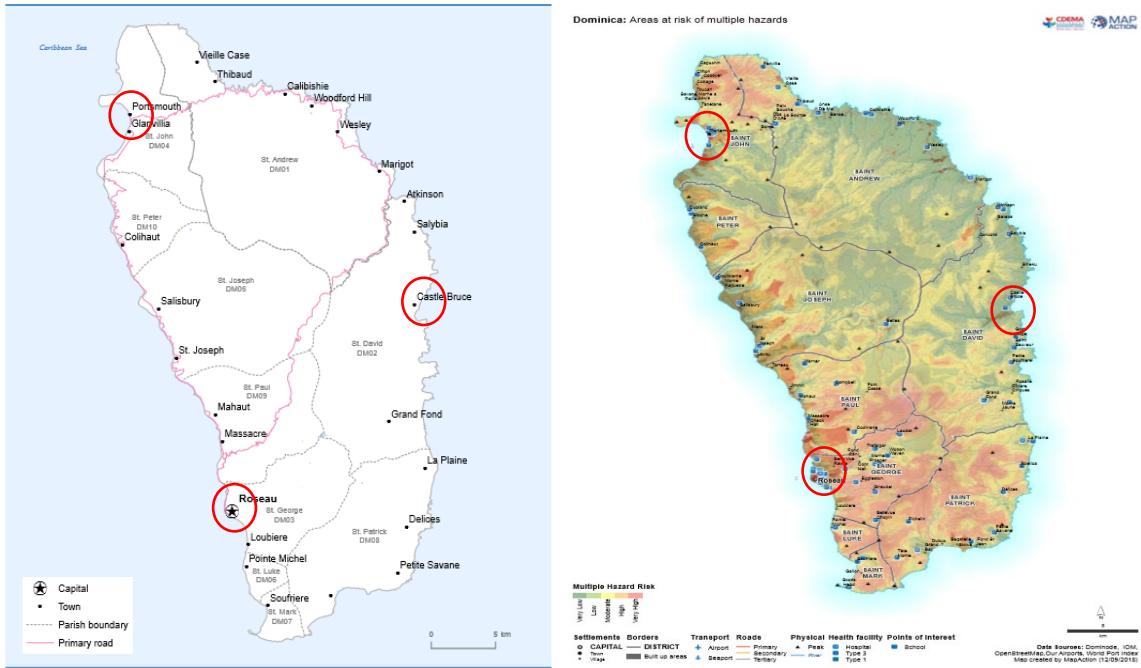
flooding because of ad hoc deforestation linked to land sale and population pressures in upper and middle course catchments. Hurricanes exacerbate these changes through foliage and branch removal resulting in reduced interception and increased river debris causing river blockages and subsequent flooding.

There is an increased threat from coastal flooding because of climate change, coupled with historic removal of vegetation from the coastline (Honeychurch, 1995) leading to a need for greater sea defences near settlements on the leeward side of the island (Benson and Clay, 2001).

4.6 Study locations within Dominica.

Dominica is a country which is subject to a range of hazards. The threat of these hazards is spatially different (**Figure 4.11**). With a greater number of settlements along the south and west coast of the island there are greater risks. We have chosen to focus our study across three contrasting areas of Dominica: **Castle Bruce** a small village on the east coast, adjacent to the Kalinago reserve, **Roseau**, the capital city, built on an alluvial fan on the southwest of the island, and, the second largest town, **Portsmouth** in Prince Rupert Bay on the northwest of the island, perched on the slopes of Morne aux Diabes.

Despite wishing to cover a range of locations our choice of locations within Dominica were subject to the following criteria: i) that they faced a range of potential risks but with different likelihood of occurrence ii) that they had a secondary school, and iii) that we covered different population groups on the island. Final decision for the study locations was made by the Ministry of Education, who upon contacting principals at each school agreed for the working partnership over the 5 years study period. Roseau as the capital was included as the main population centre and proximity to government offices; Portsmouth as the second city and Castle Bruce, despite being a village, was chosen because it met the criteria but particularly because it was the main choice of school for the indigenous population on the island.



(a)

(b)

Figure 4. 11(a) A map showing the distribution of administrative boundaries and major settlements in Dominica and (b) a multi-hazard map of Dominica (Map Action, 2018). Study sites are circled.

4.6.1 Roseau

The capital of Dominica with a population of 14725, (Dominica Government, 2011) represents the main administrative focus on the island and the location of the government and presidential building. It is located on an alluvial fan adjacent to the Roseau River. Roseau extends east-west along the Roseau River, demarcated by the steep valley walls to the north of the Roseau Tuff and Morne Bruce to the south. East of the city is the Roseau River Valley leading to Trafalgar and Wotton Waven and the volcanic complex of Play Pays, Morne Anglais and Morne Watt. Most of the population of Roseau live close to the city centre, along the coast to the north and south or on the northern valley walls leading to Goodwill. As the main economic area, it has two ports and is the focus for all cruise ship activity from October – April. The downtown area is subject to the potential impact of flooding and debris flows, while the steep valley walls represent a landslide risk for those in proximity. Its low-lying coastal position serves as a potential threat for tsunami, while the entire Roseau valley has pyroclastic deposits suggesting that future eruptions from Morne Watt, Morne Anglais or PPVC could have a direct impact on the entire city.

4.6.2 Portsmouth

The is the second largest community in Dominica, with a 2011 population of 5198 (Dominica Government, 2011). It sits on Prince Rupert's Bay and has a community which is based on tourism, agriculture, and fishing. Portsmouth sits adjacent to the Cabrits National Park to the north and the suburbs of Picard and Glanvilla to the south, home to the Ross medical university, bringing students from North America, until the 2017 hurricane. The town sits on the flank of the Morne aux Diaboles to the east and north, and the main urban and residential area follows the low relief along the bay. To the south of the town is the Indian river, a tourist attraction, which separates the main urban centre from the suburbs of Glanvilla and Picard. The coastal location of Portsmouth brings the risk of storm surges and tsunami to the population nearest the coast. The looming Morne aux Diaboles presents a potential threat to the entire population. Flood events from the Indian river have limited impact on the main urban centre due to the extensive marsh areas surrounding them. The population is not subject to landslides in the same way as Roseau, except for those people who choose to live higher up the flanks of the volcano.

4.6.3 Castle Bruce

The village of Castle Bruce is located on the east coast of Dominica, with a population of 1339 (Dominica Government, 2011). The town sits on the northern flanks of Richmond Bay, and extends south to the Castle Bruce River valley, which is largely used for agricultural purposes. Castle Bruce is the main settlement to the south of the Carib Reserve indigenous Kalinago population and draws influence from it. Most residents here are commuters to Roseau or work in agriculture or the local service or tourism industry. The area is subject to the activity from the Castle Bruce River but flood events from this would not affect the town. The upper reaches of the village are perched on steep relief and therefore subject to landslide hazards. Deep incised valleys intersect the village with the potential for flash flooding. The village is Atlantic facing therefore subject to the potential risk linked to seismic activity from the Puerto Rico trench or further afield. Its east facing position brings in large swells and storm events. Volcanic threat is unlikely, but not impossible as it sits between Morne Trois Piton and the largely inactive Morne Diablotins.

4.7 Observed hazard risk by study location.

This section summarises of hazards by location based on a preliminary visit in December 2012 and visits in 2013 and 2014. Such an assessment is necessary to contextualise the student and DRR ‘expert’ perceptions of risk in each location.

4.7.1 Hazard risk in Roseau

Roseau lies on an alluvial (deltaic) fan on the west coast of Dominica. The central Roseau area is built upon the alluvial fan, extending from the Roseau valley to the Caribbean Sea. The river Roseau approaches Roseau from a bounded valley originating from the volcanic complexes of Morne Watt, Morne Anglais and Trois Pitons. To the south of Roseau, the potentially explosive Plat Pays volcanic complex (PPVC) separates the capital from the southern coastal towns of Ponte Michel, Grand Bay and Soufriere (Figure 4.12).

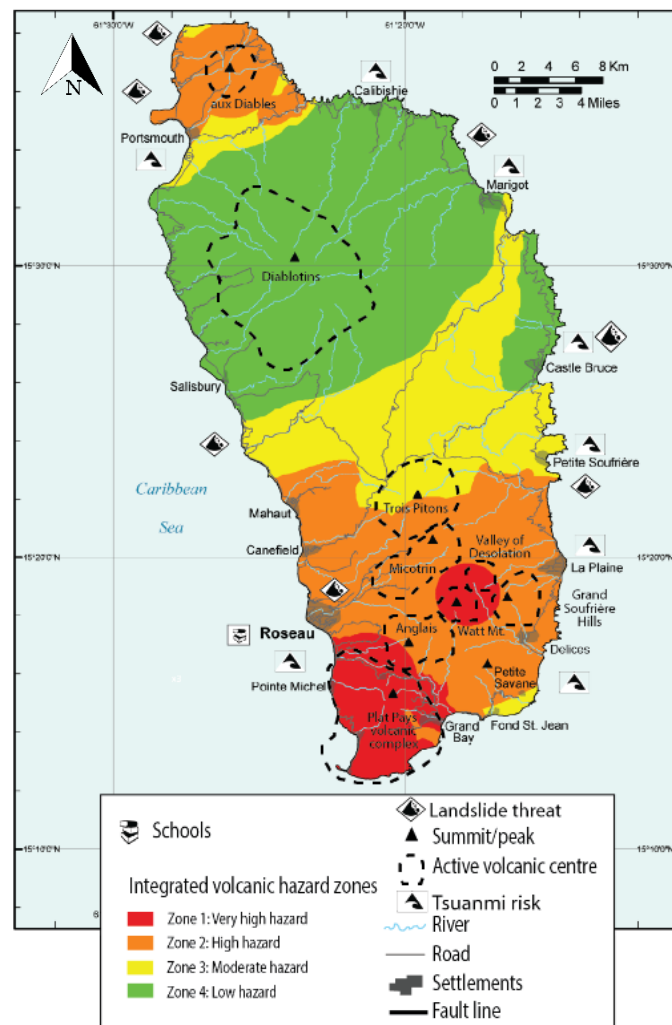


Figure 4. 12 Locations of volcanic risk in Dominica (after Lindsay et al, 2005)



Figure 4.13 Located images representing hazard risks in Roseau. Notes on images 1) Orion Academy, located on the alluvial terrace, set into the Roseau tuff cliffs; 2) View of Roseau tuff cliffs, across Roseau (from point 7) towards point 2; 3) St Georges Anglican church damaged by hurricane David 1979; 4) densely occupied Roseau centre built on the flat alluvial plain of Roseau River; 5) view south along coast towards the Plat Pays complex; 6) commercial properties along the seafront subject to coastal flooding and tsunami; 7) view of the alluvial plain looking north-west from Morne Bruce.

Roseau's situation on the floodplain of the Roseau River presents flooding as one of the greatest and most frequent threats. (**Figure 4.13**). The four bridges crossing the Roseau River south of the Bath estate have potential to restrict flow and cause a debris dam resulting in greater flood risk.

Roseau is surrounded to the east and the south with volcanic complexes (**Figure 4.12**). The stratovolcanoes of Trois Piton, Morne Watt and Morne Anglais head the Roseau River valley. The Roseau River has incised through flank deposits creating a steep sided valley (Roseau / Trafalgar River valley). The alluvial fan upon which Roseau is likely of volcanic origin (evidenced in the Roseau tuff cliffs which separate downtown Roseau north of Windsor Park and the suburb of Goodwill to the north, and Morne Bruce to the south) and overlain by subsequent river flood events. A potential future eruption from one of these three volcanoes could lead to a similar pyroclastic event as seen in Montserrat in 1995-1997. This would impact almost the entire downtown area leading to a vast impact on the economic and governmental activity in the city. To the south of Roseau are the PPVC, considered to be one of the greatest potential volcanic threats to the island (Lindsay et al 1995). This volcanic dome complex would cause significant threat from pyroclastic deposits covering the Roseau and surrounding villages. Roseau threatened by tsunamis despite not facing the west coastline of Dominica and the main tectonic boundary. The area subject to the highest risk is the coastal front which represents the main foci for tourism, trade, and commercial activity in Roseau. The central part of Roseau (**Figure 4.13 and 4.15**) is below the 30m contour potentially compromising the entire centre along the Roseau River to the Bath Estate. The impact of a cruise ship in port while a tsunami was in progress would cause significant damage.

Landslides impacts are restricted mainly to the steep escarpments which bound the Roseau valley walls (**Figure 4.14**). These could affect the residences which are on the upper part of the alluvial terrace or at the foot of the Tuff cliffs. Areas vulnerable to this include the Bath estate, Goodwill, Morne Bruce, the coastal road (Newtown) south towards Castle Comfort. The entire Roseau valley and alluvial fan is subject to a potential large alluvial debris fan like the one caused by the Matthieu landslide dam event in 1997 (van Western, 2016).

Hurricane activity has the potential to impact all of Roseau. As hurricanes produce large amounts of flood water containing debris, areas adjacent to rivers will be at particular risk. **Figures 4.15 and 4.16** show the likely areas subject to flood risk in the Roseau area. Hurricane or storm associated winds would have the greatest impact in exposed elevated areas, for example the suburban areas of Goodwill and Morne Bruce (**Figure 4.13**). Though the coastal section of Roseau would potentially suffer from the impact of storm waves, strong winds and storm surging (**Figure 4.16**) Therefore, the coastal front south from Loubiere, north to Canefield would all be at risk.

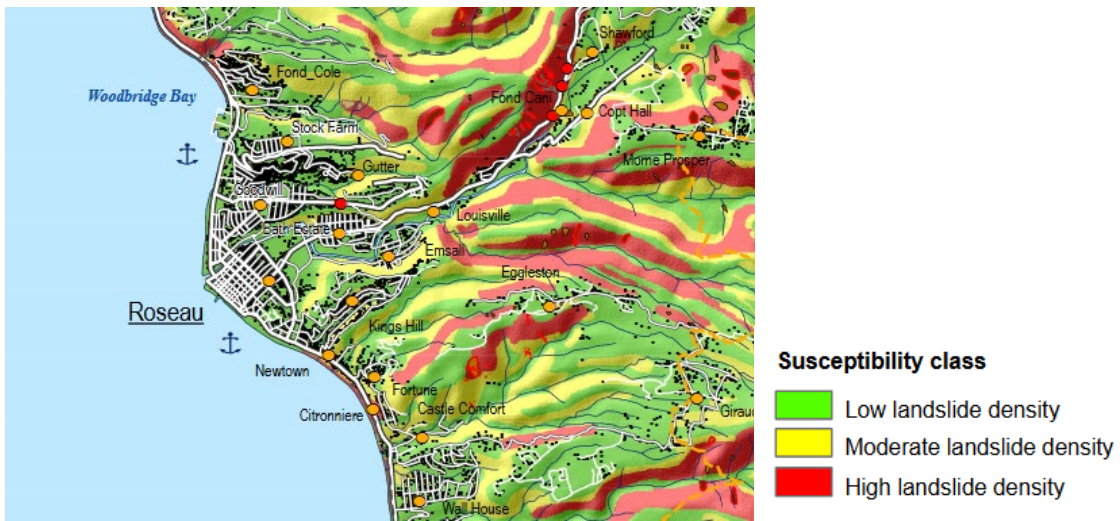


Figure 4. 14 Landslide threat around the Roseau area (after van Western, 2016)

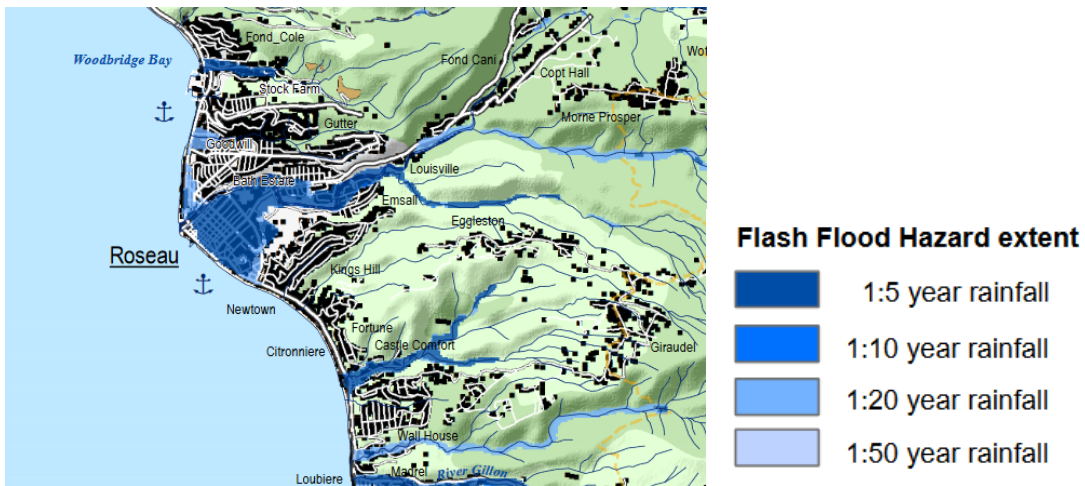


Figure 4. 15 Flood risk around the Roseau area, (after Van Western, 2016).

The threat of earthquakes would be wide-ranging and the unconsolidated alluvial material under central Roseau could lead to greater amounts of shaking. Roseau is located away from the main tectonic boundary, fault systems to the west coast could produce infrequent small to medium magnitude seismic activity.

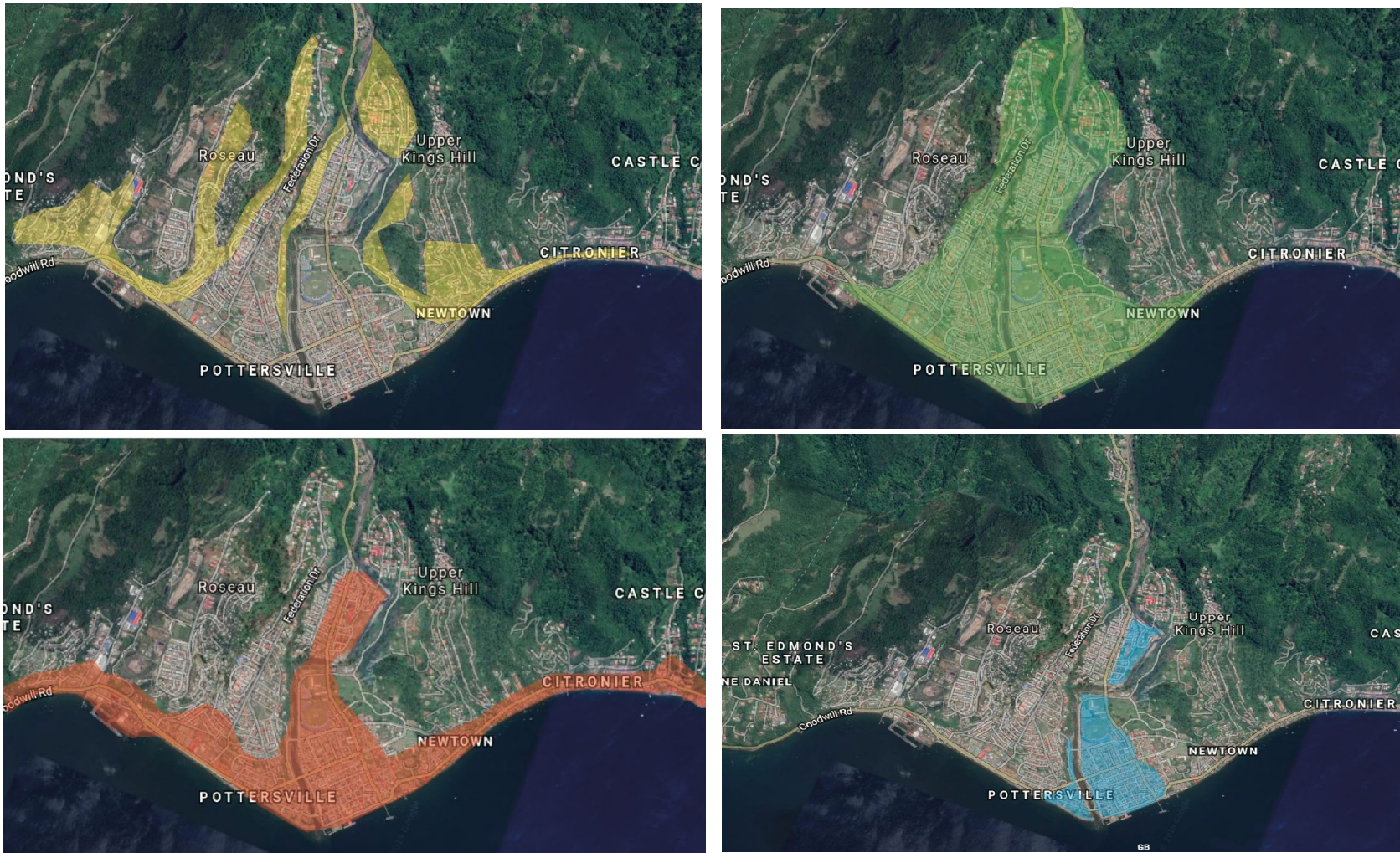


Figure 4. 16 Hazard risk maps for Roseau for selected hazards . Notes - green – volcanic; red – tsunami; blue – flood; yellow landslide.

4.7.2 Hazard risk in Portsmouth

The northerly most town, Portsmouth, is Dominica's second major town, and has a history of trade with colonial powers (Honeychurch, 1995). The town sits between the lower flank of the Morne aux Diabes volcano and is built upon a coastal bar and lagoon, to the south of a floodplain of the Indian river. To the north of Portsmouth is the Cabrits National Park, home to a secondary volcanic cone attached to the mainland as an isthmus. Portsmouth's coastal location makes it vulnerable to annual hurricanes and tropical storms despite the protection of Prince Rupert Bay and Morne aux Diabes. The main thoroughfare through Portsmouth lies adjacent to the coastline increasing vulnerability of local business. However, residential areas are mostly set back from this area but on either the flat floodplain or the foothills of Morne aux Diabes.

Figure 4.17 shows the flood threat in Portsmouth, mainly from gullies on the slopes of Morne aux Diabes or from the Indian river floodplain. Land use around the Indian river is low density reducing risk of flooding. The low-lying land in central Portsmouth, behind the main coastal road (**Figure 4.17**) shows higher risk from flooding. The commercial centre is exposed to tsunami risk and Prince Rupert Bay could amplify oncoming waves leading to potentially large run ups. Further inland the topography rises, meaning residential areas further east from Portsmouth, e.g., Grange and Chance could avoid the tsunami threat.

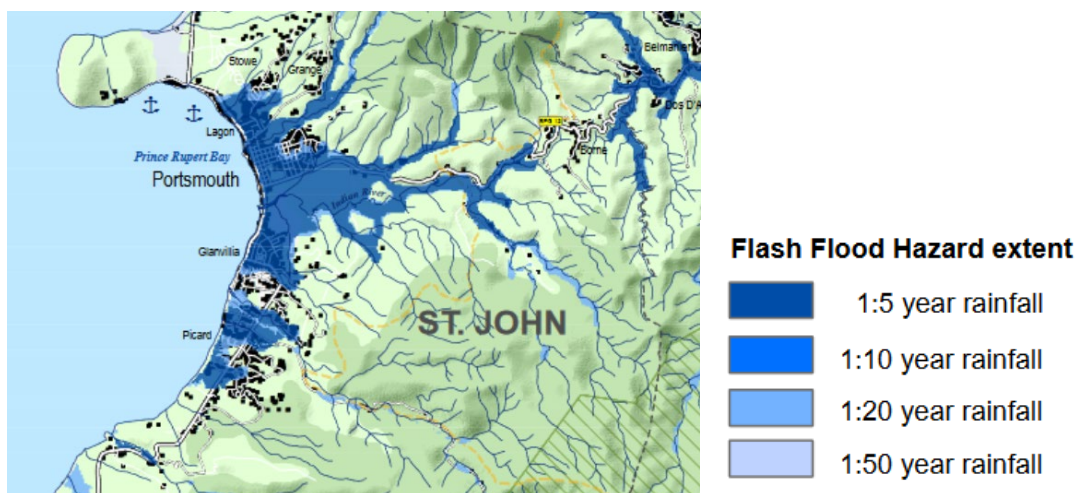


Figure 4. 17 Flood risk in Portsmouth, (after van Western 2016)

The main landslide risk, shown in **Figure 4.18** is associated with the foothills of Morne aux Diabes. **Figure 4.18** shows that this is unlikely to affect central Portsmouth but could affect accessibility from central upland villages and access to the airport.

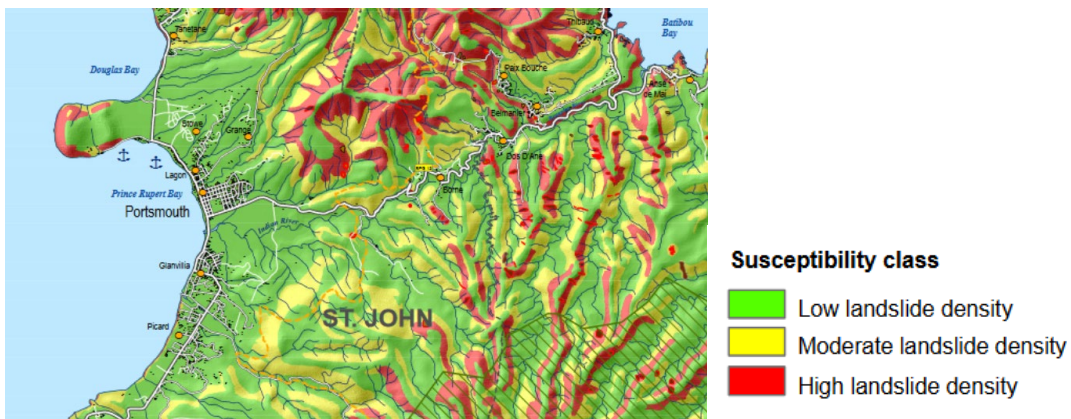


Figure 4. 18 Landslide risk in the Portsmouth area (after van Western, 2016)

The main volcanic risk to Portsmouth derives from Morne aux Diables (**Figures 4.12 and 4.20**). **Figure 4.12** shows that the likelihood of an eruption here is lower than Roseau. A future Morne aux Diables eruption would subject Portsmouth to ashfall and potentially pyroclastic flows. While the impact of volcanic risk is greater than other hazards the relative frequency of eruptions is thousands of years, therefore the perceived risk is low.

Figure 4.19 shows the projected areas of risk for the different outlined hazards in Portsmouth highlighting the vulnerability of the coastal area to the risk from multiple hazards. **Figure 4.20** shows the density of the Portsmouth population confined to the coastal plain, in valleys and its position between the volcano and the bay. It also reflects on the potential of past events and the variability in building quality which may mitigate against these potential hazard risks.



Figure 4. 19 Hazard risk map for Portsmouth showing selected hazards. Notes - green – volcanic; red – tsunami; blue – flood; yellow landslide.



Figure 4. 20 Located images representing hazard risks in Portsmouth. Notes - 1) cold volcanic spring in the crater of Morne aux Diables, 2) ignimbrite deposits from previous Morne aux Diables eruptions, 3) view towards Portsmouth from the Cabrits NP, 4) church rebuilt after 2004 earthquake , 5) playing fields built on coastal lagoon, 6) housing built on coastal lowlands in central Portsmouth, 7) Portsmouth secondary school, a hurricane shelter.

4.7.3 Hazard risk in Castle Bruce

The village of Castle Bruce is located on the discordant Atlantic coastline, just south of the Kalinago Reserve. Castle Bruce sits within a large bay bound by two adjacent headlands. The embayed feature is a large valley eroded from Morne Trois Piton or Diables volcano. Castle Bruce extends across the northern side of the bay and continues uphill, westwards, away from the coast. Its easterly aspect puts it directly in the path of Atlantic storms and hurricanes. These present the greatest threat and most frequent risk to Castle Bruce as these could cut routes to the capital via Ponte Casse or north to the airport. Flood damage to the valley would impact agricultural use.

Figure 4.21 shows flood risk in the valley around the Castle Bruce River. While this does not present a direct risk to the entire village its flooding can cut off agricultural land and the route towards Delices and Petite Savanne (**Figure 4.22**). One major threat to the village is from landslides (**Figures 4.22 and 4.23**). The village is built on a slope towards the sea and is backed by steep slopes inland. Excessive flood events could lead to surface flow and the saturation of the ground leading to landslips and flows. While landslides do not pose an immediate risk to housing, they can cut off north-south access routes isolating the Kalinago Territory and access west towards Roseau.

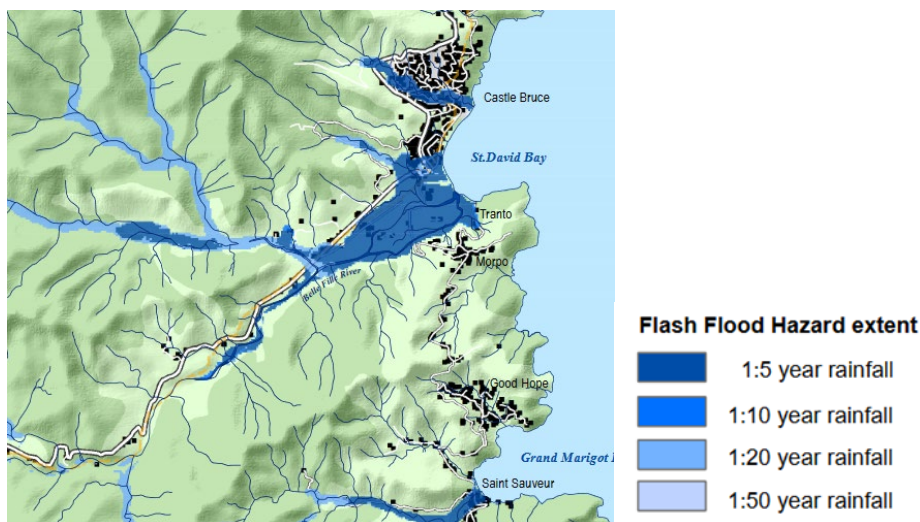


Figure 4. 21 Flood risk in the Castle Bruce area (after van Western, 2016)

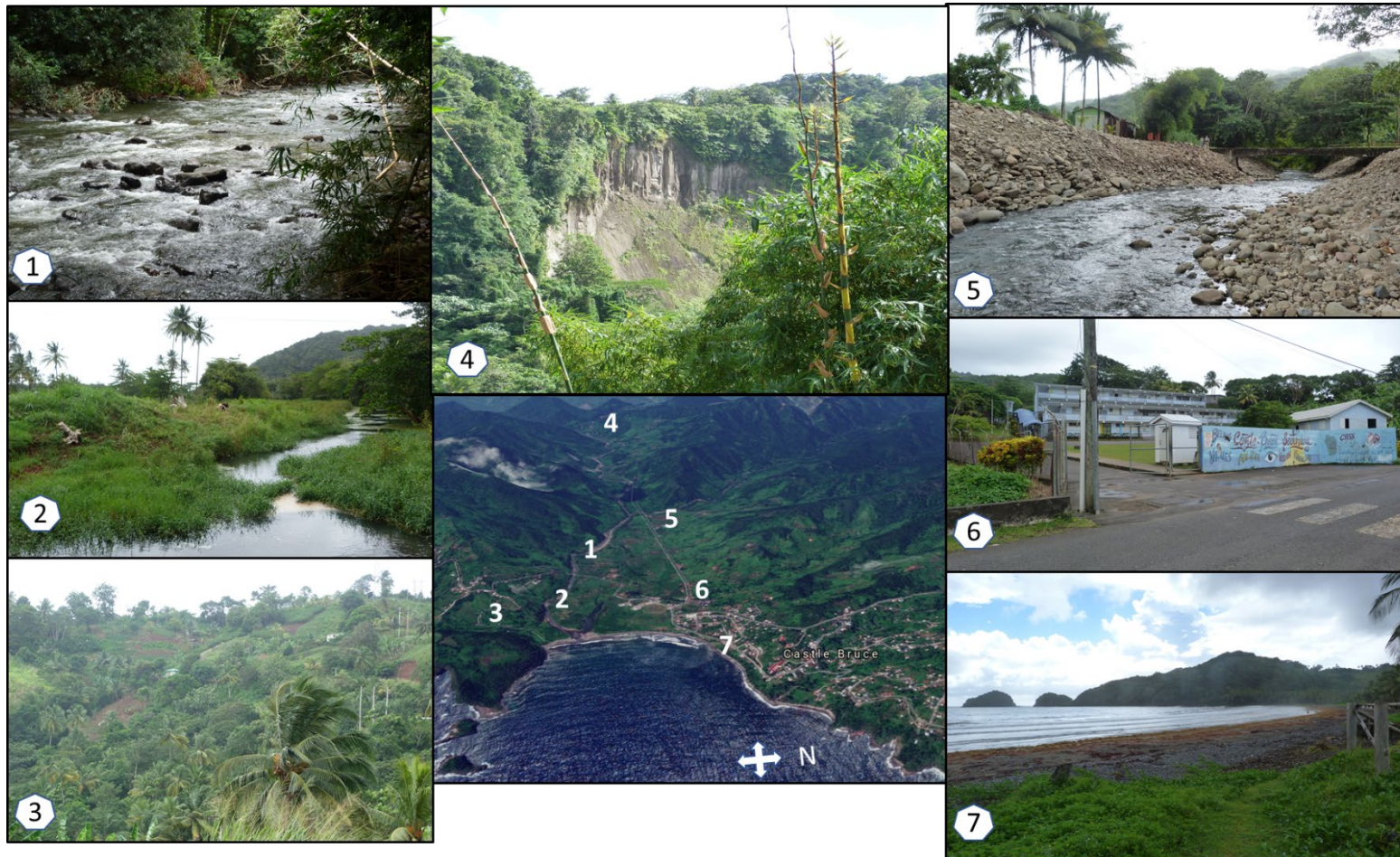


Figure 4. 22 Hazard risks in Castle Bruce. Notes – 1) large fluvial deposits in the Castle Bruce River, 2) swamp section of Castle Bruce River near mouth – flood risk; 3) Landslide scars on surrounding upland areas, 4) steep escarpment at the valley head west of Castle Bruce; 5) unsorted deposits forming a levee on a tributary of the Castle Bruce River, 6) Castle Bruce school, a local hurricane shelter, 7) view across St. David's Bay towards the southeast

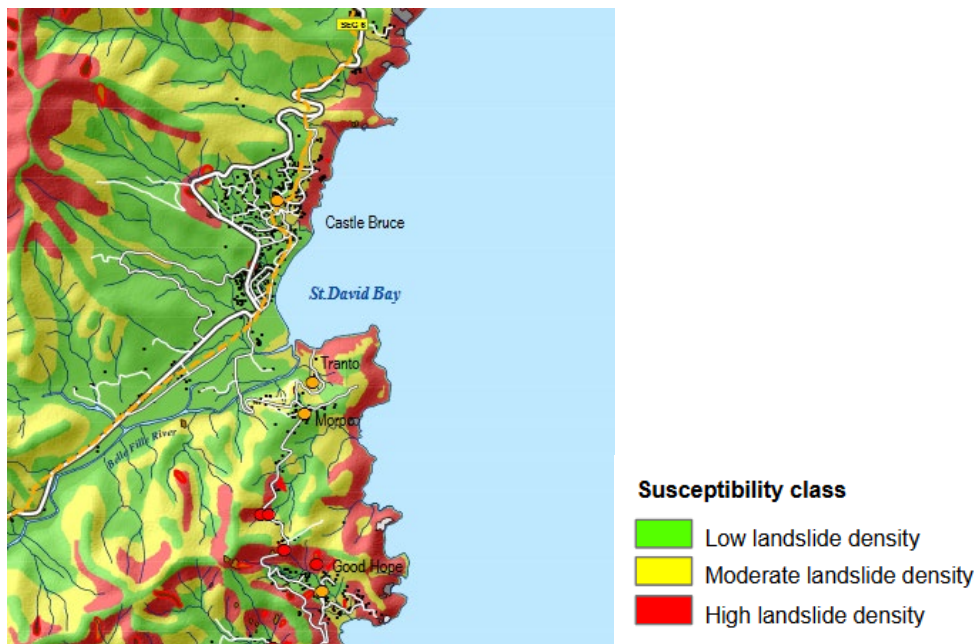


Figure 4. 23 Landslide risk around the Castle Bruce area (after van Western, 2016)

Tsunami also threatens Castle Bruce (**Figure 4.24**) as the village directly faces the South American / Caribbean plate boundary (Ward and Day, 2001). Although a low probability, seismic activity at this boundary has the potential to create tsunamis which would build towards the island and amplify in the bay leading to extensive damage to agricultural land and houses in the lower reaches of the village (Owen and Maslin, 2014). Ward and day also outline the possibility of a tsunami generated by ocean island collapse (2001). Those on the upper slopes would be out of danger (**Figure 4.22**) Proximity to the tectonic boundary could lead to earthquake activity and instability on the steep coastal slopes increasing landslide risk.

The threat of volcanic activity is less likely here than in Roseau or Portsmouth (**Figure 4.12**) but pyroclastic fallout from a large-scale eruption could fall on the village. The Castle Bruce River valley could be a route for pyroclastic flows, however, the risk for this is low (**Figure 4.22 and 4.24**).

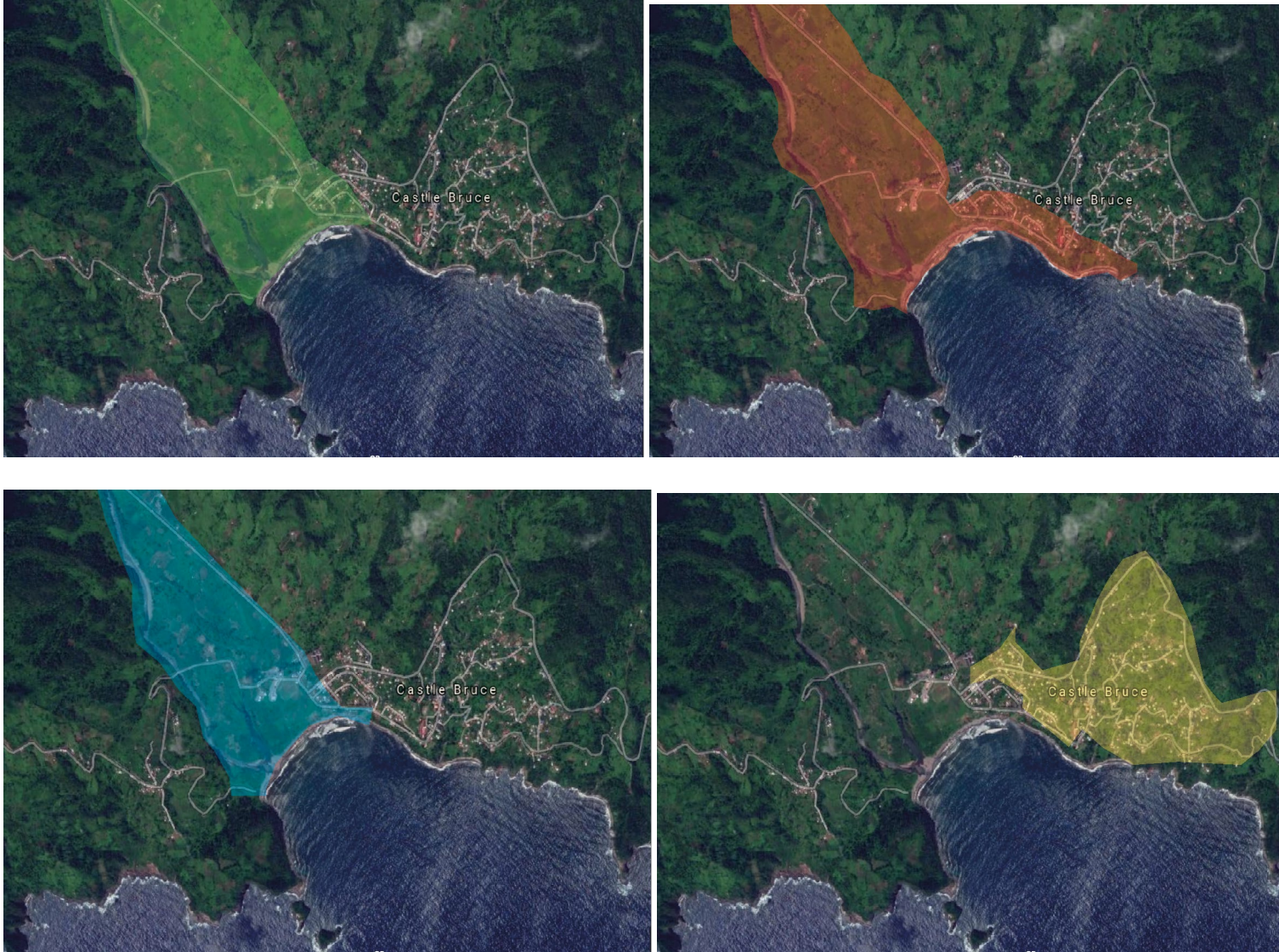


Figure 4. 24 Hazard risk map for Castle Bruce showing selected hazards. Notes = green – volcanic; red – tsunami; blue – flood; yellow landslide.

4.7.4 Probabilistic analysis of Dominican hazards

Using the information of past documented natural hazards in Dominica (Honeychurch 1995, Lindsay et al 2005a, Barclay et al 2019 and Van Western 2016) it is possible to calculate a crude measure of probabilistic disaster risk return rates. Using data since 1745, **Table 4.2** shows calculated probabilistic return of studied hazards. One significant limitation of this method is the omission of smaller scale hazards such as landslides. All values represent hazards across Dominica and do not account for spatial variations.

Table 4. 2 Probabilistic returns for hazards in Dominica

	Frequency events	Relative return period 1745-2018	Published probabilistic frequency of disaster risk.
Hurricane	69	3.96	Intervals Tropical Storm – 2.9yrs Category 1 – 5.8 Category 2 - 13.6 Category 3 – 23.8 Category 4+ - 125 (Wagenseil and Watson, 1996)
Flood	19	14.39	1 per 5-9 years (van Western, 2016)
Earthquake	23	11.87	>6Ma 1 in 55 years Barclay et al, 2019)
Volcanic eruption	2	136.5	6 per 10000 years (UWI, 2013)
Landslide	76	3.59	104 landslides per year (van Western, 2016)
Tsunami	0	273+	1 in 500 years (Harbitz et al, 2012)

Based on results in **Table 4.2**, observations in Dominica and conversations with Dr Lennox Honeychurch, **Table 4.3 and 4.4** shows hazard threat ranked, by most to least likely per location for short term and long-term occurrence. This data gives an indication of likely hazard risk but is based

on local perception and cannot therefore be definitively defined. However, for this study it serves as a useful benchmark to show likely hazard risk in 2013/4 during the start of the study period.

Table 4. 3 Short-term hazard recurrences in Dominica study locations (1-100-year recurrence interval)

Order of hazard risk (occurrence)	Roseau	Portsmouth	Castle Bruce
Most	Flooding	Hurricane	Landslide
	Landslide	Flooding	Flooding
	Hurricane	Earthquake	Hurricane
	Earthquake	Landslide	Earthquake
	Volcanic Eruption	Volcanic Eruption	Tsunami
Least	Tsunami	Tsunami	Volcanic Eruption

Table 4. 4 Long-term hazard recurrences in Dominica study locations (100-1000-year recurrence interval)

Order of hazard risk (impact)	Roseau	Portsmouth	Castle Bruce
Most	Hurricane	Hurricane	Hurricane
	Flooding	Earthquake	Earthquake
	Volcanic Eruption	Volcanic Eruption	Tsunami
	Earthquake	Flooding	Landslide
	Tsunami	Tsunami	Flooding
Least	Landslides	Landslides	Volcanic Eruption

Judgement of hazard risk is dependent on time vs. magnitude. A direct hit by a large-scale hurricane would cause universal damage across the island and therefore represents the greatest risk in terms of impact and magnitude. The geography of each area determines potential impact otherwise; Roseau surrounded by potentially explosive volcanoes, and Portsmouth located close to fault lines and Morne aux Diabes. Castle Bruce, relatively distant from volcanic threat but facing a tectonic

boundary, would have much greater risk and impact from tsunami and earthquake activity which have the potential to trigger large scale landslides.

4.8 DRR in Dominica

Disaster risk reduction at a national level was initialised after the impacts of Hurricane David in 1979, evidence by no mention of DRR in The Constitution of the Commonwealth of Dominica Chapter 1:01 of November 1978 (UNISDR, 2014). The Emergency Powers Act of 1987 first captures DRR in legal framework. The first National Emergency plan was developed in 1986, rewritten in 2001 and updated in 2009 (UNISDR 2014). Management of hazard response and disaster reduction is organised as a top-down structure through the National Emergency Planning Organisation (NEPO), run by central government, and managed on a day-to-day basis by the Office of Disaster Management (ODM), supervised by the Minister for Climate Resilience, Disaster Management and Urban Renewal. **Figure 4.25** shows the organisational structure for the implementation of disaster management.

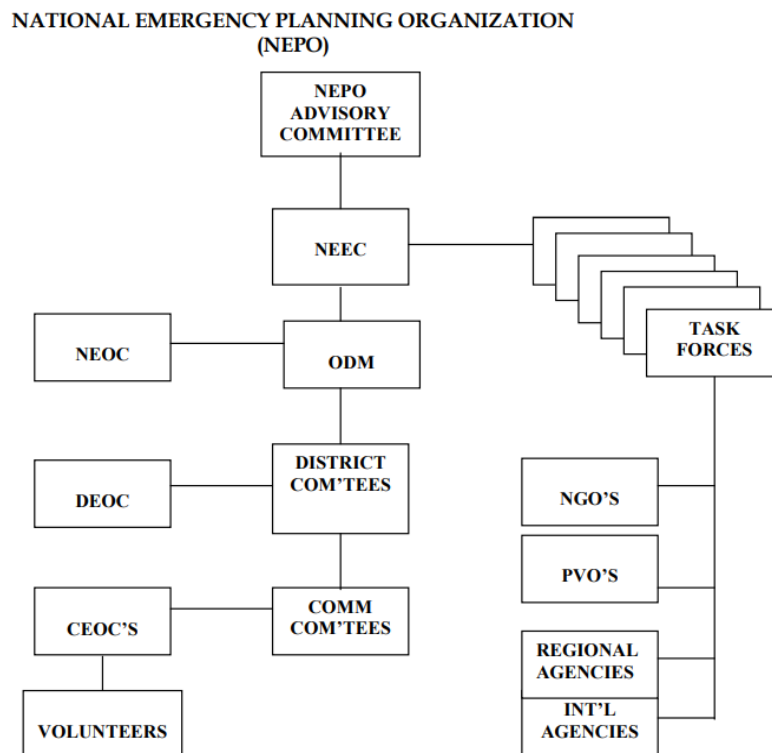


Figure 4. 25 National Emergency Planning Organisation for Disaster Management from the National disaster plan 2001 (NEPO 2001)

The key policies are outlined in the 2001 National Disaster Plan which outlines the roles and functions of NEPO before, during and post disaster. The work of ODM is overseen by the Justice, Immigration, and National Security department in government. It is the responsibility of the ODM to conduct day-to-day disaster risk reduction activities and to work on behalf of the government to co-ordinate commercial and national interests to implement the National Disaster Plan. During a disaster event the responsibility of risk reduction is primarily through NEPO and NEEC but in collaboration with the ODM and outside agencies. During disasters Dominica can seek assistance from a regional management framework through CDEMA.

The Caribbean Disaster Emergency Management Agency (CDEMA) (formerly CDERA) coordinates emergency response and relief efforts regionally, as well as establishing a practice of Comprehensive Disaster Management amongst its members. Dominica is a member of CDEMA. Their programs include the implementation of Early Warning Systems, a Caribbean Safe School Programme.

In addition to policy set by national and regional governments, Non-Governmental Organisations also work in the country to provide ongoing support. The Red Cross have permanent offices in Roseau and offer educational support, resources, and post disaster relief. Most recently IsraAid has been working with the Ministry of Education to provide post Maria DRE and support across Dominica.

The basis of the national disaster plan is to follow the stages of the disaster management cycle with an emphasis on planning, preventing and mitigating risk. **Figure 4.26** shows the process of communication during an emergency response. The National Emergency Operating Centre, set up by NEPO / NEEC act as a central conduit for disaster risk communication. **Figure 4.26** shows that the main emphasis for communication is through email, cellular phone and radio. The fragility of these communication systems was exposed in the aftermath of Hurricane Maria because of the scale of the event and the loss of infrastructure.

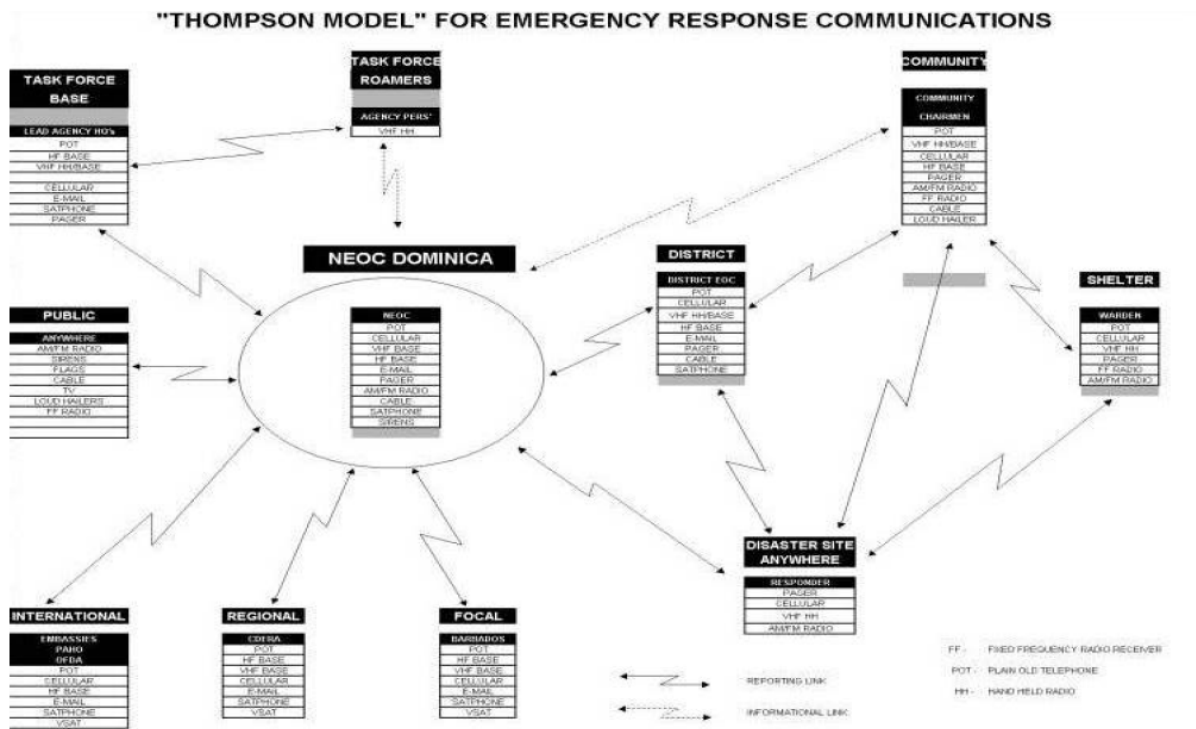


Figure 4. 26 Communication channels for emergency response in Dominica.

4.9 The education system in Dominica

Education in Dominica is compulsory between the ages of 5 to 16. Students attend primary school until the age of 11 and then secondary school between the age of 11-16 years. Schools provide free textbooks for students aged 5-14 and a governmental Trust Fund supports students who cannot provide resources for themselves or the cost of tuition beyond secondary school. At secondary school students study the Caribbean Examination Council qualifications. At secondary school students study a wide curriculum in form 1 – 3 between the ages of 11-14 years old. At 14, in the 4th form students undertake a 2-year Caribbean Secondary Education Certificate (CSEC). Post-secondary school, students’ study for the Caribbean Advanced Proficiency Examinations (CAPE) which are the equivalent to A Levels. Currently Dominica has one State College, located in Roseau. Many of the students continuing in education leave the island to study at the University of West Indies on Barbados, Antigua or Trinidad or travel further afield to the USA university system.

Teachers are not required to be qualified to the same level as the UK. Students leaving State College can attend Teacher Training College and then are given the opportunity to work in schools, allocated by the government. Some schools only employ teachers with university degrees; however, this is not a requirement by the Ministry of Education who oversee educational provision.

Students may study natural hazards and elements of disaster risk reduction, during social sciences (Form 1-3) however depth of this coverage is largely dependent on the individual teacher input. Formal coverage of natural hazards is part of the Geography CSEC, course which educates students about natural hazards in a wider context and across the Caribbean. There is a heavy focus on atmospheric hazards. Between 20-30% of students were observed to study geography at CSEC level. Some schools have general disaster reduction co-curricular activities, but these are not standardised and may coincide with national events or the onset of hurricane season. Implementation of DRE was dependent on teacher input until 2017/2018 when the government initiated its “*Climate resilience programme*” (CRRP, 2020). Part of this has included improving DRE in schools. By July 2018, all schools were expected to have a disaster plan.

4.9.1 Selected schools for the study

The selection of schools for this study was completed in agreement with the Dominican Ministry of Education and the willingness of local principals. Our choice also reflected the different types of educational establishments in Dominica. Roseau and Portsmouth were selected as major settlements on the island. Schools in Roseau included Convent School (school 1), an academically advanced state girl’s grammar school, and Orion Academy (school 2), a small private secondary school with students from expat communities. Originally, a large state school in Roseau, Dominica Grammar School was but due to a change in principals and high staff turnover it was not possible to continue. Portsmouth Secondary school (school 3) is the major secondary school on the north of the island taking from a catchment around the Morne aux Diaboles volcano, to Vielle Casse and Capuchin in the north to Salisbury in the south. Castle Bruce secondary (school 4) was selected owing to its relatively remote location on the east coast and proximity to the Kalinago reserve who send students to this school.

The selected schools represented contrasting locations and therefore hazards (**Figure 4.27**). Both Roseau schools are near the Roseau River and the exposed floodplain. They are subject to potential volcanic activity surrounding the Roseau valley, from Trois Piton, PPVC and Micotrin. School 1 is built on the alluvial fan in Roseau and potentially subject to earthquake tremors due to the unconsolidated material it is built on. School 2 is perched on the valley side, near the Bath estate, and at risk from landslides.

School 3 is built on the flanks of Morne Aux Diaboles, approximately 1km inland from the main Portsmouth centre. While being safe from tsunami threat and flood risk and built away from steep

slopes it is mainly at risk from large-scale flank collapse from the volcano. The building is used as a hurricane shelter.

School 4 is in the lower catchment of the Castle Bruce River valley, but away from the main coastal settlement of the village itself. Located on the valley sides, rather than on the agricultural floodplain, it is not directly at risk from the river, however, is crossed by a series of gullies and backed by steep slopes. These could bring falls or flows from upper valley sides. It faces the eastern coast therefore is subject to wind hazards but is a designated hurricane shelter. The varying nature of hazards affecting each school was a factor in their choice.

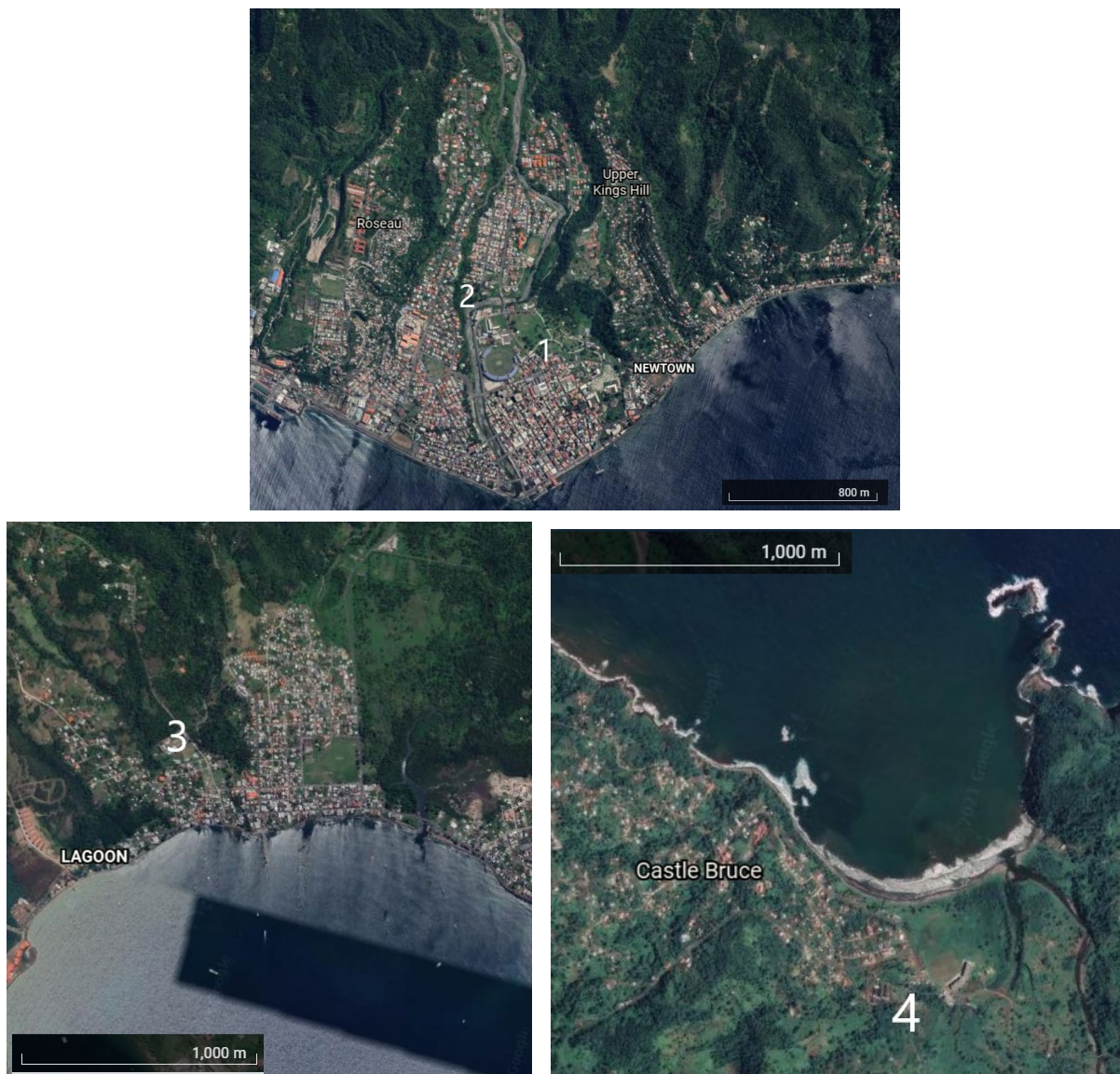


Figure 4. 27 Maps showing numbered school locations – School 1 and 2 in Roseau, school 3 in Portsmouth and school 4 in Castle Bruce (source Google Earth).

Chapter 5 – Results and Analysis (Longitudinal PRISM data)

5.1 An introduction to the results and discussion section

Chapter 5-7 will summarise the data collected during the study period 2013-2018. However, reflecting on the interdisciplinary nature of the work it will be presented, analysed and discussed in three concurrent chapters.

This study started with two aims:

- I. To understand how student disaster risk perception changes longitudinally in a multi-hazard environment.
- II. To evaluate the role of different educational measures in improving student awareness of disaster risk.

To achieve these 6 objectives were set (**section 1.7 and 1.8**). However, changes to the study (**outlined in chapter 3**) have meant that the original research questions have been amended slightly to account for the occurrence of Tropical Storm Erika (2015) and Hurricane Maria (2017).

The study of student perception change over time remains at the core of the study and we assess this in the context of using PRISM. However, changes to the intended perception (PRISM) studies were altered so that students perceived learning was conducted through non-parametric ranking and the third PRISM exercise was not conducted for this study. The occurrence of the disaster events presented an opportunity to understand how these events impacted DRR in Dominica. Therefore, a qualitative assessment of how DRR experts and officials coped with and made changes to their actions because of the events occurring since 2015-2018 (tropical storm Erika and Hurricane Maria) has been included. This educational focus of this study did not change in line with the original aims, despite taking place around the disaster events. The following research questions / themes will be presented with analysis in 3 chapters; i) quantitative longitudinal analysis using PRISM, ii) Evaluating the role of the DRR agencies in response to the disaster events, and iii) The impact of education approaches on student DRE.

1) The effectiveness of PRISM as a perception tool (**Chapter 5**)

2) A review of the PRISM exercise to understand longitudinal multi-hazard perception change. This will assess the impact of the disaster events on these perceptions and variations in perception

because of gender and location. This will also include reference to the qualitative reasons for change given by the students (**Chapter 5**).

3) A review of student socio-economic background to understand the extent to which this influences mitigation (**Chapter 5**).

4) A review of the management of DRR by the key organisations involved, between 2013-2015, because of Tropical Storm Erika and after the events of Hurricane Maria (**Chapter 6**).

5) An assessment of the methods by which students learn about hazards (**Chapter 7**)

6) A review of the educational methods employed between 2016-2018. This analysis will be made in the context of perception change, with reference to PRISM data and through an evaluation of each technique of each technique based on student feedback and outcomes. This will assess the impact of educational methods on student perception and attempt to analyse the appropriateness of use in DRE (**Chapter 7**).

Each chapter will deal with a separate theme as outlined. **Chapter 8** will then offer recommendations for future research based on the presented outcomes and then link back to the study aims in the conclusion.

5.2 Introduction to Chapter 5 – Analysis of longitudinal data from PRISM.

This chapter seeks to address the PRISM data collected during the study. This study has been designed to test a new method for collecting perception data (PRISM) and to understand the patterns shown in the longitudinal study of student perceptions. It will aim to address the following objectives:

- The effectiveness of PRISM as a perception tool (**Section 5.3**) – this will focus on the validity of the data presented using the PRISM method.
- A review of longitudinal perceptions (**section 5.4**) – this will seek to understand how perceptions of hazard risk change over time. It will assess how these changing perceptions are affected by location and gender (**section 5.6**).
- A summary of qualitative data of hazard perception– (**section 5.5**) – this will seek to understand the student reasoning for their risk placement of hazard perceptions and find links between these reasons.

- A correlate study to understand the link between socio-economic background and DRR actions (**section 5.7**) – this section seeks to understand whether the data collected from the questionnaire part of the PRISM survey shows a link between student parental education levels and actions taken to reduce disaster risk.

Each section will present the data and include a discussion to address the relevant research objective.

5.3 – The effectiveness of PRISM as a tool to measure perception.

One of the aims of this study is to assess the change in student perception longitudinally. This section will assess the validity of the data for use in assessing trends. It will attempt to do this through a series of statistical techniques to help validate the data (as outlined in section 3.7.1). As PRISM data (for exercise 1) looks at mean values, the use of the Cronbach Alpha test will show the extent to which the mean data values are valid. To help understand the extent of error with the mean a calculation of the Standard Error of the Mean will be made and Standard Deviation to understand the spread of data round the mean. This will be followed by a Shapiro-Wilk test to understand the extent to which the data is normalised, as this is a base requirement for other statistical tests.

5.3.1 Reliability of SHS mean data scores.

PRISM data from exercise 1 will be used to assess the changes in perception of students in the different schools. This study uses the mean SHS scores for the period of visits between 2014 and 2018. Although results for 2013 are given, small sample sizes constrain the mean values. All results from 2014 onward employ the alternative PRISM method outlined in the method section. Before analysing the changes in SHS values it is necessary to test the reliability of the mean data, using the Cronbach Alpha test for each hazard (**Table 5.1**).

Table 5. 1 Cronbach Alpha (α) scores for PRISM data exercise 1 (emboldened values show data classified as 'Poor – 5.0-6.0' or 'Unacceptable - <5.0' based on George and Mallory's classification (2003))

School	Hurricane	Flood	Earthquake	Volcanic	Landslide	Tsunami	Car
1	0.817	0.798	0.829	0.885	0.884	0.910	0.845
2	0.657	0.885	0.723	0.734	0.933	0.851	0.340
3	0.916	0.899	0.932	0.851	0.851	0.910	0.908
4	0.543	0.793	0.623	0.728	0.762	0.545	0.593

A reliability analysis was carried out for the data for each hazard perception from each school (section 3.7.1). The car value in school 4 (0.593) is classified “questionable” reliability based on this measure. This is surprising as the hazard associated with cars was expected to be consistent over time as this perceived a consistent problem. School 4 has low car ownership which may explain a lack of reliability, though this cannot be used for School 2. Consequently, this study will omit perceived car hazard from our analysis. Based on **Table 5.1** School 4 has poor reliability for Tsunami and Hurricane but is acceptable otherwise.

The high levels of reliability shown with this data justifies the use of PRISM as a technique to test changing perception scores. Were students inconsistent in their scoring over time, the Cronbach Alpha score would highlight this, although inter-rater reliability tests could also show this.

5.3.2 Error in SHS mean scores.

The data shown in **Table 5.2** represents the mean SHS score for each hazard during each visit, for each school. Values for standard error of the mean and standard deviation are also included, calculated in SPSS (UCLA, 2020). The standard error of the mean (SEM) refers to the estimated deviation of the sample mean within a population. Therefore, a larger SEM gives us less confidence in the sample mean. The standard deviation represents the dispersion of the values around the mean. Therefore, an increased standard deviation represents a wider spread of values around the data. In the context of perception values, larger standard deviations represent a wider range of opinion around the mean value, which will take for this study as meaning less certainty of the likely risk of that hazard. Smaller SEM values reflect the variation of our sample mean compared to a likely mean in a wider population. Therefore, smaller values will give greater confidence in our mean. In this section we will comment on the confidence of hazard mean values before we analyse the change in longitudinal change in SHS values.

The school 1 (**Table 5.2**) SEM values for hurricanes became smaller during the study period, suggesting more agreement in these. The standard deviations are consistent between 2.5-3.5cm after 2016, though April 2016 value is anomalous in comparison. Values for flooding are more consistent except for 2014 data, with SD ranging from 5.90-7.10cm. For the other hazards there is a general consistency in the values. The 2014 data often gives a higher SEM and SD except for Earthquake and Landslide values. SEM varies also in the 2018 data suggesting a broader range of views. All mean values are below 2.0 SEM suggesting relatively low variance.

The school 2 SEM values show greater variance than school 1 students reflecting sample size differences. Students at school 2 have greater ranges in SD values for hurricane, flood and landslide hazards, but similar ranges for the geophysical hazards (earthquake, volcano and tsunami). SEM values are over 2 for the volcanic mean value, suggesting that there is a difference in opinion linked to this hazard. Students also gave greater variance in their responses in April 2017.

Table 5. 2 Changing mean SHS scores (2014-2018), values for SEM and SD for each hazard.

		H	SEM	SD	F	SEM	SD	EQ	SEM	SD	VE	SEM	SD	L	SEM	SD	T	SEM	SD
School 1	Oct 2014 n=24	4.6	.90	4.43	14.5	1.57	7.68	12.4	1.29	6.30	10.7	1.65	8.08	11.2	1.38	6.77	19.1	1.58	7.75
	Apr 2016 n= 26	7.3	1.2	6.32	10.5	1.26	6.43	13.3	1.54	7.85	16.9	1.36	6.93	6.4	1.23	6.26	23.2	1.27	6.48
	Oct 2016 n= 25	4.5	.76	3.56	12.6	1.21	6.06	16.3	1.43	7.17	13.8	1.61	8.06	10.9	1.60	8.00	24.4	.94	4.70
	Apr 2017 n= 30	6.3	.58	3.17	11.6	1.08	5.90	13.6	1.06	5.80	16.0	1.22	6.70	10.7	1.26	6.92	23.9	.97	5.30
	Apr 2018 n= 26	2.8	.50	2.55	8.5	1.39	7.10	17.2	1.13	5.77	18.1	1.40	7.14	12.7	1.75	8.91	26.7	1.65	8.43
School 2	Oct 2014 n= 15	7.2	1.42	5.51	15.3	1.90	7.35	14.4	1.53	5.94	15.8	2.00	7.72	9.8	1.45	5.61	23.3	1.72	6.67
	Apr 2016 n= 16	9.9	2.03	8.12	16.4	1.46	5.85	9.6	1.81	7.23	11.8	1.63	6.53	10.7	1.88	7.50	23.1	1.49	5.98

	Oct 2016 n= 18	9	1.43	6.06	13.9	1.91	8.10	9	1.11	4.71	12.6	2.01	8.52	11.9	1.85	7.84	21.0	1.82	7.72
	Apr 2017 n= 18	7.2	1.35	5.73	15.2	2.15	9.11	13.2	1.68	7.13	13	2.05	8.68	13.9	2.06	8.76	22.0	1.81	7.70
	Apr 2018 n= 20	5.7	1.29	5.76	12.2	1.80	8.04	12.8	1.46	6.52	11.7	1.22	5.44	11.8	1.95	8.74	16.2	1.71	7.64
	School 3																		
	Oct 2014 n= 12	6.3	1.14	3.94	14.3	2.97	10.30	11	1.87	6.47	13.3	2.4	8.31	12.6	2.37	8.20	19.7	3.05	10.58
	Apr 2016 n= 24	8.0	.85	4.16	14.8	1.74	8.55	16.9	1.53	7.51	20	1.54	7.52	16.1	1.39	6.82	23.7	1.41	6.89
	Oct 2016 n= 22	6.7	.82	3.84	14.9	1.31	6.13	11.0	1.33	6.25	14.6	1.73	8.11	11.3	1.28	6.00	23.2	1.16	5.43
	Apr 2017 n= 24	7.3	.63	3.10	15.0	1.27	6.25	12.9	1.26	6.16	17.0	1.52	7.47	13.9	1.37	6.72	23.3	1.01	4.92

	Apr 2018 n= 17	3.7	.52	2.16	10.4	.99	4.07	14.9	1.19	4.92	17.4	1.10	4.55	9.8	1.16	4.78	22.9	1.45	5.98
School 4	Oct 2014 n=20	8.1	1.82	6.57	17.7	1.93	6.95	19.1	1.57	5.66	19.5	2.33	8.40	15.5	1.88	6.79	17.5	2.79	10.08
	Apr 2016 n=28	7.1	.54	2.97	16.0	1.46	7.98	13.8	1.04	5.70	20.9	1.16	6.36	8.5	.85	4.66	24	.97	5.31
	Oct 2016 n=29	5.4	.42	2.28	15.5	1.28	6.91	10.9	.95	5.09	19.8	1.26	6.80	9.8	1.05	5.66	22.4	1.13	6.08
	Apr 2017 n=30	8.2	.86	4.54	15	1.33	7.04	11.9	.91	4.82	18.7	1.08	5.70	11.5	1.13	6.00	22.4	.93	4.91
	Apr 2018 n=13	2.4	.31	1.38	8.7	.84	3.74	15.8	1.13	5.05	21.6	1.11	4.97	7.4	1.13	5.03	21.8	1.05	4.70

Key to table – n = number of students per session; H = Hurricane, F = flood, EQ = Earthquake, VE = Volcanic Eruption, L = Landslide; T = Tsunami; SEM = Standard error of the mean; SD = Standard deviation. Green boxes and emboldened values represent high variance (SEM) >2.0. Yellow boxes (bold text) represent SD over 66% of the mean.

Results in school 3 are like school 1 and 2. Hurricane SEM values start high and reduce over time. While school C shows similar ranges in SD patterns with school B, larger ranges on geophysical hazards. Greater variance in the data is evident from the 2014 cohort. Through the study period SEM values and SD values reduce, suggesting greater agreement in hazard perceptions.

School 4 has similar patterns to school 3 but is less extreme in variance. 2014 values return notably higher SD values for hurricane, volcanic eruption, and tsunami. Both SEM and SD values reduce over time, with clear falls for both hurricane and flood in 2018. Variance for other hazards rises across the cohort in 2018.

Overall, there is a similar pattern across the schools with relatively low SEM, except in first form students (2014) suggesting that this may be either caused by the age of the students or, in the case of school 2 the sample size. Perception of hurricane hazard gives the average lowest variance reflecting its frequent occurrence, although it has the highest SD variance of hazards. This may reflect the wide-ranging opinions or examples of variance around the low clustered mean SHS scores. School 1 and 2 show higher SD scores than the other schools suggesting a wider range of views, however generally SD scores are within 66% for most hazards, except hurricanes and landslides. School 3 has relatively low variance based on SD. Younger students (values from 2014) have slightly higher SEM and SD scores, suggesting that perception becomes less erratic with age. Generally over time the variance decreases across all hazards especially for regularly experienced in Dominica (hurricanes, floods and landslides). Post Hurricane Maria values have led to increased variance in some schools, for some hydrometeorological hazards, which may reflect the experiences encountered by these students. The lack of variance in the data suggests therefore that with increased use of PRISM testing and with increased age there is greater familiarity with the technique, improving its validation for use.

5.3.3 Data validation for mean SHS scores

Statisticians like to test whether distribution of data is normal because statistical tests, such as t-tests, assume a normalised data set. Shapiro-Wilk (SWT) tests this if data with a $p = >0.05$ score is not normalised (Van den Berg 2020). Van den Berg (2020) indicates that sample sizes >20 , because of the 'central limit theorem', will be normally distributed. Therefore **Table 5.3** shows the results of SWT for exercise 1 PRISM data on hazard risk perception.

Table 5. 3 SWT test of normality of data, by school, hazard, and time.

		H	F	EQ	VE	L	T
School 1	Oct 2014	.00	.57	.20	.05	.07	.01
	Apr 2016	.01	.15	.36	.58	.16	.00
	Oct 2016	.11	.56	.07	.04	.01	.00
	Apr 2017	.73	.18	.28	.16	.08	.00
	Apr 2018	.02	.55	.35	.68	.03	.04

		H	F	EQ	VE	L	T
School 2	Oct 2014	.02	.26	.40	.10	.88	.01
	Apr 2016	.09	.85	.01	.72	.10	.00
	Oct 2016	.89	.13	.14	.23	.38	.00
	Apr 2017	.00	.18	.28	.07	.05	.00
	Apr 2018	.00	.79	.11	.32	.01	.54

		H	F	EQ	VE	L	T
School 3	Oct 2014	.01	.13	.04	.62	.03	.01
	Apr 2016	.23	.21	.19	.15	.07	.00
	Oct 2016	.25	.72	.92	.26	.37	.01
	Apr 2017	.21	.97	.20	.83	.29	.04
	Apr 2018	.31	.54	.89	.75	.08	.00

		H	F	EQ	VE	L	T
School 4	Oct 2014	.12	.76	.57	.03	.26	.01
	Apr 2016	.96	.41	.91	.20	.38	.00
	Oct 2016	.00	.20	.03	.37	.01	.00
	Apr 2017	.00	.88	.11	.19	.19	.00
	Apr 2018	.72	.62	.16	.35	.04	.17

Notes for tables. Key – H = Hurricane, F = Flood, EQ = Earthquake, VE = Volcanic Eruption, L = Landslide, T = Tsunami. Emboldened values indicate a score below $p=0.05$; blue shade represents where sample was $n \leq 20$.

Shapiro Wilk (SWT) determines 'normality' in data. **Table 5.3** shows blue shaded areas to indicate W scores where the sample size is below 20 and the outcome is not normalised (below $p=0.05$). These scores suggest the data is skewed, i.e., a clustering of opinions is towards one end of a data set. This is likely if people agree about the hazard or there are bipolar views. If people are less certain of the likely perceived impact of a hazard, then the scores would represent more of a normal distribution.

A significant proportion of the data shows evidence of non-normal distribution. 60% of the hazards recorded for school 1, 36% of values for school 2, 32% for school 3 and 40% for school 4 do not show normal distribution. This is evident for perceptions of hurricanes (9) and tsunami (14) which have the greatest number of SWT values below $p=0.05$. These high numbers of non-normality suggest that for these hazards that the perceived opinion is grouped around one set of values. For tsunami it is only in 2018 that school 2 and 4 show a normal distribution. In the case of hurricanes, mean group SHS values were often low and both standard deviations and standard error of the mean are lowest for this hazard. For tsunami, it is likely that a grouping of high SHS perceived values shows a

grouping of data between 20-23 SHS. Looking across the data sets skewed distribution is more evident for students in Year 1 (2014) and after Hurricane Maria in 2018.

5.3.4 How effective is PRISM as a tool to measure perception?

The PRISM tool, developed by Stefan Buchi and Tom Sensky (1998 &1999), was designed to measure patient suffering in a metaphorical sense. The original study showed that the distance of disk placement correlated inversely with pain, functional impairment, and depression, but positively with coping. Patients who placed disks closer to “self” had greater control of the illness in their lives and were able to manage it more effectively (Buchi and Sensky, 1998 &1999). Other benefits of this method were the ease with which patients understood the concept (Buchi and Sensky, 1998, Kassardjian et al, 2008) and the speed with which it could be conducted (Buchi et al, 2002). Krikorian et al, (1999) and Lima-Verde et al, (2013) showed the potential for the method to be used across languages. Initial studies also showed that longitudinal samples taken showed high correlation scores at 0.95 ($p<0.001$) and 0.79 ($p<0.001$), validating its use as an alternative means to measure the patient view of suffering / ability to cope (Buchi et al, 2002, Cox et al, 2015, Fotiou et al, 2015). The consequence of this validation was that Sensky and Buchi felt the benefits associated with PRISM could lead it to being a useful research tool (Sensky and Buchi, 1999, Buchi et al, 2002) to gather attitudes to health, the environment or workplace (Sensky and Buchi, 2016). Zimmerman et al, (2013) were the first to use the technique beyond the study of suffering, instead using PRISM to appraise hazards faced by travellers and experts. Since then, a series of uses have been proposed for PRISM including psychological assessment of employees (Roman-Calderon et al, 2020), offender assessments (Buchi and Sensky, 2016). The use of PRISM was identified as useful with children (Cox et al, 2014). In recent studies Parham et al, (2015), Yildiz et al, (2020) Bodas, (2020) used PRISM to assess attitudes towards short term hazard perception. This study used PRISM to assess longitudinal perception and influences on it, for a contrasting student population, in a multi hazard environment.

To assess the effectiveness of the PRISM tool for hazard perception we will answer the following questions to determine the extent to which our use coped with the benefits and limitations identified by Sensky and Buchi (2016).

5.3.5 Benefits of using the PRISM test.

The use of PRISM in this study followed the same methodology as Sensky and Buchi (Sensky and Buchi, 1998,1999 & 2016). Initially three PRISM exercises were planned with the students, but timing issues meant that attention waned after the first exercise and qualitative responses were brief for later exercises. Therefore, it was necessary to refine the methodology to conduct mass testing without the problems of students biasing each other (Sensky and Buchi, 2016). For the final 4 data collection sessions (between 2016-2018) an adapted methodology, enabling group collection was devised. This approach differed mainly in the use of paper instead of a PRISM board (as in Rumpf et al 2004), stickers instead of disks (Duncan et al, 2005) and students writing comments instead of recording them. While this approach saved enormous amounts of time, completing an exercise for all students in 20 minutes, student comments were limited by their ability to express themselves in writing. This is problematic as one of the constructs of this method was to reduce the use of text, allowing verbal justifications. This study notes that student comments became more detailed over the time, suggesting that older students were more able to express their views about disk placement. Despite this, the method was well understood and the concept, if clearly defined at the start of the exercise, was clearly understood, and remembered in subsequent data collection sessions, saving time on explaining the task. It therefore served as a reliable tool for measuring perception in the context of this study and was understood by students in secondary schools, therefore serving as a potential useful tool for future study.

5.3.6 Use of PRISM with children

Sensky and Buchi (2016) recognise that most of the studies using PRISM have been with adults. Melbardis and Jemec (2011) suggested that use of PRISM with students below 12 years old led to inconsistent responses as they are unable to comprehend the concept of metaphor to express attitudes towards suffering. This study found that all the participants understood the PRISM concept applied to a risk perception context when carefully explained and exemplified at the start, although care was taken not to use examples which may influence the response regarding hazard risk perception. **Tables 5.2 and 5.3** show that across the 4 schools' students at the youngest age, 11, gave slightly more extreme results, than in following years. They tended to group disks close together, and closer to self, except for the risk associated with tsunami. However, in subsequent years individual and class averages show that the data was slightly more spread between the potential range of SHS values of 0-27.5cm. Importantly the order of hazard risk did not often change in the early years meaning that as the students became older, or more familiar with the PRISM

concept, that their perception of risk was still consistent. This consistency was also maintained when the PRISM method was adapted from using a board in form 1 and form 2 (2013-2014) and when using the paper approach in and after form 3 (2015/16). However, the early studies were based on small sample sizes, owing to time constraints with the students, therefore further testing on the understanding of PRISM as students age through secondary school is necessary.

Comments made by students in the qualitative aspect of the study did change over the time series. In early years, form 1 and 2 comments were often briefer and focused on justifying the perceived highest risk hazard. As the students got older many were more open with their comments and willing to explain reasons for a range of disk placements. As mentioned, this may reflect the change in method used to capture this information or just familiarity with the author and interviewing format. The huge benefit of this method was to capture personalised reasoning behind disk placement, particularly after Hurricane Maria and Tropical Storm Erika. It was evident that allowing participants open-ended justifications led to detailed reasoning, particularly among older and adult participants, some who were candid in their approach. Anecdotally, in comparison to open ended responses from questionnaire responses it was evident that the conducting of the PRISM exercise allowed an emotional link between the participant and the interviewer which is not evident from completed questionnaires.

A further benefit of the PRISM method, particularly for use with children is the issue of reading age. The limited use of text in the construction of the exercise allowed the children much greater comfort and allowed both blind, SEND (special educational needs and disability) and students with English as an Additional Language (EAL) to complete the exercise without confusion or need for assistance, if clear examples and instruction were given.

5.3.7 Is PRISM subject to bias?

Kahneman and Tversky (1974) and Kahneman (2012) explain that in collecting attitudes, the respondent can be influenced through the framing concept, where information is presented in a way which may alter their decision. To avoid these standard instructions were given at the start of each session to avoid this problem. However, it is not possible to show whether students were truly affected by framing, in the setting of this task. One judgement can be made when looking at the results. Common results, such as the known impact of hurricanes, or the less perceived risk associated with tsunami (**Figure 5.1 – section 5.4**) show little variation over time, suggesting that such framing bias was not part of the results.

The confirmation bias (Kahneman, 2012) shows that people can make decisions without considering the full range of possibilities, because decisions are made on “*What You See Is All There Is*”, i.e., you are influenced by what you are familiar with, or equally not familiar with. Students in each of the schools collectively placed hurricanes as the greatest risk, while tsunami as the least likely risk (**Figure 5.1 – section 5.4**). This supports the view of Kahneman and Tversky, (1974) that “*people only recognise the threat in front of them, not those in the distance*”. These represent the hazards most perceived to be faced and never faced. Therefore, the students are hard-wired with the confirmation bias towards their risk perception. On the PRISM board this is represented by students placing the hurricane disk, often, very close to self, despite not experiencing one directly, or placing tsunami at the furthest point away from self because they have not experienced one without considering the impact of such events. This highlights a potential problem with the rectangular design of the PRISM board, as it encourages the placement of extreme perception values (**chapter 8**). Interestingly, this was not the case for volcanic eruptions, another hazard not experienced on Dominica but had mixed positioning on the PRISM board. One of the benefits of using PRISM over the Likert method for assessing perception is the ability to have a continuous scale. However, the shape of the board influences the direction of the disk placement, therefore biasing the placement of disks in one area of the board. One suggestion for future research could be a redesign of the board to alleviate this problem (**section 8.1**).

5.3.8 PRISM reliability

Validation of the PRISM test shows that samples taken over short time periods (2-6 hours) indicate strong positive correlations above 0.79 ($p < 0.001$) indicating that the use of the test for testing suffering is valid (Buchi and Sensky, 2002) and these results were repeated in later studies (Cox et al, 2015, Fotiou et al, 2015). No study has used PRISM to test multi-hazard risk perceptions over time. The time periods used in this study are not short term like those used by the studies mentioned therefore it was necessary to test statistically to determine the reliability of the data. **Table 5.1** shows results from a Cronbach Alpha test to determine the reliability of the data. These results show that comparable data scores for each hazard risk are at an acceptable level ($\alpha = > 0.6$). Results from school 1 and 3 were often > 0.8 , considered excellent reliability, however there is greater variability in the results from school 2 which were > 0.6 and results in school 4 whereby 4 of the 7 studied hazards had reliability scores > 0.6 but 3 did not. One factor in this was the small sample sizes, which were determined by the school principals. Overall, the data presented allows for confidence from our sample shown by the statistical reliability. It was not, however, possible to calculate the level of agreement between different categories using Fleiss’ kappa as this was not available in SPSS.

However, in future studies this calculation would indicate the inter-rater reliability and would provide further weight to support the Cronbach Alpha reliability scores. Future studies would seek to increase sample size to further the reliability of understanding multi-hazard perception using PRISM, after these initially positive results.

In summary there is inevitable scepticism over the use of PRISM owing to its novelty and simplicity (Buchi and Sensky, 2016). PRISM has become a validated method in the health profession as a measure of suffering. With its growing range of applications, this study has shown that the PRISM concept can be applied to the understanding changes in hazard risk perception. Presently the use of the tool is in its infancy in DRR, however with growing use, further validation of the method can be added to the results of our study as a simple method to understand changing hazard risk perception, within different communities, to people of different ages.

Overall, this study suggests that PRISM is an effective tool for use with students to collect their perceptions and can be carried out with relatively low cost, resource input and time while returning useful data. Further study involving PRISM is suggested in *recommendations for future research*. One avenue of study focuses on the relevance of angular position of disk placement, to determine Sensky and Buchi's (2016) hypothesis that spatial placement on the board reflects psychological state of the participant, i.e., placement on a long axis suggests optimism versus placement on a short axis suggesting limited potential for movement and therefore pessimism. One other suggested adaptation is the development of an online application for the use of PRISM on iPad / tablet. Currently iPRISM is available (Sensky and Buchi 2016) but the ability to configure the program is limited. One side project linked to this study has been the development of such an application with the Computer Science department in Portsmouth, with design blueprints made, however, due to staffing and capacity issues no final design has been made. Such a design would limit the need for transporting resources to conduct the task and rely on the increasing use of mobile technology across the world.

5.4 Assessing longitudinal change in student perception.

5.4.1 Comparing student SHS scores with experts.

'Expert' data was collected on visits to Dominica represented by adults who work either in DRE (often Geography teachers), government or NGO staff who work directly in disaster management or local people who have published material or written for academic purposes. While this study terms

these as experts there is recognition of the limitation in their understanding of actual risk in each location. Expert scores are linked to one of the three study locations dependent on their residence location. Few of the experts have qualifications in geoscience, earth science and all have practical or academic understanding of the impacts associated with no more than two of the hazards shown. All expert values were collected between 2014-2017 and scores given (**Table 5.4**) represent the average for this period. It was not possible to meet all the experts on the 2018 visit due to the impacts of Hurricane Maria. Students perceived values are assumed to be based on experience or information from third parties. **Table 5.4** shows the comparative mean SHS scores for experts and for students from each school.

Table 5. 4 A comparison of mean SHS values between experts and students by location and time.

		H	An	F	An	EQ	An	VE	An	L	An	T	An
Roseau	2014-2017	6.2	52.6	11.1	32.6	7.9	38.8	7.6	68	9.5	56.6	12.8	22
Experts													
School 1	Oct 2014	4.6	38.4	14.5	35.5	12.4	24.3	10.7	21.4	11.2	41.3	19.1	37.5
	Apr 2016	7.3	36.2	10.5	34.8	13.3	22.3	16.9	34.1	6.4	15.3	23.2	32.8
	October 2016	4.5	31.4	12.6	34.3	16.3	34.7	13.8	32.9	10.9	32	24.4	32.7
	Apr 2017	6.3	25.3	11.6	32.2	13.6	36	16.0	33	10.7	37.3	23.9	32
	Apr 2018	2.8	14	8.5	34.2	17.2	34.8	18.1	36.5	12.7	29.6	26.7	26.7
School 2	Oct 2014	7.2	27.3	15.3	19.4	14.4	43.3	15.8	12.9	9.8	46.1	23.3	22.6
	Apr 2016	9.9	23.4	16.4	30.8	9.6	34.5	11.8	24.9	10.7	31.4	23.1	31.8
	October 2016	9	33.7	13.9	32.1	9.0	27.9	12.6	24.7	11.9	28.9	21.0	28.7
	Apr 2017	7.2	25.8	15.2	35.5	13.2	43.6	13	28.9	13.9	37.8	22.0	31.4
	Apr 2018	5.7	52.1	12.2	37.5	12.8	31.8	11.7	36.7	11.8	32.8	16.2	35.2

Port	2014-												
Experts	2017	7.8	43.5	15.0	23.5	8.3	77	10.3	50.5	14.7	3.5	16.1	60.5
School 3	Oct 2014	6.3	23	14.3	8.3	11.0	7.8	13.3	46	12.6	42.1	19.7	22.3
	Apr 2016	8.0	28.2	14.8	34.0	16.9	31.9	20	27.2	16.1	30.1	23.7	28.6
	October 2016	6.7	38.4	14.9	28.5	11.0	25.8	14.6	33.3	11.3	30.5	23.2	28.8
	Apr 2017	7.3	38.1	15.0	30.6	12.9	28.5	17.0	31.7	13.9	38.5	23.3	31.7
	Apr 2018	3.7	45.5	10.4	34.7	14.9	29.7	17.4	31.4	9.8	44.9	22.9	35.9
CB	2014-												
Experts	2017	6.8	7	27	38	13.3	41	12.9	2	14.1	71	22.3	14
School 4	Oct 2014	8.1	7.6	17.7	14.0	19.1	19.4	19.5	10.9	15.5	23.8	17.5	43.8
	Apr 2016	7.1	35.7	16.0	13.8	13.8	34.1	20.9	32.1	8.5	35	24	36.5
	October 2016	5.4	32.6	15.5	27.3	10.9	23.6	19.8	26.7	9.8	24.9	22.4	30.9
	Apr 2017	8.2	27.9	15	31.3	11.9	35.6	18.7	29.2	11.5	28.7	22.4	23.8
	Apr 2018	2.4	19.1	8.7	24.6	15.8	26.2	21.6	27.4	7.4	26.6	21.8	27.2

Key – H = Hurricane; F = Flood, EQ = Earthquake, VE = Volcanic Eruption; L = Landslide; T = Tsunami; Colours = PRISM hazard disk colour; An = angle from “Self” (shaded columns); rows shaded light blue = ‘expert’ values. Emboldened numbers represent student values within 1.5cm of expert values.

In all cases both students and experts rank the hurricane values as most risk to them. Despite expert opinions not incorporating the impact of Hurricane Maria, there is a range of 0.1-4.1cm variance in expert and student hurricane perceptions. For hazards regularly experienced by the population, there is greater agreement between expert and student. Flooding has a SHS variance range of 0.1-10cm, with greater difference shown by the Castle Bruce students. Portsmouth students agree with expert opinions of the low flood risk to the population. The landslide score variance is dependent on location; in Roseau SHS variance ranges from 0.3-4.4cm, in Castle Bruce it is 1.4-6.7 and in Portsmouth it is 0.8-4.9 suggesting a greater variation in experience of landslides from those travelling across more remote rural areas to get to school.

There are much greater differences with the geophysical hazards. In Roseau, the tsunami variance ranges from 7.7-13.9cm, while in Portsmouth it is slightly lower between 3.6-7.7cm. In both cases the experts have a heightened perception on tsunami risk compared to students. Except for 2014, perceived values of tsunami risk in Castle Bruce are similar, both considering the risk to be unlikely. Earthquake risk has similar differences to tsunami, but students from Portsmouth have a closer perception of this risk; in Portsmouth variance ranges from 2.7-8.6cm but on all occasions, students view this risk as less likely than experts. In Castle Bruce the earthquake variances range from 0.5-5.8cm however, the higher differences were from younger groups in earlier surveys. In Roseau, where there have been less earthquakes experienced, the range for earthquakes is 4.5-9.3cm. However, in all cases the experts perceived this risk greater than the students. The perception of volcanic eruptions has the largest overall variance after a tsunami. In Roseau, the variance ranges from 3.1-10.5cm, in Portsmouth 3.0-9.7cm and in Castle Bruce it is 5.9-8.7cm. In all instances the risk associated with volcanic eruptions is perceived greater by the experts than it is the students.

The order which both experts and students perceive the risk from hazards is different, except for hurricane risk. In Roseau, the infrequent geophysical risk of volcanic eruptions and earthquakes is considered far more of a threat by experts than by students. Generally, in Roseau students order perceived hazards by their direct experience, while experts have considered the possibility of a known unknown. It is similar in Portsmouth with experts perceiving the threat of earthquakes and volcanoes directly after hurricanes. Students perceive earthquakes as one of the more important risks, many having experienced minor shaking. Despite living on the flanks of a large stratovolcano few perceive this a likely risk.

Castle Bruce experts placed a greater risk on earthquakes and volcanic eruptions than students; despite Castle Bruce not considered high-risk for these hazards (Lindsay et al, 2005). Students and experts have similar perceptions for landslides, but differ greatly for the flood risk, with experts suggesting this is not a threat. The position of Castle Bruce village is away from Castle Bruce River. However, the school is in this flood zone and may account for student perceptions.

Overall, there is agreement that students and experts perceive hurricane risk to be greatest, and tsunami risk the least. However, there is clear discrepancy between expert and student perception of volcanic and earthquake hazards. PRISM allows this gap to be quantified. These results reflect the under-representation of geophysical risk in the school curriculum. However, this may also be reflected through a lack of direct or recent student experience, locally and regionally. The results also show variation in expert values by location of the values given. It is also unclear of the extent to which expert values are biased based on their own experiences and the extent to which they have

considered frequency and magnitude. Overall, these comparisons are useful to understand the relative difference between each group. While expert opinions may not represent actual risk, they are based on greater experience. Therefore, quantifying the gap between student and expert risk helps channel which risk needs focus in the curriculum.

5.4.2 Differences in expert and student perceptions.

In the study of risk perception, the expert values are used as a relative comparison to determine the variance between their views and that of the layperson (Wachinger et al, 2013). In our study students hazard perceptions are largely guided by their own social, cultural beliefs and heuristics (Renn, 2008) as it is assumed that they have had limited educational input at the start of the study period. The term expert reflects an individual who has acquired knowledge or skills and is able to transfer them in the context (Benner, 1982, Weinstein, 1993, Shanteau, 1993). The expert perceptions collected in this study reflect those who have experience of working in disaster risk reduction roles, however, some do not have direct experience of dealing with the multiple hazards they are asked to reflect on, with none of them geoscientists. Despite this, the perceptions given represent a relative benchmark around which we can compare student perception therefore serve as useful. Even if they are not the actual perceived risk, they are a reflective reality.

The results in **Table 5.4** show that both the experts and students perceived hurricanes as the greatest overall threat. This agrees with Johnston, Ronan and Standing (2014) who argue that students will show a greater understanding of the most frequent hazards. Despite hurricanes not being as frequent as other hydrometeorological hazards, it presents an annual event with the potential for larger magnitudes. The likelihood of other hydrometeorological hazards, flooding, and landslides, are more likely but are perceived as lower importance due to their lower magnitude. This disagrees with Avvisati et al, (2019) who suggest that greater frequency in hazard leads to greater accuracy in perception. In Dominica landslides and flooding are frequent, more frequent than hurricanes. Yet the student's perception of these risks is not that different to the expert opinions. There is a clear gap in the difference between the student and expert perceived threat of earthquake and volcanic hazard. The experts in both Roseau and Portsmouth, two locations surrounded by composite volcanoes (Lindsay et al, 2005), accounted for the much greater potential risk of an eruption or seismic activity, while the students often made little account for this. Equally in these locations the threat of tsunami was underestimated by students.

Beyond the threat of hurricanes there are discrepancies between the student and expert perceptions for other hazards. Student order of perceived hazards is mostly based on their experiences and those of their families (**Table 5.19**). They do therefore not account for the likelihood of hazard potential. These experiences make judgements on hazard by the frequency and magnitude relationship they, or their family, have experienced. Therefore, students experiencing small scale frequent floods will not make the same judgement as an expert who understands the frequency magnitude relationship. Experts, however, have made their judgements both based on their experiences, and their perception of probabilistic outcome. This has resulted in the potential for risk associated with a particular hazard not accounted for by students. It is also clear that there is a disconnect between hydrometeorological hazards which represent common occurrences and the low frequency geophysical. This pattern persists throughout the period of study suggesting that the education students received up until 2017 did not teach them about the probabilistic occurrence, rather instead knowledge of what the hazard was. It should be the goal of DRE in this context to ensure that the student perception matches the local expert perception in at least the perceived order of risk, accounting for the frequency magnitude relationship of hazards as outlined in the CHARIM handbook (van Westen and Jetten, 2016). This would require experts to play a contributing role to DRE and allow for a relative understanding of the gap between the lay person and expert. However, being cautious of the fact that risk perception is transient and subject to change, therefore requiring constant reassessment of risk locally.

5.4.3 Longitudinal trends in student perception

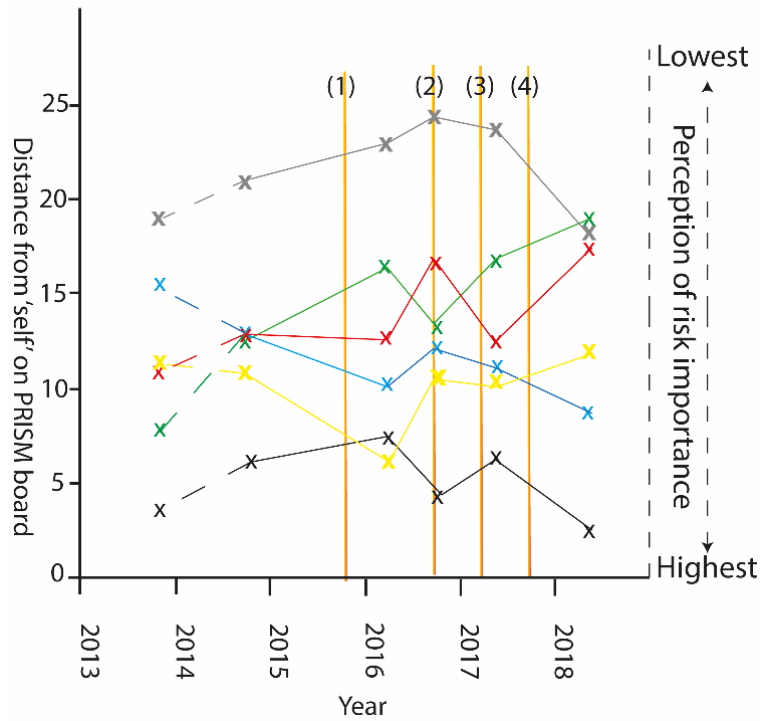
This section considers the mean changes in SHS student risk perception between 2013-2018. This will show how the mean SHS values changed over time and relative to each other. This section will also consider the impact of hazardous events on student perception.

Figure 5.1 show the 5-year change in average student SHS perception values linked to risk events impacting Dominica. These events were chosen as they represent larger magnitude or significant events in the study period. Tropical Storm Erika caused the greatest impact in narrow river valleys in southern and western locations across Dominica. Both earthquakes (**Figure 5.1**) had epicentres between the island of Dominica and Martinique. They led to localised shaking in southern and central Dominica which varied depending on local geology. Hurricane Maria caused widespread damage to communities across the island. Structural damage was prolific in low lying coastal locations, flood damage occurred closest to river channels and damage to property roofs was evident in upland areas and exposed areas. During this period other events affected neighbouring islands such as the impact of Hurricane Matthew (2016) on St Lucia, or the impact of Hurricane Irma in Antigua and Barbuda but these impacts are not directly considered.

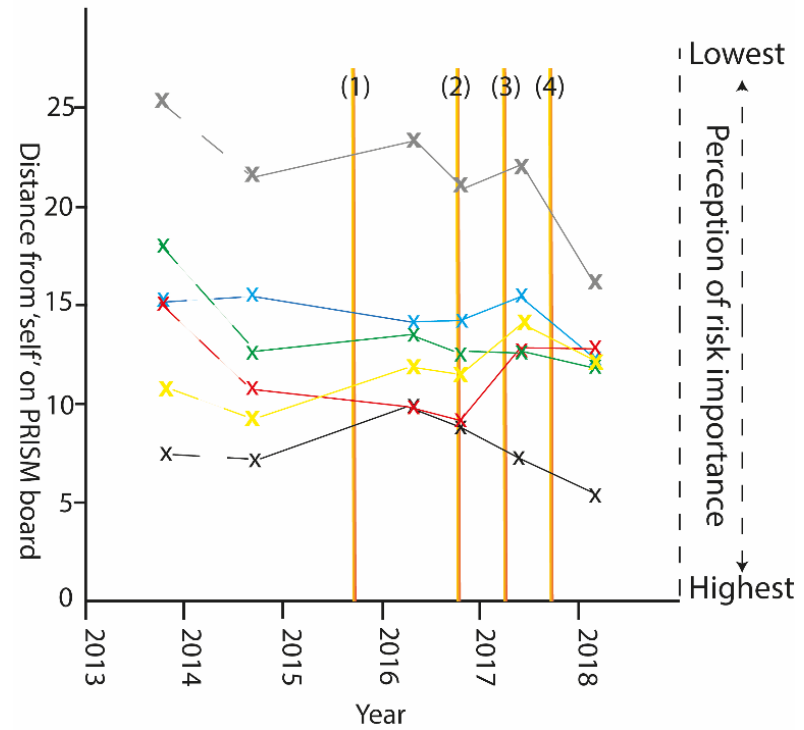
Overall students perceive hurricanes to present the greatest risk in Dominica. At all points, in all locations (except April 2016 in School 1) it is considered to have the highest potential risk. Equally tsunami risk is almost always considered to be the lowest risk to Dominican students. In all locations the landslide risk is high, and within the top three threats, across all locations. These perceptions link closely to experience of frequent events faced by students or their families on the island. Across the 5-year period, the pattern of risk perception by location is relatively similar, with a period of fluctuation between 2014-2017 and a significant change to perception values (often intensifying) after Hurricane Maria.

Figure 5. 1 5-year SHS perception changes for school 1-4

5 year changing percpetion, SHS average scores, for students from school 1

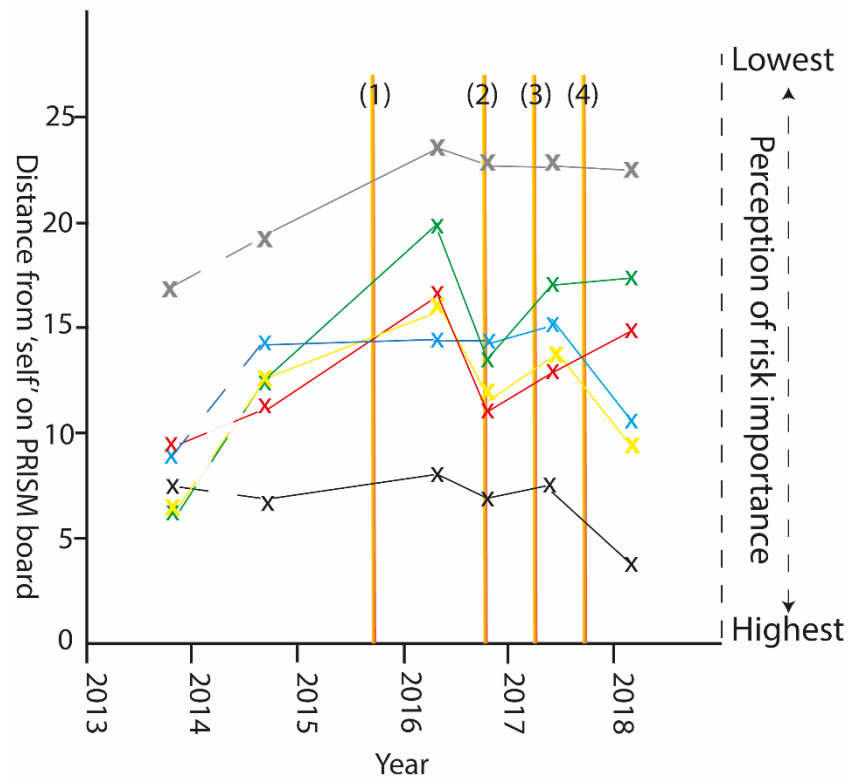


5 year changing percpetion, SHS average scores, for students from school 2

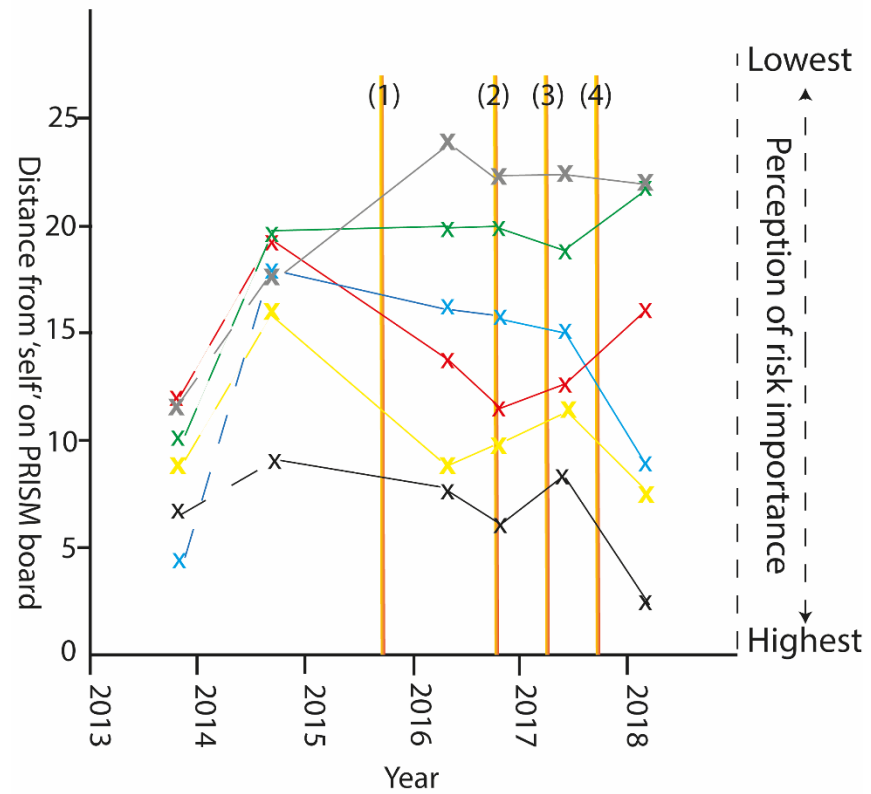


Note for figure – (1) Tropical Storm Erika, (2) 2016 Earthquake SW Island(3) 2017 Earthquake SE Island, (4) Hurricane Maria. Colours – black – hurricane; yellow – landslide; red – earthquake; green – volcanic eruption; blue – flood; grey – tsunami.

5 year changing perception, SHS average scores, for students from school 3



5 year changing perception, SHS average scores, for students from school 4



Note for figure – (1) Tropical Storm Erika, (2) 2016 Earthquake SW island (3) 2017 Earthquake SE island, (4) Hurricane Maria. Colours – black – hurricane; yellow – landslide; red – earthquake; green – volcanic eruption; blue – flood; grey – tsunami.

The SHS perception results from school 1 and 2 are similar for hurricane and tsunami hazard. Hurricane is considered, by both sets of students, the greatest potential risk throughout the time. In both schools' hurricanes perception follows a similar decline in importance between 2014-2016 and is not seemingly affected by the impact of Tropical Storm Erika in 2015. Tropical Storm Erika produced the greatest level of damage in Dominica but was mainly a rainfall event (Pasch & Penny, 2016). Therefore, students did not interpret this as a hurricane, due to the lack of associated wind. After this school 1 students' hurricane perception fluctuates until after 2017 when perceptions intensified due to the impact of Hurricane Maria. School 2 shows a similar pattern after 2017, but between 2016 and 2018 there is a gradual intensification of the hurricane perception, which some students linked to the near passing of hurricane Matthew in 2016. The risk perception of tsunami follows a broadly similar pattern, least likely. In school 1 this risk gradually reduces until 2016 and then marginally intensifies after 2017, with a larger increase post Maria. In school 2 the same reduction in risk occurs between 2014-2016 followed by fluctuation until post Maria where there is an intensification. In both school 1 and 2 the intensification of risk perceived increases between 22-16cm SHS, representing the largest change in perception post Hurricane Maria. Flood perception follows a similar pattern in both schools and perceived flood risk intensifies after Tropical Storm Erika. Both schools in Roseau were unaffected directly by the storm, however students travelling from beyond the city were affected by road closures during this time because of landslides. Post 2016, the perceived risk of flooding reduced reaching pre-Erika levels by the start of 2017 in both schools. Hurricane Maria caused significant flooding around Roseau which led to an increased perception of flood risk after the event. In school 1 average SHS values intensified from a pre-Maria average of 11.0cm to below 9cm. In school 2 the values intensified from an average of 15cm to 12cm.

Other risk perceptions trends between school 1 and 2 were not similar. Landslide risk perception intensified in school 1 after Tropical Storm Erika, owing to the greater proportion of students who travelled from areas south of Roseau which were greatest affected. Landslide SHS scores intensified from 10-6.0cm, yet after 2016 the perception of landslides risk reduced. Between 2016-2018 the landslide SHS values changed from 6-11cm – with 2018 representing the lowest level of perceived landslide risk, between 2014-2018, despite the impact of Hurricane Maria which caused significant landslide events across Dominica. In comparison, despite school 2's position adjacent to a vertical escarpment in the Roseau Valley, the perception of landslide risk score reduced from 10cm to 14cm in April 2017. Hurricane Maria caused the landslide risk perception to fall again at a similar rate to the perception of flooding. This may suggest that students in school 2 better understood the links between hurricanes, flood and landslide risk than those in school 1.

Earthquake and volcanic risk perceptions are similar between schools 1 and 2, although earthquakes are generally considered to be of greater risk. School 1 had an earthquake SHS perception value near 13cm between 2014-2017, with a fluctuation around the October 2016 earthquake which caused the student perception of earthquakes to be reduced. However, the impact of the 2017 earthquake did lead to a sharper intensification of perception back to pre-2016 levels. By contrast the SHS values for volcanic eruptions were less, >15cm, however, intensified after the 2016 earthquake and decreased again after the 2017 earthquake. Some students in school 1 commented that they felt more shaking after the 2017 earthquake and their teachers commented that they had taught them about seismic activity and volcanic activity in 2016. This poses a possible explanation for the fluctuating earthquake and volcanic values but also raises the question of the influence of educational input influencing (correctly or incorrectly) student perception. After 2017 the effect of Hurricane Maria was to reduce the perception for students from school, of both volcanic and earthquake risk by the largest amount across the study period. Despite both schools located in Roseau, school 2 students perceived the risk of earthquakes differently. The impact of the 2016 earthquake was more widely felt by the students at school 2 who resided in more northerly locations, which received greater shaking from the 2016 hazard. This may have contributed to these students intensifying earthquake risk perception scores. Conversely, although the 2017 earthquake caused greater shaking in the south of the island nearer Roseau, this caused less impact on the school 2 student perception, many who live further north. The mix of students from a larger catchment can mix the perceptions for hazards due to the differing spatial impacts. Post Maria's impact on earthquake perception was like school 1 students, reducing perceived risk although at a reduced rate. The school 2 student perception of volcanic eruptions fluctuated consistently between SHS values of 12.5cm-14.0cm. The impact of the 2016 and 2017 earthquakes was limited, within standard error, and post Maria the perception barely altered them. This consistency relates both to the lack of volcanic activity on the island or in the region during the study period and the students general lack of awareness of the volcanic risk around them.

Students in school 3 showed consistent perceptions of hurricanes and tsunami risk during the study. Despite minor fluctuations (within variations linked to SEM) the perceived SHS of hurricanes remains between 5cm-8cm, except for 2018 when it intensified significantly. Tsunami SHS values remained stable between 21cm-24cm (**Figure 5.1**). However, the greatest change in school 3 student perception during the study period was that of volcanic and earthquake risk. Between 2014 and 2017 perception values mirror each other but fluctuate between SHS scores of 10-20cm. Landslide perception values mirrored the changes shown by earthquakes during this time, but flood values remain a relatively low consistent risk between 13-15cm. After 2017, the hydro

meteorological hazards associated with Hurricane Maria intensified, however, geophysical hazards were perceived as a lower relative risk.

Tropical Storm Erika had little impact on the northern part of Dominica, around Portsmouth, which explains why this event did not have the effect of intensifying risk perception for any hazard. The 2016 earthquake had a greater impact on the Portsmouth area than the 2017 event. Located off the southwest coast this had the impact of causing localised low level shaking around Portsmouth. This intensified the perception of earthquakes, and volcanic eruptions as people were aware of magmatic seismicity within Morne aux Diabes. The 2017 earthquake had little impact on school 3 student perception and this period shows a general reduction in risk perception for all hazards.

Hurricanes were perceived by school 3 students as the greatest risk, followed by Landslides, Earthquakes, Flood, then Volcanic Eruptions and Tsunami. Between the study period, while most hazards retained this relative order there was a gradual intensification of risk of each of these hazards. After the 2017 hurricane, the impact on risk perception was to intensify those frequently experienced hazards (e.g., hurricane, flood, and landslide) while reducing perceived risk for geophysical hazards.

The impact of Tropical storm Maria had little change on the perceptions of students in Castle Bruce. While there was some intensification of hazard perception from hurricanes, flooding and landslides, there was also an intensification of earthquakes, which had not occurred until this point. Though this was not the case for either volcanic eruptions or tsunamis which were still considered less likely. The impact of the earthquake in early October 2016 had a greater impact on the perception of school 4 students than the 2017 earthquake despite its closer proximity to Castle Bruce. However, students noted that the shaking linked to the 2016 event was felt more widely across the southern part of the island. The 2016 earthquake had the greatest impact intensifying the perception of both earthquake and tsunami risk. However, it had minimal effect of changing the perceptions of both landslides and volcanic eruptions (within the range of expected change shown by the SEM - **Table 5.2**). Hurricane Maria had the most striking impact on changing the risk perceptions of hazards. Hydrometeorological hazard risk intensified while risk associated with geophysical hazards were reduced, like school 3.

5.4.4 Relationships between hazards using SHS values.

Figure 5.1 shows the mean SHS changes; however, it is important to understand the relationships between the SHS values to understand the link between student thinking about individual hazards. Does one hazard score correlate with another? This may allow an insight into the relationship hazards perceived by the students. This will also help determine the extent to which known event had an impact on other hazards.

The data in Tables **5.5-5.8** show the Pearson product correlation values for hazards at $p=0.01$ and $p=0.05$. The table only includes significant relationships shown at these levels of confidence. **Table 5.5** shows that school 1 students showed variable strength in relationships between hazards between 2014-2018. The strongest relationship is shown between earthquakes and volcanic activity perceptions (.755 at $p=0.01$) in 2017. This positive correlation shows that a rise in earthquake perception was strongly correlated with that of volcanic eruptions. This represents the period after a local earthquake which affected the south of the island. In this same period (2017) students also showed a positive relationship between tsunami and volcanic eruption perceptions (.464 at $p=0.05$). During 2017 high statistical significance ($p=0.01$) was shown between landslides and earthquake perceptions, and landslide and Volcanic eruption perception, indicating an understanding of the link between geophysical hazards. Although post Tropical storm Erika strong correlations between earthquake and hurricane perception scores (.660 @ $p=0.01$) and earthquake and hurricane perception values (.545 @ $p=0.01$) may counter this perceived understanding. Post Hurricane Maria correlations (in 2018) show very strong correlations between flood and tsunami perception values (.653 @ $p=0.01$) and between car and volcanic eruption perception scores (.548 @ $p=0.01$) which may not be the obvious links post hurricane.

Table 5.6 shows that students in school 2 show their highest correlation scores in 2014 with a -.755 correlation between hurricane and tsunami. This strong correlation indicates the valid belief that these are not connected. However, in October 2016, students perceive a positive correlation of .501 between these same two hazards suggesting limited understanding. Hurricane and earthquake values correlate strongly in October 2016, 2017, and 2018, which again have no obvious link. Tsunami and flood hazard perceptions correlate strongly at $p=0.01$ in April 2016 and 2017. While other strong correlations (at $p=0.01$) exist in April 16 between Volcanic activity and earthquakes (.643) and earthquakes and landslides (.625). Generally, across the study period hurricane values show the strongest correlation with other hazards. These results suggest that correlations between hazards do not show accurate reflections of expected relationships between hazards, which questions the validity of understanding in school 2.

Table 5. 5 Pearson product correlation values between hazards for School 1

	Hurricane	Flood	Earthquake	Volcanic Eruption	Landslide	Tsunami	Car
Flood	.452* (14)						
Earthquake	.545** (A16) .403* (O16)	.439* (18)					
Volcanic Eruption	.660** (O16) .393* (18)		.755** (17)				
Landslide	.487* (A16) .494* (18)		.483* (O16) .642** (17)	.441* (A16) .530** (17)			
Tsunami		.496** (17) .653** (18)	.487* (O16) .439* (18)	.445* (14) .420* (A16) .464** (17)			
Car				.548** (18)			

Notes – number in brackets refers to date (e.g., A16 = April 2016, O16 = October 2016). Statistical significance of correlation with two-tiered Pearson’s product correlation : * = p0.05, ** p=0.01 (emboldened). Highlighted boxes represent possible correlations showing linked student understanding between hazards.

Table 5. 6 Pearson product correlation values between hazards for School 2

	Hurricane	Flood	Earthquake	Volcanic Eruption	Landslide	Tsunami
Flood						
Earthquake	.575* (O16) .599** (17) .592** (18)					
Volcanic Eruption	.508* (17)		.643** (A16)			
Landslide	.607** (O16)		.625** (A16)	.576* (O16) .602** (17)		
Tsunami	-.755** (14) .501* (O16)	.635** (A16) .605** (17)		.407* (18)		
Car	.580* (A16) .692** (O16)				.693** (14)	

Notes – number in brackets refers to date (e.g., A16 = April 2016, O16 = October 2016). Statistical significance of correlation with two-tiered Pearson’s product correlation : * = p<0.05, ** p=0.01 (emboldened). Highlighted boxes represent possible correlations showing linked student understanding between hazards.

Table 5. 7 Pearson product correlation values between hazards for School 3

	Hurricane	Flood	Earthquake	Volcanic Eruption	Landslide	Tsunami	Car
Flood	.674** (O16)						
Earthquake		.764** (14)					
Volcanic Eruption	.460* (A16)	.598** (A16)	.538** (O16)				
Landslide	.729** (14)	.611* (14) .450* (A16)		.479* (O16) .535** (17)			
Tsunami		.737** (14) .486* (A16)	.654* (14)	.451* (A16)			
Car		.426* (17) .529* (18)		.578* (14)			

Notes – number in brackets refers to date (e.g., A16 = April 2016, O16 = October 2016). Statistical significance of correlation with two-tiered Pearson’s product correlation : * = p<0.05, ** p<0.01 (emboldened). Highlighted boxes represent possible correlations showing linked student understanding between hazards

Table 5. 8 Pearson product correlation values between hazards for School 4

	Hurricane	Flood	Earthquake	Volcanic Er.	Landslide	Tsunami	Car
Flood	.421* (A16) .465* (17) .516* (18)						
Earthquake	.372* (A16) .533** (17) .451* (18)	.405* (A16) .503* (18)					
Volcanic Eruption	.393* (A16)	.443* (17)	.368* (A16)				
Landslide	.369* (A16) .463* (17)	.545** (17) .458* (18)	.413* (A16) -.375* (O16)	.445* (18)			
Tsunami	.516** (A16)	.409* (17)	.515** (A16) .563** (18)	.654** (A16) .455* (O16) .604** (17)			
Car	.685** (17) .454* (18)	-.552** (O16) .629** (18)	.378* (17)				

Notes – number in brackets refers to date (e.g., A16 = April 2016, O16 = October 2016). Statistical significance of correlation with two-tiered Pearson’s product correlation : * = p<0.05, ** p<0.01 (emboldened). Highlighted boxes represent possible correlations showing linked student understanding between hazards.

Table 5.7 shows the strongest correlation for school 3 students is shown between earthquake and flood perception values (.764 @ $p=0.01$) in 2014. In this year there were also high correlations for tsunami and flooding (.737) and landslides and hurricanes (.729). Flooding SHS scores showed the greatest correlation with other values. October 2016 showed $p=0.01$ correlation scores between Flooding and Hurricanes and volcanic eruption and earthquakes. There were few correlations shows in the data after Hurricane Maria, except for correlation between flooding and cars (.529 @ $p=0.05$). The greatest number of correlating paired values was after Tropical Storm Erika in April 2016 with the strongest correlation shown between flooding and volcanic eruption (.598 @ $p=0.01$). Like school 2 these correlations do not meet the expected changes one would expect to see and therefore questions student understanding of hazard links based on relative changes in SHS data.

Table 5.8 shows that School 4 students show the greatest number of positive correlations between the flood and hurricane hazard. The hurricane hazard correlates with most of the other hazards positively. Suggesting that the impact of this hazard alters or links to the perception of others. Strong correlations exist between volcanic eruptions and tsunami (.654 and .604 – where $p=0.01$). The impact of tropical storm Erika can be seen from the positive correlations in April 2016 between (hurricane) storm and other hazards as there are multiple significant positive correlations in this period. There are also strong positive correlations between hurricane and flooding and earthquake after Hurricane Maria outlining the impact of the hurricane on the perception of these hazards. There is also a positive correlation (.458) between flood and landslide which shows an understanding of the link between these hazards. These students show strong positive correlations between volcanic activity and tsunami but not volcanic activity and earthquakes, although there are significant correlations between earthquake activity and tsunami (.5151 and .563 at $p=0.01$) highlighting an understanding of the impact between these hazards. A mixed understanding of the perceived impact of earthquake and landslide. In April 2016, the students perceived a positive correlation (.413) yet a negative correlation in October 2016. This was after a series of earthquakes in this time which the locals would have experienced ground shaking. There is also a significant correlation between car hazards and flooding (October 2016 and 2018) suggesting that there may be a link between these two hazards, and similarly for hurricane and car hazards in 2017 and 2018.

5.4.5 Analysing the relationship in temporal change to SHS values.

Assessing the difference in SHS values between each study period, between different hazard types, helps determine the inter-relationship between each hazard and each session. This can therefore determine the impact of an event occurring in the period between two sessions. **Tables 5.9-5.12** show correlations (at $p=0.05$ and $p=0.01$) of temporal perception changes.

Table 5.9 shows for school 1 students that between 2014-2016 during the period of Tropical Storm Erika the strongest correlation was between tsunami and earthquake. In the remaining transition periods flooding has a series of correlations with other hazards, most notably hurricane, landslides, and tsunami - suggesting that an increased (reduced intensity) SHS score in flooding has a similar impact on the perception of other hazards. This suggests these values are drifting from “self” in this period. Between the period 2017 and 2018 there is also a strong correlation between the geophysical hazards, volcanoes and tsunami, and volcano and earthquake. These perception values all intensified in this period in school 1 students suggesting a link between these geophysical hazards.

Table 5.10 shows that students from school 2 show the greatest number of correlations between 2016 and 2017. During tropical storm Erika, a significant negative correlation exists between hurricane and tsunami, suggesting increased perception of hurricanes led to reduced perceptions of tsunami. During 2016-17 evidence of significant positive correlations between earthquake and volcanic eruption and earthquake and tsunami - suggesting these values equally moved away from ‘self’, indicating a drift in perceptions. Between April 2016-October 2016 and 2017-2018 there were strong positive correlations between volcanic eruption and earthquake (0.671 and 0.642) which may be linked to the 2016-2017 seismic activity and suggest that students perceive a link between these hazards. During 2017-2018 there were significant negative correlations between flooding and earthquakes, and tsunamis. Roseau was significantly affected by flooding, but this suggests that the impact of it had a reduced perception of the geophysical hazards.

Table 5. 9 Statistically significant correlations between perceived hazards for school 1, 2014-2018

		Apr 2014-Apr 2016 (n=23)	Apr 2016- Oct 2016 (n=25)	Oct 2016 – Apr 2017 (n=24)	Apr 2017 – Apr 2018 (n=24)
Strength of relationship	One tailed p=0.05	Volcanic eruption + Tsunami 0.404	Volcanic eruption + Tsunami 0.380	Flood + Earthquake 0.390	Flood + Car -0.386
	Two Tailed P=0.05	Tsunami + Earthquake 0.496	Hurricane + Flood 0.444	Car + Landslide -0.433	Earthquake + Flood 0.415
			Hurricane + Earthquake 0.396		Landslide + Flood 0.431
			Hurricane + Landslide 0.479		Tsunami + Flood 0.464
			Flood + Landslide 0.421		Volcanic eruption + Earthquake 0.427
			Flood + Tsunami 0.399		Volcanic eruption + Tsunami 0.428
			Earthquake + Landslide 0.448		
				Volcanic eruption + Tsunami 0.524	

Notes for table – green shaded boxes represent possible or likely correlations therefore show a link understanding in student awareness.

Table 5. 10 Statistically significant correlations between perceived hazards for school 2, 2014-2018

		Apr 2014-Apr 2016 (n=14)	Apr 2016- Oct 2016 (n=16)	Oct 2016 – Apr 2017 (n=17)	Apr 2017 – Apr 2018 (n=18)
Strength of relationship	One tailed p=0.05			Hurricane + Car 0.480	
				Earthquake + Volcanic eruption 0.468	
				Volcanic eruption + Tsunami 0.462	
	Two Tailed P=0.05	Hurricane + Tsunami -0.543	Hurricane + Car 0.606	Hurricane + Tsunami 0.523	Hurricane + Car 0.476
		Earthquake + Volcanic eruption 0.623		Landslide + Volcanic eruption 0.495	Flood + Earthquake -0.533
		Earthquake + Tsunami 0.638		Tsunami + Car 0.572	Flood + Volcanic eruption -0.569
Two-tailed p=0.01		Volcanic eruption + Earthquake 0.671	Hurricane + Landslide 0.634	Volcanic eruption + Earthquake 0.623	

Notes for table – green shaded boxes represent possible or likely correlations therefore show a link understanding in student awareness.

Table 5. 11 Statistically significant correlations between perceived hazards for school 3, 2014-2018

		Apr 2014-Apr 2016 (n=12)	Apr 2016- Oct 2016 (n=12)	Oct 2016 – Apr 2017 (n=22)	Apr 2017 – Apr 2018 (n=17)
Strength of Relationship	One tailed p=0.05	Flood + Landslide 0.561		Hurricane + Flood 0.363	Landslide + Volcanic eruption 0.439
				Volcanic eruption + Earthquake 0.371	
	Two Tailed P=0.05		Landslide + Volcanic eruption 0.448	Hurricane + Landslide -0.500	Flood + Hurricane 0.523
			Landslide + Tsunami -0.475	Tsunami + Flood 0.473	Earthquake + Car 0.519
				Landslide + Car 0.426	
	Two tailed p=0.01	Earthquake + Flood 0.788	Flood + Hurricane 0.597	Flood + Earthquake 0.564	Volcanic eruption + Car -0.787
			Volcanic eruption + Car -0.585		

Notes for table – green shaded boxes represent possible or likely correlations therefore show a link understanding in student awareness.

Table 5. 12 Statistically significant correlations between perceived hazards for school 4, 2014-2018

		Apr 2014-Apr 2016 (n=13)	Apr 2016- Oct 2016 (n=29)	Oct 2016 – Apr 2017 (n=27)	Apr 2017 – Apr 2018 (n=19)
Strength of Relationship	One tailed p=0.05	Flood + Volcanic eruption 0.514	Tsunami + Volcanic eruption 0.364		Hurricane + Car 0.399
		Flood + Car 0.551			Flood + Volcanic eruption 0.440
					Earthquake + Car 0.425
					Tsunami + Car -0.418
	Two Tailed P=0.05		Hurricane + Volcanic eruption 0.377	Flood + Hurricane 0.435	
			Flood + Landslide 0.400	Hurricane + Tsunami 0.388	
				Earthquake + Car 0.412	
				Volcanic eruption + Tsunami 0.421	
	Two-tailed p=0.01		Hurricane + Tsunami 0.640	Hurricane + Volcanic eruption 0.504	
			Volcanic eruption + Tsunami 0.643	Hurricane + Car 0.521	

Notes for table – green shaded boxes represent possible or likely correlations therefore show a link understanding in student awareness.

Table 5.11 shows that the school 3 students had similar results to those in school 2. Significant positive correlations in 2016 and 2017-2018 (0.448, 0.439) suggest that these hazards both moved away from 'self' at similar rates in 2016. The increased perception of landslide values in 2017-2018 negatively correlated with tsunami risk. In the periods between 2016-2018 there are significant positive relationships shown between hurricane and flood. Between 2016-2017 there is evidence of a significant relationship between earthquakes and volcanoes SHS values, but this relationship does not occur between other sessions. Interestingly there is a negative relationship between hurricane and landslide between 2016-2017 and a positive relationship between flood risk and tsunami in the same period. This shows that some of the more obvious relationships are clearly understood, e.g., hurricane and flooding, but others are not evident clearly in the student population.

The results for school 4 students shown in **Table 5.12** are again like that of school 2 and 3. School 4 students showed the greatest number of significant relationships evident between 2016-2017. Post Tropical Storm Erika, in 2016, there is evidence of a strong positive correlation between tsunami and volcanic eruptions, but also between hurricanes and tsunamis. Between 2016-2017 visits, there is strong correlation between flood and hurricane risk, but also between hurricane and tsunami, and volcanic eruption and tsunami. Very strong evidence of positive correlation (0.504) exists between hurricane and volcanic eruption, suggesting that an increased threat in hurricane hazard increases the threat of volcanic eruption. In school 4 the correlates between survey periods do not confirm the expected changes that link hydrometeorological or geophysical hazards.

These results indicate some evidence of the impact of one hazard occurrence on the other. Similar results in school 2-4 show that students either grasp the relative relationship between changing perceived hazards, or they show the relationship of one hazard affecting another. Equally it could represent a lack of understanding on the part of the student.

5.4.6 Control group comparisons

The original study design involved comparing the sample student scores at the end of their 5th form with 5th form students in 2013 to compare perceptions of students with different experiences of DRR education. The same was to be the case comparing 1st form students in 2018 with the 2013 values from the study. However, the impact of key disaster events, e.g., Hurricane Maria across Dominica make this an unfair comparison. Despite this limitation **Tables 5.13 any 5.14** shows these comparative mean SHS values.

Table 5. 13 A comparison of SHS perception data of 5th form school leavers in 2013/4 and 2018 (note shaded boxes show similar PRISM scores, within 1.5cm for each group).

School	Hurricane	Flood	Earthquake	Volcanic eruption	Landslide	Tsunami
1 – 2014	3.3	5.2	7.1	7.9	3.6	16.1
1 – 2018	2.8	8.5	17.2	18.1	12.7	26.7
2 – 2014	7.1	10.1	7.8	9.5	8.2	12.7
2- 2018	5.7	12.2	12.8	11.7	11.8	16.7
3 – 2014	5.4	16.2	9.3	8.3	14.0	12.4
3 – 2018	3.7	10.4	14.9	17.4	9.8	22.9
4 – 2014	4.9	13.9	11.1	14.5	7.7	16.0
4 - 2018	2.4	8.7	15.8	21.6	7.4	21.8

Table 5. 14 A comparison of SHS perception data of 1st form students in 2013/4 (study group) and 2018 (note shaded boxes show similar PRISM scores, within 1.5cm for each group).

School	Hurricane	Flood	Earthquake	Volcanic eruption	Landslide	Tsunami
1 – 2014	7.4	10.5	13.6	16.3	16.8	23.4
1 – 2018	5.8	7.8	10.4	21	9.8	25.6
2 – 2014	7.0	15.4	11.1	13.8	9.1	21.9
2- 2018	3.5	6.3	14.1	12.5	8.7	15.2
3 – 2014	6.2	14.3	11.0	13.3	12.6	19.7
3 – 2018	8.2	12.9	11.3	14.8	14.2	22.5
4 – 2014	8.1	17.7	19.1	19.5	15.5	17.5
4 - 2018	5.3	14.4	8.8	24.5	10.2	26.8

Table 5.13 shows that in all schools the 2018 5th form has an unsurprisingly intensified view of hurricane risk. This is not the case for flooding as the students from School 1 and 2 in Roseau, despite the impacts of Hurricane Maria perceived this as a reduced risk compared to 5th form students in 2014. However, students in schools 3 and 4 in 2018 did perceive the flood risk as more important. Similar patterns were shown for landslide risk, with School 1 and 2 students in 2014 showing a greater importance of this risk whereas those from 3 and 4 perceiving it as slightly less important than 2018 counterparts. Earthquake risk was more important to those 5th form in 2014, explained due to 'earthquake swarms' and activity which had led to the destruction of a Portsmouth church in 2004. Volcanic eruption threat was also perceived as more important to the 2014 5th form students, though there were notable differences here in school 1, 2 and 4. Tsunami risk also followed a similar pattern to volcanic risk with a greater perceived risk from the 2014 5th form students. These results highlight the impact of disaster events causing change on the less experienced hazards, e.g., with geophysical hazards.

Comparing **tables 5.13 and 5.14** results we can see that the first form students in 2018 have a similar pattern to the 5th form students, with hurricanes and flooding perceived as a greater risk in 2018 than 2014 counterparts, except in school 3. Landslide risk did not follow this pattern. First formers from school 1 and 2 perceive the threat of landslides more than 2014 students, but the perceived risk in both School 3 and 4 by 2018 was reduced. This raises a question as to whether first form students understand the link between landslides, flood, and hurricane risk?

For the geophysical risks there is a similar pattern across three schools 1, 3 and 4. 2018 school students perceived earthquake risk as greater but placed less importance for both volcanic eruption and tsunami. School 2, however, were opposite to the pattern described. Students in 2018 perceived earthquakes with reduced importance, while they placed greater importance on both volcanic and tsunami risk. Despite this, similar patterns do exist across most students when comparing 2014 and 2018 first form students, with the impact of Hurricane Maria clear on the perception of the two group.

5.4.7 Patterns in longitudinal risk perception

Figure 5.1 show the patterns of perception change over the 5-year study period based on the PRISM activity, exercise 1. Hurricane threat was consistently considered one of the greatest threats to students (and experts) in the study period. Geophysical hazards were generally perceived to be the least threat over the study period, particularly volcanic eruptions, and tsunami. Generally,

hydrometeorological hazards were perceived as of greater importance in risk, however this varies by school. The impact of hazard events did influence changing perception trends. It is possible to see that despite the short-term changes to perception the order of perceived hazards stays relatively similar throughout the study period.

Earthquakes in 2016, 2017 had the effect of increasing the earthquake risk. However, this effect was spatially sensitive to the area's students who had felt seismic shaking. This was more notable in 2016 in school 3 and 4, but less so in the Roseau area. The students from school 1 felt the impact of the 2017 earthquake more than that of the 2016. The impact of Tropical Storm Erika was noticeable in school 1 as many students were in the southern part of the island where the impact of the storm was worst. However, in other areas notably school 3 and 4 there was minimal direct impact on perceptions trends. The main impact of the storm had little impact on the hurricane trend, as the event was not interpreted as a hurricane, instead it was perceived as a flood by students, because of the damage caused by increased discharge from the high rainfall event. It also led to greater occurrence of landslides therefore the trend for landslide risk in school 1, 3 and 4 becomes of greater importance. The effect on both landslides and flooding largely returned to the 2014 trend by 2017, suggesting that the impact of Tropical Storm Erika was no greater than 1-2 years in affecting student perceptions. The impact of Hurricane Maria in late 2017 had a significant impact on student perception. It led to an increase in perceived risk importance for hydrometeorological hazards in all school locations. Significantly it moved the hurricane perceived importance to the closest point to self in the study period, which reflects the intensity and magnitude of this event being one that had not been faced before. Similar impacts were had for flooding and landslides, though this was dependent on the location, as school 1 received greater flood damage compared to landslide, while in school 3 and 4 the damage from both flooding and landslides were more prominent as many students lived in or near steep sided river valleys. Hurricane Maria also had the impact of reducing the perceived risk importance associated with many of the geophysical hazards. In school 1, 3 and 4, despite the level of volcanic and earthquake risk staying the same as pre-Maria times, the perception of these was reduced. Similarly, after Tropical Storm Erika, the tsunami perception was also reduced. This suggests that in the immediate period after a large magnitude event, that students are potentially more vulnerable to the impact of other, less frequent events as their perceptions are reduced in importance towards these. It would be interesting to study student perceptions after Maria, to determine the extent of hazard fatigue to see if similar patterns occurred with Maria as with Tropical Storm Erika.

The intensity and magnitude of these disastrous events, particularly Hurricane Maria, had a black swan impact on the population as they were unable to foresee the likelihood of such a large event

and therefore it warped their perceptions of other events (Taleb, 2007). Yet how did this impact the students during this time? **Figures 5.2-5.5 (section 5.5)** show that the student perception of these hazards was evident through the qualitative comments relating to these events and the student experience associated with them. In 2015 and 2018 the highest number of comments were made about the named events, Tropical Storm Erika and Hurricane Maria, suggesting that they had a large impact on student perception. In the sessions after April 2016, students made fewer comments about Tropical Storm Erika therefore indicating that there was a disaster perception fatigue in this time, which supports the trends in **Figure 5.1**. After Maria we see a similar pattern, in mention of Hurricane Maria, however with no further data it is hard to confirm how long the disaster fatigue was with this event. Student comments after both hazards show a much greater link to family and emotion, compared to the periods when there were no hazards.

Baheri et al, (2008) and Wachinger et al, (2013) suggest that experiences with large magnitude or unexpected events can lead to a perception of helplessness. This was evident in some of the student comments, particularly about Hurricane Maria, but less so with Erika. Students were concerned less about their loss of possessions but more with the loss of basic services and amenities. There was a change in mindset towards survival. Many were also concerned more for the wellbeing of others, family, and friends, than they made comments about themselves, showing a sense of resilience. However, the comments made were collected 7 months after the event and could therefore have been different if taken at an earlier stage.

Bird et al, 2009 explains the importance of communication in accurately perceiving risk, while Mileti and Darlington, (1997) and Ronan and Johnston, (2010) explain the importance of media in reducing risk. Comments made about both Tropical Storm Erika and Hurricane Maria highlighted the lack of warning given by the media, which may reflect the death count and the comments made by some about people going out to watch the events, or not adequately preparing and subsequently losing their lives. This study therefore agrees that the media have an important role to play in the warning of disaster events, and the role it can also play in the response.

5.5 A qualitative assessment of student perception change (2014-2018)

This section uses the qualitative data from the PRISM exercise 1. Student responses were deductively coded, allowing the use of themes applicable to all student comments. Reasons are not made about specific hazards but underpin the theme behind them. The themes used for this study include:

- I. *Named event* – was the reason for placement in relation to a named event, either experienced directly or indirectly by the student.
- II. *A direct experience* – this theme relates to specific events experienced by the student.
- III. *Inexperience* – this theme was a justification based on a lack of direct or indirect experience of a given hazard.
- IV. *Family / community* – an indirect experience theme of an event which influences placement but not directly experienced yet still relevant to the individual.
- V. *Linked understanding* – this theme identifies examples of comments which show understanding, causality, between two hazards within reasoning.
- VI. *An emotional link* – this theme identifies comments which convey emotion from the individual as part of their justification.
- VII. *Location / proximity* – this theme relates to a justification linking hazard to their place.
- VIII. *Probabilistic* - this theme relates to a comment which identifies the probability of a given hazard occurring as part of a decision.

This section presents data on how the student decision changes relative to each theme. This provides an understanding of the key themes which underline the decision making behind PRISM disk placement and give an insight to which issues are important to the students when considering risk.

5.5.1 Themes in longitudinal student hazard perception

The results in **tables 5.15-5.18** show the frequency which students identified these themes to justify disk placement and **figures 5.2-5.5** show the percentage of students who responded themes in their qualitative comments to PRISM exercise 1 (Raw data is given in supplementary files @ [PRISM data](#) – or contact author for file).

Table 5. 15 Frequency of student response to each thematic category over time in school 1 (colour show values from Figure 6.25).

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
2014	4	30	39	22	26	0	35	39
A2016	73	77	23	42	35	0	8	4
O2016	24	80	24	28	20	0	16	36
2017	3	47	23	30	30	3	23	50
2018	96	100	50	46	62	46	73	35

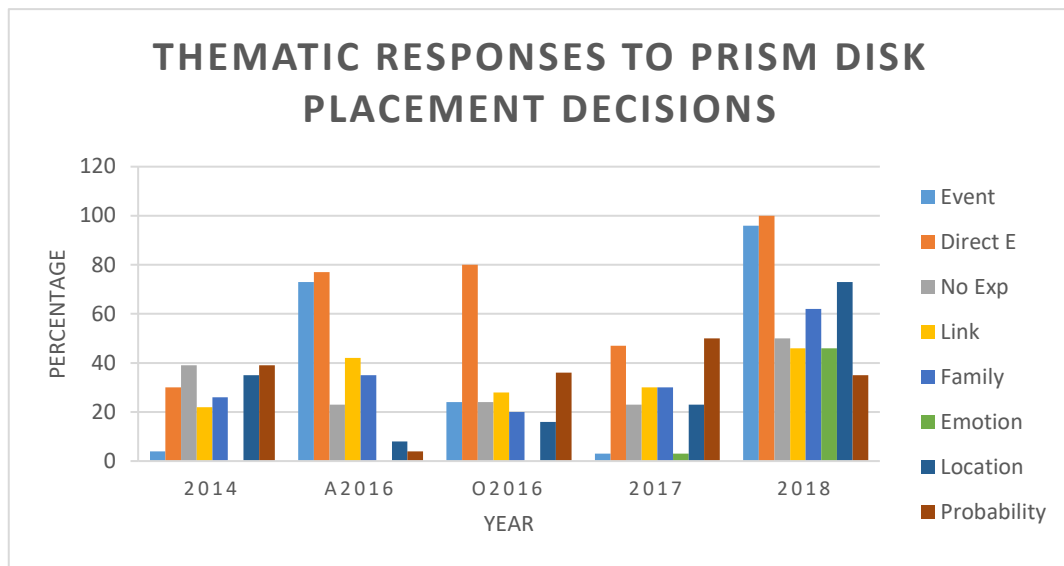


Figure 5. 2 Bar chart showing percentage response by thematic category, 2014-2018 in school 1

Table 5. 16 Frequency of student response to each thematic category over time in school 2

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
2014	0	33	33	20	20	0	40	47
A2016	81	63	25	31	38	13	6	31
O2016	17	39	22	22	0	6	44	56
2017	11	39	22	11	6	6	33	56
2018	85	90	20	40	65	20	0	0

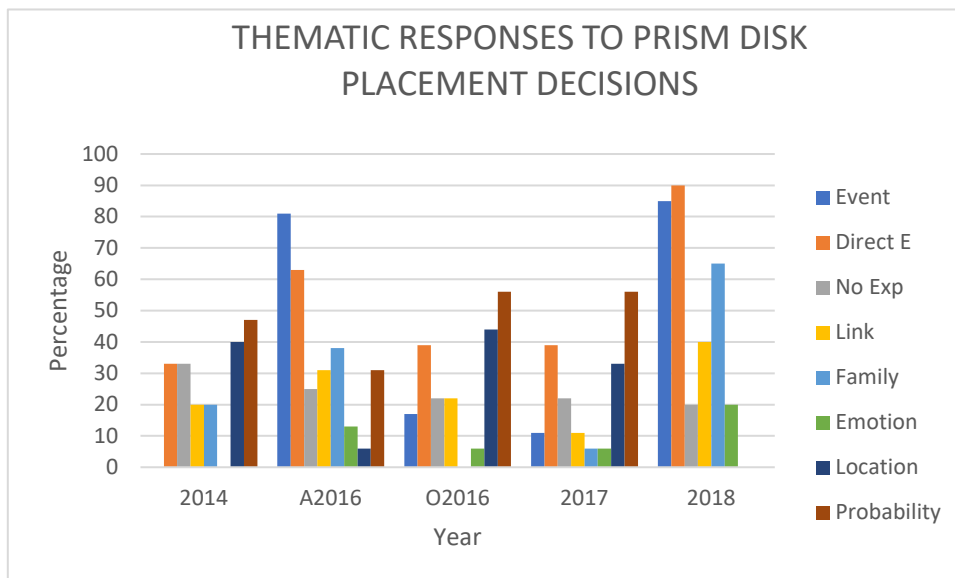


Figure 5. 3 Bar chart showing percentage response by thematic category, 2014-2018 in school 2

Table 5. 17 Frequency of student response to each thematic category over time in school 3

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
2014	0	33	58	0	8	8	58	58
A2016	90	75	42	54	4	0	21	4
O2016	19	57	57	43	5	5	43	14
2017	13	63	54	29	29	8	38	29

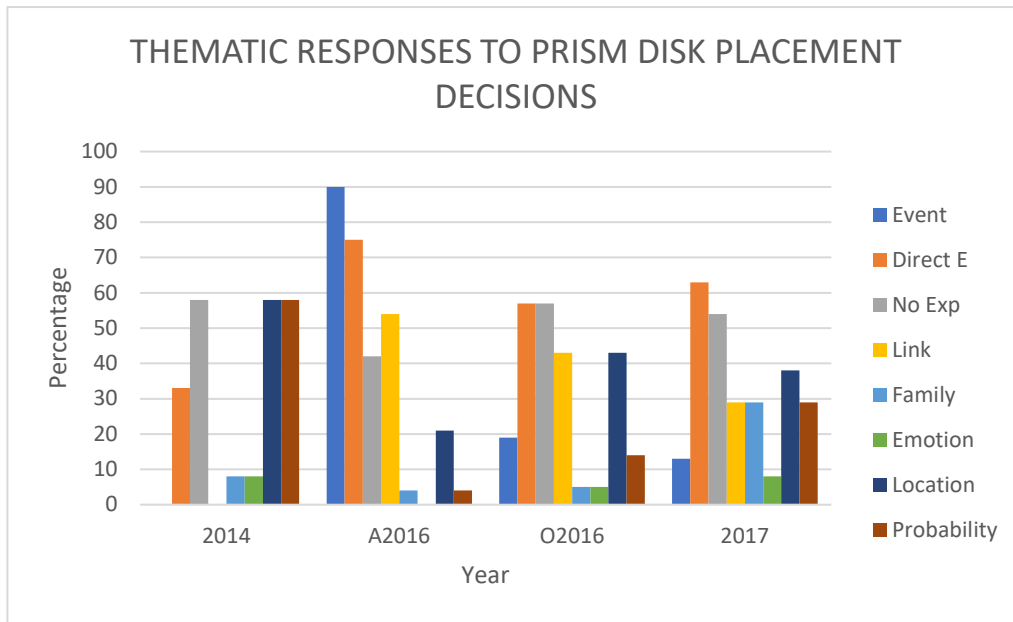


Figure 5. 4 Bar chart showing percentage response by thematic category, 2014-2017 in school 3

Table 5. 18 Frequency of student response to each thematic category over time in school 4

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
2014	8	8	54	23	38	8	31	69
A2016	70	67	33	53	37	10	3	30
O2016	17	45	41	31	14	3	24	38
2017	18	54	29	14	18	4	39	71

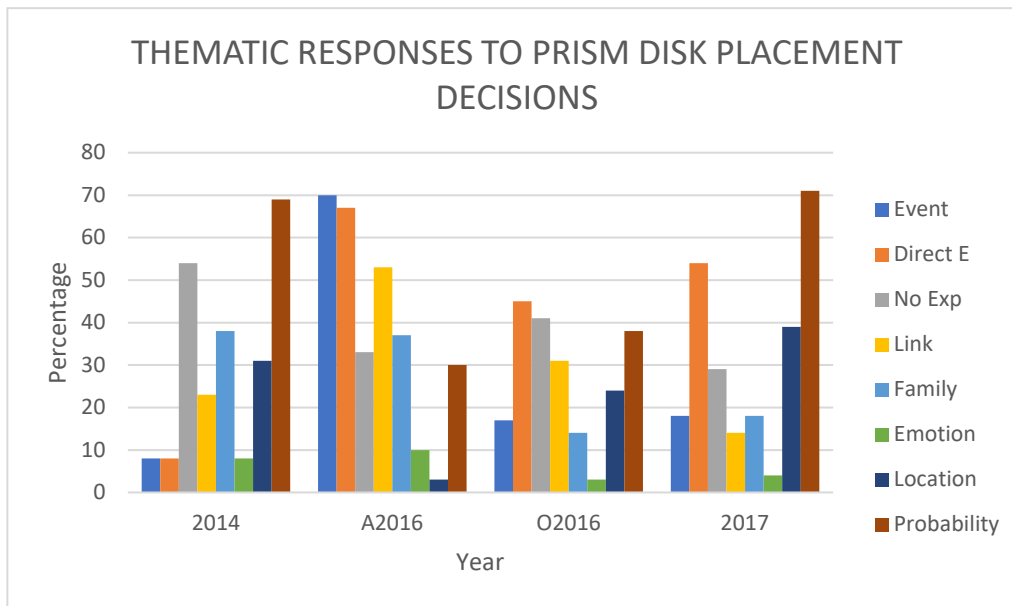


Figure 5. 5 Bar chart showing percentage response by thematic category, 2014-2017 in school 4

Results shown in **tables 5.15-5.18** show student frequency of themed response in PRISM comments and **figures 5.2-5.5** shows the student percentage data allocated to different themes. The results show some consistency across each school. The justification of disk placement was cited by an event, especially in April 2016, after Tropical Storm Erika, and after Hurricane Maria (for school 1 and 2). In most schools the choice of a named event was less common in the other time periods, and showed decreasing use until 2017, which may indicate a decay in this reason further from an event. It also corresponds to reduced importance on the PRISM board shown by disk placement further from “self”.

Figures 5.2-5.5 show that direct experience, as a reason, followed a similar pattern to a named event, but was more prevalent in all time periods. It was most prevalent after Tropical Storm Erika and HM but was one of the highest cited reasons for locating a disk on the PRISM board. This suggests that students reflect and make decisions based on their own experiences. The use of the ‘no experience’ reason for placing a PRISM disk was consistent around 30% in the periods not directly after the disasters but was much lower in these periods directly after a disaster. This suggests that the reason for placement of disks was more powerful in these periods after an event than in the other periods. In these other periods (2014, O2016 and 2017) students were able to draw on both their own experiences and lack of experiences to determine positions. The link to family as a reason (contextualising their reason in the experience of another relative or community member) was varied in different schools. In periods without a hazard the link to family / community

was relatively low, however this was increased after Tropical Storm Erika and Hurricane Maria. However, school 3 students made more connections to the impacts on their community members than in other schools across the collection period. This may reflect community dynamics or a more active regard for DRR in the community. Student ability to link hazards was more prominent directly after a hazard, but less common in the intervening periods. This suggests that the understanding is heightened by an event, or they did not consider links at other times.

Figures 5.2-5.5 show that the pattern for the reason emotion was generally low across the periods except for school 1 and 2 in 2018 after Hurricane Maria. The extremity of this event led to the emotional reflection, not evident in the other periods. It did not score high after Tropical Storm Erika, which may reflect the focused impact in areas away from the schools tested.

The use of location to explain disk placement, for example citing that they were in proximity to risk, was common in explanations between hazard events. In most schools the location factor was higher for younger students but in some cases, it became important after 2015.

The references to the probability as a justification of disk placement was variable. It was higher in 2014 but dropped significantly in April 2016 as students justified their choices reflecting on recent events rather than future ones. This value generally increased across October 2016 and 2017 but significantly fell (in schools 1 and 2) after Hurricane Maria.

In the times periods where there were greater time gaps between hydrometeorological hazards, e.g., 2014 and 2017, students comment less on the past events instead focusing on their own experiences and situation to justify choices. However, the impact of large events, such as Maria, led students to focus on self-impact or impacts on close family and friends leading to greater emotional response.

5.5.2 Relationships in thematic responses to student risk perception

This section presents results which indicate the relationship between the thematic responses for students within each school shown in **tables 5.19-5.22**. **Table 5.19** shows the cumulative results of all links made by all students in the study period. The emboldened numbers highlight themes with potential significant links. **Tables 5.19-5.22** are association matrices showing total number of correlating themes in student responses to PRISM exercise 1.

Table 5. 19 Association matrix to show occurrence of combined themes in student justifications to exercise 1, in School 1 (2014-2018) (top 4 themes are emboldened)

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
Event								
Direct Ex	42							
No Exp	17	24						
Link	22	32	11					
Family	20	29	13	8				
Emotion	12	12	4	4	10			
Location	18	28	11	13	11	8		
Probability	11	20	12	12	11	3	13	

Table 5. 20 Association matrix to show occurrence of combined themes in student justifications to exercise 1, in School 2 (2014-2018) (top four themes are emboldened).

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
Event								
Direct Ex	27							
No Exp	6	4						
Link	4	14	1					
Family	5	17	6	5				
Emotion	2	3	1	2	3			
Location	2	9	2	3	1	1		
Probability	6	6	4	6	2	2	12	

Table 5. 21 Association matrix to show occurrence of combined themes in student justifications to exercise 1, in School 3 (2014-2017) (top 4 themes are emboldened)

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
Event								
Direct Ex	20							
No Exp	14	15						
Link	13	12	15					
Family	2	4	4	0				
Emotion	0	2	0	2	1			
Location	6	10	13	11	3	0		
Probability	2	5	9	3	5	1	7	

Table 5. 22 Association matrix to show occurrence of combined themes in student justifications to exercise 1, in School 4 (2014-2017) (top 4 themes are emboldened).

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
Event								
Direct Ex	20							
No Exp	6	11						
Link	16	15	7					
Family	8	9	10	10				
Emotion	2	3	1	1	1			
Location	3	10	10	5	1	0		
Probability	10	23	13	8	10	6	7	

Table 5. 23 Cumulative association matrix showing results from tables 6.45-6.48 (figures in bold represent main linked themes).

	Event	Direct E	No Exp	Link	Family	Emotion	Location	Probability
Event								
Direct Ex	109							
No Exp	43	54						
Link	55	73	34					
Family	35	59	33	23				
Emotion	16	20	6	9	15			
Location	29	57	36	32	16	9		
Probability	29	54	38	39	28	12	39	

Tables 5.19-5.22 show the greatest frequency between ‘direct experience’ and a ‘named event’, for all students except in school 4. When students referred to a ‘named event’ they contextualised it overwhelmingly in their experience. The link between ‘direct experience’ and ‘linking hazards’ was also common. This means that when explaining their reason for placing a disk they often showed an understanding between that hazard and a linked causal factor or secondary hazard. This was particularly prevalent in school 1 and 2 and may reflect their academic understanding. Students in school 1 and 2 often had a greater number of links between their ‘direct experiences’ and ‘family or community’ experiences. This means their own experience was contextualised in that of those important to them. These results are prevalent in 2018 (which school 3 and 4 did not have) and the experiences they faced in dealing with Hurricane Maria.

The link between ‘direct experiences’ and ‘no experience’ was common in at least two schools. Students would justify a disk placement based on their own experience but then make a further justification of another hazard linked to their lack of experience.

Table 5.23 shows that the greatest cumulative number of responses (109) derive from the link between ‘a named event’ and ‘direct experience’, followed by ‘direct experience’ and ‘linkages between hazards’ (73). In all schools ‘direct experience’ linked well to all themes except emotion (which scored only 20 times). ‘Emotion’ was not linked consistently with any of the other themes.

The theme 'probability' had links with most themes except emotion, suggesting that students explained the likelihood of an event based on 'direct experience', 'lack of experience' or the experience of others. 'Location' was also used with probability as students would comment on why their area was likely to be affected by a given hazard.

Overall, these results show that a 'named event' had the most impact on the student perception, which was also evident in the SHS values in exercise 1. Students' comments were centred around their own experiences and those of close family and community member, but this finding is important as it underlines the impact that experience of an event can have on an individual viewpoint. This is important because it could sharpen preparation towards a repeat risk event but could limit preparation if two different risk events happened in short succession.

5.5.3 Student perception of hazard linkages

This study has established that students have a greater perception of more frequently experienced hazards (**section 5.4**), and that there are differences in student perception occur based on gender and location (**section 5.6**). However, Bird et al, (2009) show that perception of primary hazards is often well understood but that of secondary hazard is less well understood. The results confirm this, especially about the hydrometeorological hazards. However, Solana and Kilburn, (2003) question the understanding between hazards. Those students see hazards as isolated events and do not grasp the subtlety of how one can lead to another. As such one would expect to see strong positive correlations between the meteorological hazards, hurricane, flooding and landslides. Whereas a good grasp of linkage between earthquake and volcanic risk or earthquake and landslide / tsunami might indicate a strong knowledge of these hazards.

While there are some strong correlations ($p < 0.05$) showing these links, they are variable by location and over time. Across the 5 data collection periods school 4 shows the greatest number of expected correlations, with 3 periods showing a strong correlation between flooding and hurricane, 3 showing a positive relationship between volcanoes and tsunami and 2 period showing a link between tsunami and earthquake, and flooding and landslides. The link between volcano and earthquake only is significant on one occasion. However, there are 3 occasions for strong links between earthquakes and hurricanes. Students from school 3 show less significant correlations between hazards, suggesting less understanding, with the greatest number of positive correlations between flooding and tsunami and flooding and landslides. Though they also link volcanic eruptions and landslides, but only on one occasion volcanic eruptions and earthquakes. School 2 recognises the greatest

number of strong correlations between earthquake and hurricane, and tsunami and flooding, whereas in school 1 the greatest number of significant relationships exists between tsunami, and volcano, earthquake, and flooding.

These results show that students exhibit some understanding of the links in their decisions, but the relationships are not clear, in all the time periods across all 4 schools, the most likely relationship between hurricane and flooding occurs 5/25 possible times, whereas strong correlations exist between hurricanes and earthquakes 8/25 times. This shares the greatest number of correlations with volcano and tsunami which also appears 8/25 possible times. These results show that there is a mixed understanding of the relationships between hazards, and they vary by location. School 4 identified 18 likely correlations compared 7 unlikely. School 3 identified 11 likely relationships and 3 unlikely. School 2 identified 8 likely and 6 unlikely correlations, and school 1 15 likely and 5 unlikely relationships. This shows that while there is some definite evidence to suggest that students do grasp the links that this is not consistent, which therefore makes it difficult to definitively agree with Bird et al, (2009), and Solana and Kilburn (2003). However, analysis of student qualitative comments (**Tables 5.19-5.22**) show that students are more likely to make linked comments after a disaster event. More evidence of this, particularly the links between the hurricane occurrence, rainfall and flood and landslide hazards were evident. On average approximately 45% of students made links after Tropical Storm Erika, and 43% after Hurricane Maria, compared to 23% of students at other times. However, there were fewer comments about the geophysical hazards, suggesting that students have a poorer understanding of these less frequent events, or they simply did not mention them. Overall, it seems that students do have linked understanding and there are greater links between primary and secondary hazards after a disaster, but these are not considered in times between hazards to the same extent.

5.5.4 What were the drivers influencing perception?

Student perceptions are influenced by a range of factors, but some patterns are common in the data in this study. As mentioned above, experience of events has an impact on perception. Wiley and Giannotti, (2017) and Avvisati et al, (2019) suggest that in a multi-hazard environment common hazards were better perceived, and better understood. This is certainly the case for the hurricane hazard, where there is generally agreement between students and experts over their significance. However, this study agreed with Bird et al, 2009 that while primary hazards are well understood, that the secondary hazards in this case, landslides, and flooding, showed a poorer understanding. One reason for this agreement may be linked to bias. Confirmation bias (**section 5.3.7**) suggested by Kahneman and Tversky, (1974) Kahneman, (2012) show that individual perception can be biased by a

pre-existing belief, without a reassessment of evidence. This was found to be the case in a DRR context by Johnston et al, (1999). It appears that the belief that is reinforced annually by the Caribbean media and disaster risk agencies that hurricanes are the most important has an impact on the student perception of other hazards. The perception of geophysical hazards is underestimated compared to the experts. The impact of a hydrometeorological event has an impact on the perception of other hazards. Therefore, the belief that hurricanes are the greatest threat creates a bias which can lead to misrepresentation of other hazards. Equally, the student experience of hydrometeorological events can create a normalisation bias (Taleb, 2007) which leads to an underestimation of the same event. This concept is like the 'fluency heuristic' (Duffy, 2019), the idea that people pay more attention to well-known stories. This social science theme means that the reinforced hurricane message, while encouraging people to take mitigative action will lead people to overlook the impact of other potentially dangerous as they view these with suspicion based on their reality of hurricane occurrence. This may therefore represent the large changes in perception associated with post Maria, because of the underestimation of such a high magnitude event due to them experiencing frequent lower magnitude events. This has great implications for a future large-scale flood event, or a large-scale landslide which has not yet been perceived. It also raises concern over the potential for a large seismic event, as most students perceive earthquakes as minor shaking which has limited structural impact. This attitude can lead to future apathy regarding hazard preparation for events other than hurricanes. It underlines the importance of education to improve the response to future emergency situations. (Fischhoff et al, 1995). One other potential control on the perceptions which we have some evidence for is emotion. The results in **figures 5.2-5.5** show that emotion was a strong component in justifying perception immediately after a disastrous event. Kahneman, (2012) and Duffy, (2019) show that people make decisions based less on fact, and more on emotion. This emotion was evident most around the disastrous events. This suggests that educational methods for learning about hazards should have some emotive context rather than just fact transfer. Gautam et al, (2017) has shown in Water, Sanitation and Hygiene (WASH) studies, that designing an emotive reasoning behind mitigative changes encourages people to act. This concept has been well linked to political decision making (Duffy, 2019, Egan, 2018). They have shown that people's decision making can be determined by political allegiance. After Hurricane Maria, there was anecdotal evidence that government supporting areas received support quickest. It would be interesting to follow the students, beyond school to determine whether their perception of hazard readiness is supported by their political views. This would indicate whether trust is an influencing factor (Siegrist & Cvetkovich, 2002, Viklund 2003, Paton, 2008). However, for students at school, the main level of trust is linked to their relationship with family and friends.

5.6 Assessing the impact of location and gender on student perception.

This section assesses changing SHS scores compared to student home location to see if there are spatial differences. This section divides students into one of three categories; those who reside within the geographical location of the school (central), those in coastal locations outside the school area and those in upland /steep valley locations outside the school area. This may have implications for DRR delivery especially if there are clear spatial differences. If location is a significant factor, we should see a significant difference between the mean values for each group of students (calculated by the two-tier independent t-test where significance is equal to $p=0.10$). As the sample sizes for each group are small relatively, the Cohen's d effect score is included to indicate the extent to which this might reflect a realistic difference in real life (van den Berg 2020). For this comparison effect scores are interpreted as: 0.2 - small effect, 0.5 – medium effect and 0.8 - large effect (van den Berg, 2020). for this study large effect scores >0.700 are considered due to the small data set used. SPSS was used to calculate independent t-test and effect scores.

5.6.1 Analysing differences in perception by location (central vs coastal)

Table 5.24 shows the results from independent t-test results comparing the SHS values for students who live in central locations (near their school) vs those who live in coastal locations. Statistically significant differences shown for each hazard and school (**Table 5.24**). Results from school 4 includes the Kalinago student population who live on the reserve in coastal locations. **Table 5.25** shows mean SHS values by location.

Tables 5.24 and 5.25 indicate that school 1 students show little difference in SHS perception of hazards between coastal locations and the central locations. An effect scores of .77 in 2018 shows a possible difference in perceptions of hurricane, with coastal populations showing an average SHS of 2.1 compared to 3.8 in the central area. Broadly students show a similarity in perception values. The mean data shows some difference in average SHS for tsunami in 2014 and 2018, but this is not reflected in the statistical significance or effect scores. Although students living by the coast have an increased perception of tsunamis compared to those in the central area.

Table 5. 24 Statistically significant difference p-values (t-test) between student hazard perceptions in central locations and coastal locations (note shaded boxes represent multiple cases of significant difference between locations)

School	1		2		3		4 (vs KT)	
Stat test	2 tailed (sign)	Cohen's d	2 tailed (sign)	Cohen's d	2 tailed (sign)	Cohen's d	2 tailed (sign)	Cohen's d
Hurricane		.77 (18)		-.73 (14)	.08 (A16)	-1.46 (A16)	.055 (O16)	-1.21 (14)
			.10 (17)		-1.20 (O16)	.04 (17)	.836 (A16)	
					-1.81 (17)		.970 (O16)	
							.137 (17)	
							.78 (18)	
Flood			.01 (14)	1.7 (14)	.03 (14)	2.1 (14)	.052 (18)	-.878 (14)
			.09 (17)	.87 (A16)				.873 (O16)
				.86 (O16)				.819 (17)
				1.1 (17)				1.18 (18)
				1.4 (18)				

Earthquake							.10 (14)	2.26 (14)
							.103 (18)	1.05 (18)
Volcanic Eruption	0.90 (14)	.79 (14)			.068 (A16)	-1.19 (A16)		1.39 (14)
Landslide				.76 (14)		-1.2 (14)	.026 (O16)	1.15 (O16)
							.064 (17)	1.12 (17)
							.010 (18)	1.75 (18)
Tsunami			.07 (A16)	.82 (14)				
			.013 (17)	1.2 (A16)				
				1.7 (17)				1.83 (14)
				.84 (18)				

Table 5. 25 Mean SHS values for perceived hazards by location (central vs coastal) in school 1 (shaded scores show similar results between each location – within <1.5cm on PRISM board).

		14	A16	O16	17	18
Hurricane	Central	7.3	7.8	5.3	6.9	3.8
	Coastal	5.6	8.0	4.8	7.7	2.1
Flood	Central	15.1	9.3	12.9	11.3	7.3
	Coastal	12.0	10.3	12.8	12.0	6.1
Earthquake	Central	13.6	13.7	17.0	14.7	16.5
	Coastal	13.9	14.4	17.2	13.0	17.3
Volcanic E	Central	15.6	15.1	13.4	15.3	18.5
	Coastal	10.3	19.0	13.8	15.6	18.0
Landslide	Central	10.7	5.9	12.0	12.8	13.1
	Coastal	10.5	8.0	10.7	9.0	12.5
Tsunami	Central	23.3	25.1	24.5	24.2	18.2
	Coastal	19.5	21.4	24.6	22.1	13.0

Table 5. 26 Mean SHS values for perceived hazards by location (central vs coastal) in school 2 (shaded scores show similar results between each location – within <1.5cm on PRISM board).

		14	A16	O16	17	18
Hurricane	Central	6.8	12.2	8.3	8.1	4.2
	Coastal	10.9	8.4	12.3	5.8	5.6
Flood	Central	18.3	16.4	13.1	17.1	14.7
	Coastal	8.6	12.0	7.7	8.6	5.6
Earthquake	Central	12.6	10.5	9.2	13.5	13.2
	Coastal	10.4	12.6	11.3	10.7	12.5

Volcanic E	Central	13.9	12.7	13.7	14.4	12.1
	Coastal	11.7	11.8	15.9	10.3	11.5
Landslide	Central	9.0	14.1	12.6	16.9	12.2
	Coastal	12.9	12.0	16.5	13.3	15.5
Tsunami	Central	22.0	25.0	21.8	25.7	17.1
	Coastal	16.6	17.9	21.2	14.2	10.9

Tables 5.24 and 5.26 show notable differences for school 2 students for the flood and tsunami hazard between the central and coastal locations. Coastal residents have a greater perception of the flood risk than those in the central areas, reflecting both the threat local rivers passing through coastal locations and the threat from the sea. The perception of flood risk near the central Roseau is much reduced, which reflects those that live in suburbs elevated from the Roseau River floodplain. These differences are also evident in the Cohen's d effect scores between 2014 and 2017. Tsunami data has a similar trend to the flood data with coastal students placing greater importance on this risk, except in October 2016. Perception values in each location for earthquake and volcanic risk are similar, with a narrow range in SHS values for earthquake (2.8cm) and volcanic eruptions (4.1cm). Neither of these hazards show any statistically significance in their differences.

Table 5. 27 Mean SHS values for perceived hazards by location (central vs coastal) in school 3 (shaded scores show similar results between each location – within <1.5cm on PRISM board).

		14	A16	O16	17	18
Hurricane	Central	4.3	5.2	4.0	4.6	
	Coastal	4.1	8.3	6.5	8.3	
Flood	Central	12.1	12.3	13.8	12.0	
	Coastal	6.0	13.7	15.5	15.8	
Earthquake	Central	8.8	16.4	8.3	10.9	
	Coastal	5.9	13.1	11.2	12.5	
Volcanic E	Central	12.5	14.8	13.4	16.1	

	Coastal	15.7	23.1	13.5	15.5	
Landslide	Central	6.3	16.0	10.2	12.8	
	Coastal	12.5	16.1	12.9	13.0	
Tsunami	Central	18.4	21.5	19.6	21.6	
	Coastal	10.2	20.2	21.8	20.4	

Tables 5.24 and 5.27 show school 3 student data between 2014-2017 for central (Portsmouth) and coastal students. Data was not collected for school 3 in 2018 due to the continuing impacts of Hurricane Maria. Students in the central area perceived the threat of hurricanes as a greater threat than those by the coast in April 2016 and 2017. Students in the coastal locations showed a slightly intensified perception of tsunami threat, however there was no statistical significance in difference or effect size difference between the values for these locations. In 2014 there were significant differences for flooding and landslide hazards. Those in coastal locations perceived flooding as a greater threat (6.0cm) compared to those in central Portsmouth (12.1cm) however this pattern did not continue beyond 2014, questioning whether younger students have a more extreme perception. Similar patterns existed for landslide risk in 2014, though this pattern did continue beyond 2014, despite differences not being significant. In April 2016 there was an isolated difference in perception of volcanic eruptions however the reduced perception of volcanoes by coastal students was anomalous compared to other years.

Table 5. 28 Mean SHS values for perceived hazards by location (central vs coastal) in school 4 (shaded scores show similar results between each location – within <1.5cm on PRISM board).

		14	A16	O16	17	18
Hurricane	Central	6.1	7.3	5.1	9.7	2.8
	Coastal	14.1	5.5	3.9	4.5	1.6
Flood	Central	12.8	16.5	17.9	15.5	10.0
	Coastal	17.1	15.2	11.2	10.2	5.4
Earthquake	Central	22.1	14.9	9.3	12.9	18.2
	Coastal	16.6	14.1	10.9	10.8	13.3

Volcanic E	Central	26.0	23.2	20.4	19.3	23.5
	Coastal	14.8	22.1	17.2	17.4	23.4
Landslide	Central	15.7	7.8	12.2	15.6	12.1
	Coastal	14.5	7.3	6.7	9.3	4.5
Tsunami	Central	25.5	23.4	20.4	23.3	22.2
	Coastal	15.6	25.6	21.5	19.7	19.6

Table 5.24 and 5.28 show comparisons between students in school 4 (central vs coastal students including Kalinago Territory KT). Except for 2014, students in coastal locations perceived hurricane greater risk than those in the central area. Statistically significant differences are shown for October 2016 and 2017 between these groups, and large effect scores exist for all data collection periods. There are clear differences in the perception of flood risk in April 2016 and 2018. Large effect scores underline this difference for 2014, October 2016, 2017, and 2018, and a statistically significant difference shown in 2018. Values for perception of earthquakes were similar in 2017 but students in 2018 showed significant differences, with coastal students putting higher risk perception on earthquakes compared to those in the central area, reflecting the increased impact of coastal students from Hurricane Maria which led to intensification of other familiar hazards. Volcanic eruption and tsunami risk values are generally similar between 2016-18 except for 2014. The coastal students from the Kalinago Territory put much greater importance in landslide perception which is explained by the steep topography onto which the reserve is built, shown by high effect scores >1.1 for this hazard. Overall students in coastal locations show greater perceived differences in hydrometeorological hazards than for geophysical hazards. School 4 has the greatest numbers of significance differences between the two groups, while school 1 shows the greatest similarity. This may reflect the relative position of school 1 near the coast and within the centre of the town. These results show that school location has some impact on the relative perception of multi-hazards and these differences should be considered when providing information to help student make decisions over improving risk capacity.

5.6.2 Analysing differences in perception by location (central vs upland students)

This section compares the difference between the students who live in the central areas compared to those who come from upland areas or steep river valley locations. **Table 5.30** shows the significant differences and the Cohens d effect scores for these groups. **Tables 5.29,5.31-5.33** show the differences in mean values between the upland and centrally located students.

Table 5.29 and 5.30 show the results for school 1. The hurricane risk and earthquake perceptions are broadly similar between the two groups. Students from central Roseau have increased perception of flood risk after 2014 evident in high effect scores in April 2016 and 2018. In April 2016 and 2018 the difference in volcanic eruption is evident but not statistically significant. Students from the upland areas have a greater perception of landslide risk than those in central locations, but only in 2017 does an effect score of 0.717 indicate a statistical difference. Tsunami values show a greater difference statistically. After April 2016 there is statistical significance in the difference between the groups, and between April 2016-18 there are effect scores over .700. With Roseau being near the coast the values in these locations show a greater perception of tsunami risk compared to upland locations.

Table 5. 29 Mean SHS values for perceived hazards by location (upland and central) in school 1 (shaded scores show similar results between each location – within <1.5cm on PRISM board)

		14	A16	O16	17	18
Hurricane	Central	7.3	7.8	5.3	6.9	3.7
	Upland	7.4	6.2	3.9	5.5	2.8
Flood	Central	15.1	9.3	13.0	11.3	7.3
	Upland	15.4	14.1	14.0	11.5	16.2
Earthquake	Central	13.7	13.7	17.0	14.7	16.5
	Upland	15.6	15.1	13.4	15.3	18.5
Volcanic eruption	Central	16.0	12.6	15.1	18.4	17.4
	Upland	14.8	22.1	17.2	17.4	23.4
Landslide	Central	10.7	5.9	12.0	12.8	13.1
	Upland	11.4	3.9	7.9	7.6	12.5
Tsunami	Central	23.3	25.1	24.5	24.2	18.2
	Upland	20.2	21.1	27.3	26.6	26.4

Table 5. 30 Statistically significant difference p-values (t-test) between student hazard perceptions in central locations and upland locations (note shaded boxes represent multiple cases of significant difference between locations).

School	1		2		3		4	
	2 tailed (sign)	Cohen's d	2 tailed (sign)	Cohen's d	2 tailed (sign)	Cohen's d	2 tailed (sign)	Cohen's d
Hurricane				.93 (14)	.012 (A16)	-.967 (A16)		
					.015 (O16)	-1.11 (O16)		
					.003 (17)	-1.4 (17)		
Flood		-.743 (A16)		-.98 (O16)		-7.04 (17)		-.983 (14)
		-1.30 (18)						
Earthquake						-.849 (14)		
Volcanic Eruption				.73 (O16)	0.73 (A16)	-.941 (A16)	.067 (14)	1.02 (14)
							.089 (A16)	1.05 (18)
							.059 (18)	
Landslide		.718 (17)		.88 (O16)	.031 (14)	-1.52 (14)	.008 (18)	.824 (17)
				.82 (17)				1.79 (18)
Tsunami	.025 (O16)	.705 (A16)	.01 (14)	-1.6 (14)		-.854 (14)	0.064 (14)	1.01 (14)
		-.881 (O16)	.06 (A16)	-1.3 (A16)		-1.20 (A16)		
		-1.43 (18)				-.78 (Oc16)		

Table 5. 31 Mean SHS values for perceived hazards by location (upland and central) in school 2 (shaded scores show similar results between each location – within <1.5cm on PRISM board).

		14	A16	O16	17	18
Hurricane	Central	6.8	12.2	8.3	8.1	4.2
	Upland	3.5	8.3	6.3	6.9	7.7
Flood	Central	18.3	16.4	13.1	17.1	14.7
	Upland	17.2	16.3	20.6	17.7	15.5
Earthquake	Central	12.6	10.5	9.2	13.5	13.2
	Upland	9.03	7.04	6.7	14.3	12.4
Volcanic eruption	Central	13.9	12.7	13.7	14.4	12.1
	Upland	15.6	14.6	8.7	13.7	11.5
Landslide	Central	9.0	14.1	12.6	16.9	12.2
	Upland	5.4	9.4	7.0	9.6	7.5
Tsunami	Central	22.0	25.0	21.8	25.7	17.1
	Upland	27.3	27.1	19.7	25.8	20.4

Table 5.30 and 5.31 show that school 2 students show the greatest differences in 2014 and 2016 periods. Hurricane perception varies over time, with those in upland locations showing greater intensity in risk perception between 2014-2017. In 2018 the centrally located students had more intense perception of hurricanes due to the damage created by Hurricane Maria. Flood scores are quite similar between each group, but those in central locations have a greater perception of the flood risk after October 2016 (effect score of -.98). The perceptions of both earthquake and volcanic eruption are similar and show little difference. The greatest differences are evident in the landslide and tsunami hazard. Those in upland locations place a much higher perceived risk with landslide hazards and effect scores >.8 are shown in October 2016 and 2017. Tsunami risk is generally a greater risk for those in the central location, except for October 2016, which links to the closer coastal proximity. However statistically significant differences and large effect scores show differences between the groups in 2014 and April 2016.

Table 5. 32 Mean SHS values for perceived hazards by location (upland and central) in school 3 (shaded scores show similar results between each location – within <1.5cm on PRISM board)

		14	A16	O16	17	18
Hurricane	Central	4.3	5.2	3.9	4.6	
	Upland	6.8	9.4	8.1	8.4	
Flood	Central	12.1	12.3	13.8	12.0	
	Upland	18.6	16.5	15.2	16.4	
Earthquake	Central	8.8	16.4	8.3	10.9	
	Upland	14.2	18.2	12.2	14.1	
Volcanic eruption	Central	12.5	14.8	13.4	16.1	
	Upland	13.0	21.7	15.6	18.0	
Landslide	Central	6.3	16.0	10.2	12.8	
	Upland	16.8	16.0	11.2	14.8	
Tsunami	Central	18.4	21.5	19.6	21.6	
	Upland	23.8	25.9	25.5	25.0	

Table 5.30 and 5.32 indicate that school 3 students show greater differences in perception between upland and centrally located group than other schools. Hurricane risk shows significant differences for April 2016, October 2016 and 2017 with those in the central areas perceiving hurricane risk greater than those in the upland regions. This is the same for mean flood risk differences, despite not being statistically significant. Students in central regions perceive all other risks greater than the upland students. However, there are isolated examples of significance, for example with volcanic perception in April 2016 (93% confidence) and for landslides (96.9% confidence). The tsunami result shows the clearest difference with effect scores greater than .75 in April 2016, October 2016 and 2017.

Table 5. 33 Mean SHS values for perceived hazards by location (upland and central) in school 4 (shaded scores show similar results between each location – within <1.5cm on PRISM board)

		14	A16	O16	17	18
Hurricane	Central	6.1	7.3	5.1	9.7	2.8
	Upland	6.3	7.7	6.2	9.2	2.5
Flood	Central	12.8	16.5	17.9	15.5	10.0
	Upland	20.1	16.1	15.8	17.1	9.5
Earthquake	Central	22.1	14.9	9.3	12.9	18.2
	Upland	18.9	12.9	12.0	12.0	15.1
Volcanic eruption	Central	26.0	23.2	20.4	19.3	23.5
	Upland	18.7	18.9	20.4	19.1	18.7
Landslide	Central	15.7	7.8	12.2	15.6	12.1
	Upland	15.7	9.5	9.6	10.5	5.1
Tsunami	Central	25.5	23.4	20.4	23.3	22.2
	Upland	14.9	23.7	24.0	23.3	22.8

Tables 5.30 and 5.33 indicate that school 4 students show little difference in hurricane and earthquake perceptions. An effect score of -.983 for flood risk in 2014 indicates a difference but there is no other evidence for this. Students showed the greatest difference for volcanic eruption values, showing statistically significant differences in 2014, April 2016 and 2018. On all occasions, students in upland areas showing a heightened risk perception. Landslide risk is also perceived greater in upland areas in 2017 and 2018 with at 99% level of significance in 2018. Tsunami data shows differences in 2014 and October 2016 but only the 2014 data shows statistical significance. Overall students in upland areas show fewer differences with central locations. Differences are mostly in relation to effect on area or an event, e.g., hydrometeorological hazards are perceived greater in areas which are affected by them, particularly floods and landslides. This does not follow

for less frequent hazards. Across the four school's tsunami shows the greatest difference in perceived risk and earthquakes the least difference.

5.6.3 Analysing gender differences in perception

This section assesses differences in hazard perception based on student gender. It is not possible to do this in school 1 as it is a single-sex school. Differential statistics and two-tier independent sample t-tests, calculated in SPSS, were used to determine differences between gender. Mean SHS values for gender differences in each school are shown in **Tables 5.34-5.36** and significant differences and effect score data is shown in **Table 5.37**. As with spatial comparison significant differences are identified $p < .10$ (90%), and effect scores are shown where Cohen's d values were $> .70$.

Table 5. 34 Mean perceived SHS for hazards by gender in school 2 (shaded scores show similar results between genders – within < 1.5 cm on PRISM board)

		14	A16	O16	17	18
Hurricane	Male	8.6	15.5	11.5	5.9	6.1
	Female	5.2	4.3	6.0	8.0	5.3
Flood	Male	16.1	15.2	13.3	12.9	8.9
	Female	14.6	11.5	13.5	16.1	14.9
Earthquake	Male	13.8	14.8	10.9	10.6	12.1
	Female	7.99	5.33	7.1	15.1	13.3
Volcanic eruption	Male	14.3	17.6	16.1	13.7	13.5
	Female	13.1	8.5	9.2	11.9	10.3
Landslide	Male	10.0	15.0	15.6	14.2	14.7
	Female	8.0	8.9	8.2	12.4	9.4
Tsunami	Male	22.5	23.2	21.2	19.5	14.5
	Female	21.2	23.7	20.8	24.3	17.7

Tables 5.34 and 5.37 show that female students perceive risk greater until 2016 after which boy's perception intensifies. Females in school 2 perceive hurricanes as a greater risk, except in April 2017, with significant differences in April and October 2016. Flood risk does not follow the same pattern. Until October 2016 female students perceive flood risk as more dangerous, after which the pattern reverses. This difference was most significant in 2018 (90% confidence). Earthquake data follows a similar pattern to floods. There are significant differences between 2014-October 2016 and effect scores indicate differences in 2017 and 2018. This reflects the change in boys' perception of earthquakes after the 2017 seismicity. Volcanic and landslide risks are perceived as a greater threat by females, but similar patterns to earthquake perception is evident post 2017 as the perception of boys intensifies. The only hazard without significant difference is tsunami. These values show similarity in the mean between 2014-2016 but boys perception intensifies after 2017. Overall, **Table 5.34 and 5.37** show that there are clear differences shown between the gender, particularly in the 2014-2016, after which boys' perception of risk intensifies for all hazards except earthquake.

Table 5. 35 Mean perceived SHS for hazards by gender in school 3 (shaded scores show similar results between genders – within <1.5cm on PRISM board)

		14	A16	O16	17	18
Hurricane	Male	4.2	7.6	6.2	7.0	
	Female	8.3	8.3	7.1	7.6	
Flood	Male	10.6	13.6	14.3	13.3	
	Female	18.1	15.8	15.4	16.5	
Earthquake	Male	8.9	16.2	8.4	11.4	
	Female	13.2	17.4	13.1	14.1	
Volcanic eruption	Male	9.9	18.2	11.4	14.0	
	Female	16.6	21.4	17.2	19.6	
Landslide	Male	8.5	15.7	10.1	12.0	
	Female	16.6	16.4	12.2	15.5	
Tsunami	Male	15.6	22.9	22.0	21.7	
	Female	23.8	24.4	24.2	24.6	

Differences in school 3 are less obvious than school 2. **Tables 5.35 and 5.37** show that boys have an intensified perception of hurricane risk compared to girls, but only 2014 has a significant difference (91%) and an effect score of -1.18. Flooding trends similarly to hurricanes, although none of the differences are statistically significant, despite a 2014 effect score of -.749. In a reverse of the trend in school 2, male students perceive all risks greater than girls. Significant differences occur in October 2016 for both earthquake and volcanic risk perception and volcanic risk in 2017. Relatively large mean differences occur in all years for volcanic hazard without the differences being statistically significant. Male and female students perceive landslides risk similarly, except in 2014 where there is a statistically significant difference at $p=.091$. Tsunami values are also similar, but there is an effect score of -.800 in 2014, another example of more extreme differences in 2014. Overall, **Tables 5.35 and 5.37** show that boys in school 3 perceive the risk of all hazards more importantly than the girls and greatest differences are evident in 2014 and October 2016.

Table 5. 36 Mean perceived SHS for hazards by gender in school 4 (shaded scores show similar results between genders – within <1.5cm on PRISM board)

		14	A16	O16	17	18
Hurricane	Male	7.8	5.7	4.7	6.7	2.1
	Female	8.6	8.5	6.2	9.7	2.6
Flood	Male	15.7	14.6	15.5	12.7	7.5
	Female	19.0	17.4	15.5	17.3	9.6
Earthquake	Male	22.8	12.6	10.1	11.1	15.7
	Female	16.8	15.0	11.8	12.7	15.8
Volcanic eruption	Male	26.6	21.5	20.0	18.6	22.2
	Female	15.0	20.4	19.6	18.8	21.1
Landslide	Male	17.4	8.6	9.9	11.3	7.5
	Female	14.3	8.3	9.7	11.6	7.3
Tsunami	Male	18.3	24.2	23.7	21.3	21.5
	Female	17.0	23.9	21.0	23.5	22.0

Table 5.36 and 5.37 show that school 4 students show least difference in SHS values by gender. Values do not follow a single sex trend as in school 3. Males perceive hurricanes and flood risk more than females (significant differences between April 2016-2017); though this gap closed after Hurricane Maria. Except for 2014 perceptions of earthquake and volcanic eruptions are similar. Males perceive the threat of earthquakes greater than females, but this trend is reversed for volcanic eruptions. Neither landslide nor tsunami show significant differences in perception.

Overall **Table 5.37** shows that there are mixed perceptions by gender. In school 2 girls show increased risk perceptions across most hazards, while boys have increased risk perceptions in school 3. Hurricane, earthquake, and volcanic risk are perceived with the greatest differences mainly in 2014 and 2016. However, despite differences in hurricane risk perception similar pattern for flood, earthquake or tsunami perception do not exist. Therefore, it is difficult to conclusively show evidence for significant differences in perceptions based on gender. However, there are patterns of difference which could be further explored.

Table 5. 37 Significant difference p -values (t-test) and effect scores (Cohen’s d) for perceived hazards by gender in schools 2-4. (note shaded boxes represent multiple cases of significant difference between genders).

School	1		2		3		4	
	2 tailed (sign)	Cohen’s d	2 tailed (sign)	Cohen’s d	2 tailed (sign)	Cohen’s d	2 tailed (sign)	Cohen’s d
Hurricane			.004 (A16)	1.15 (A16)	.092 (14)	-1.18	.009 (A16)	1.06 (A16)
			.047 (O16)	.992 (O16)			.098 (O16)	
							0.78 (17)	
Flood			0.96 (18)	-.78 (18)		-.749 (14)	.083 (17)	
Earthquake			.05 (14)	1.09 (14)	.063 (O16)	-.767 (14)	.030 (14)	1.22 (14)
			.008 (A16)	-1.14 (O16)				
			.09 (O16)	-1.59 (17)				
				-1.1 (18)				
Volcanic Eruption			.002 (A16)	1.96 (A16)	.095 (O16)	-.746 (O16)	.004 (14)	1.83 (14)
			.097 (O16)	.860 (O16)	.064 (17)	-.791 (17)		
Landslide			.047 (O16)	.874 (A16) 1.05 (O16)	0.91 (14)	-1.1 (14)		
Tsunami						-.800 (14)		

5.6.4 The role of gender and spatial variation in risk perception?

Few studies of gender differences in student risk perception exist to date, though Khan et al, (2020) argue it is important to understand these differences as not all students think alike. Of the few existing gender risk studies in adult populations, females have a greater capacity for risk and a better understanding of them (Sattur and Cheng, 2019, Harris et al, 2016), despite being affected by them more, while males are more risk averse (Morioka, 2014, Lightfoot et al, 2020, Liu et al, 2020). This study differentiates the gender perception of hazards based on frequency and location.

Tsunamis which represent hazards which have not occurred in the lifetime of students showed there was little difference in perceived risk in all schools by gender. Yet for volcanic eruption another low frequency risk, after 2016 there was a significant difference between the perceptions of male and female students, in schools 2 and 3, yet in school 4 there were only significant differences in males and females in 2014. This suggests that there is no consistent pattern in difference. Earthquakes showed greater difference by gender in school 2 but less so in school 3 and 4. One would expect less significant difference for a frequently perceived risk, for example hurricanes, but this was not the case, as differences were evident in mainly 2014 and 2016 but less so in 2017. The data suggests that the differences experienced are not consistent even after Tropical Storm Erika, as there was a significant difference shown in April 2016 between boys and girls in both school 2 and 4. However, as mentioned above students did not perceive this event as a hurricane. There are less differences shown for flooding and landslides, suggesting that males and female students perceive this hazard more similarly, which is to be expected considering the extent to which these are experienced.

The results from this study agree with some of the adult studies mentioned that boys tend to be more risk averse than girls as they had lower SHS scores suggesting a greater perceived importance and therefore risk. T-test results in **Table 5.37** also show that there were a greater number of differences in the younger student populations in 2014 and in 2016. The 2014 result may be explained by the lack of understanding through education, and the 2016 results may be skewed by the impact of Tropical Storm Erika. However, comparing the data in **Table 5.4** (expert values) with that in **tables 5.34-5.36** (gender averages by school) there is evidence for agreement with Sattur and Cheng, (2019) and Harris et al, (2016) who suggest that females have a greater understanding of the hazard. In school 4, the females have greater agreement with experts than the boys. This is also the case for hydrometeorological hazards in school 3, though boys are generally in agreement with the geophysical hazards. This is also the case for school 2, though perception of female flood risk varies in comparison, generally female students are closer to expert perceptions than the boys. There is evidence that of difference by gender, particularly that boys are more risk averse and that girls have

a smaller difference in perception compared to experts, however with small sample sizes, and not being able to compare school 1 further study would need to be conducted to determine the extent of the findings shown.

The results for location tested the extent to which there were significant differences in perception between the students in central locations (near the school) vs coastal locations beyond the school location, and between central locations and students from upland locations. Previous studies of spatial variation in student perception, within a defined geographical region have not been conducted before. However, expectation was those students living in coastal locations and in upland areas may be more aware of hydrometeorological hazards, as they live in areas potentially subject to more flooding or landslides.

This study has found that comparing the coastal locations with town centre locations showed little difference in perception of geophysical hazards, across the 4 schools except for isolated cases in 2014 and 2016. **Table 5.24** shows that there were more differences for the hydrometeorological hazards, as expected, but these varied by location. Few differences were evident in school 1 and 2 except for differences in flood risk perception in school 2 which had significant differences in 2014 ($p=.01$) and in 2017 ($p=0.19$). However, there was a Cohen's D effect score over .86 in all periods of time suggesting that there were differences between the coastal and central populations in school 2 students. A similar pattern was evident for school 4, but less so for school 3. Instead, significant differences were evident for school 3 and 4 coastal and central populations between 2016-17 in school 3 and 4, with school 4 having an effect score over .78 for all time periods. School 4 had significant differences for all hydrometeorological hazards, but fewer for geophysical, except earthquakes which showed significant differences in 2018 and 2018. This therefore adds some weight to the argument that there were significant differences between coastal and central students for hydrometeorological hazards, though the inconsistent pattern suggests that this relationship needs further testing. Interestingly the lack of significant difference in geophysical hazards between locations may suggest that students lack understanding of the likely threat, which was evident in the long-term perception changes reported above.

Comparing the perceptions of students located in upland / steep river valleys, versus those in the central locations near the school, which were all within the urban area or the urban fringe, in relatively low altitude areas, one would expect differences in perception of tsunami – i.e. central students perceiving it a greater risk; landslide as upland areas (especially in Dominica) are steeper topography, and potentially volcanic eruption, as upland areas are at closer proximity to the craters. **Table 5.30** shows the difference in tsunami was evident across all schools, with significant

relationship in both 2014 and 2016 in most locations. Landslides also showed some evidence of difference, though only significant differences were evident in school 3 (in 2014) and school 4 in 2018, despite evidence of high effect scores. There was also some evidence of difference in perception of volcanic eruption, however, this was not the case for students in school 1 and 2 who live nearest the most dangerous volcanoes in Dominica, and greater for students in school 4, where there is relatively less risk for the central location. Perhaps this suggests a greater understanding of volcanic risk in school 4 or a lack of it in school 1 and 2. Most likely the reason for this is linked to student comments about volcanic risk that it is has not happened therefore it is low risk. This links again to the normalisation bias (Taleb, 2007).

Overall, school 4 had the greatest differences in perception between students in central locations and other locations. Students from the Kalinago Territory (mostly in coastal locations) were more risk averse than those in central locations, which may reflect their cultural differences. There is some evidence to suggest that students in different locations perceive the risk from different hazards differently. This is significant, particularly as educational material needs to reflect these differences so that students can relate to the risk in their own area, rather than learning about generic hazard risk, which is the current approach.

5.7 Correlating DRR measures with socioeconomic levels

Part of the PRISM exercise was to collect additional data which related to the individual to determine their socioeconomic level (this is found in the supplementary files: [PRISM data](#)). This section will correlate the level of parental education with the number of DRR measures students kept in their homes to test the objective to determine a link between socioeconomic level and action for DRR. This data was collected in either 2013 or 2014 on the first meeting with the students. Parental education was assumed not to change in the data collection period and items to prepare for a hazard are reflective of pre 2015 (pre-Tropical Storm Erika and H Maria). The results for each school are shown in **Table 5.38** :

Table 5. 38 Correlate data, by school, between parental educational levels and hazard reduction measure numbers (values in *italics* = significant at p=0.01).

	School 1 (n=32)	School 2 (n=21)	School 3 (n=24)	School 4 (n=32)
Correlate	.536	.198	<i>.607</i>	<i>.678</i>
P value	<i>.002</i>	.391	<i>.002</i>	<i>.000</i>

Table 5.38 shows that all the schools showed a positive correlation significant to $p=0.01$ except school 2. School 4 showed the strongest significance with a $p=0.0001$, while both school 1 and 3 had a $p=0.002$. School 2 was the only school without significant correlations between parental education and number of preparatory items for DRR.

Figure 5.6-5.9 shows scatter graphs for each school to represent the relationships shown in **Table 5.38**. Parental education was scored on a scale of 0-8. With 0 = no education, 1 = one parent completed primary, 2 = 2 parents completed primary, 3 = one parent completed senior school, 4 = two parents completing senior school, 5 = one parent completing undergraduate, 6 = two parents completing undergraduate, 7 = one parent completing post grad and 8 = both parents completing post graduate course. The students were asked to verbally list items that they had as preparation e.g., tinned food, stored water, constructed roof. The total number of preparations was the value used in the correlation. Scattergraphs show stronger relationships between for schools 1,3 and 4 with almost no correlation in school 3. The small sample challenges this finding, but such strong correlation in **Table 5.38** suggests that there may be evidence supporting the correlation.

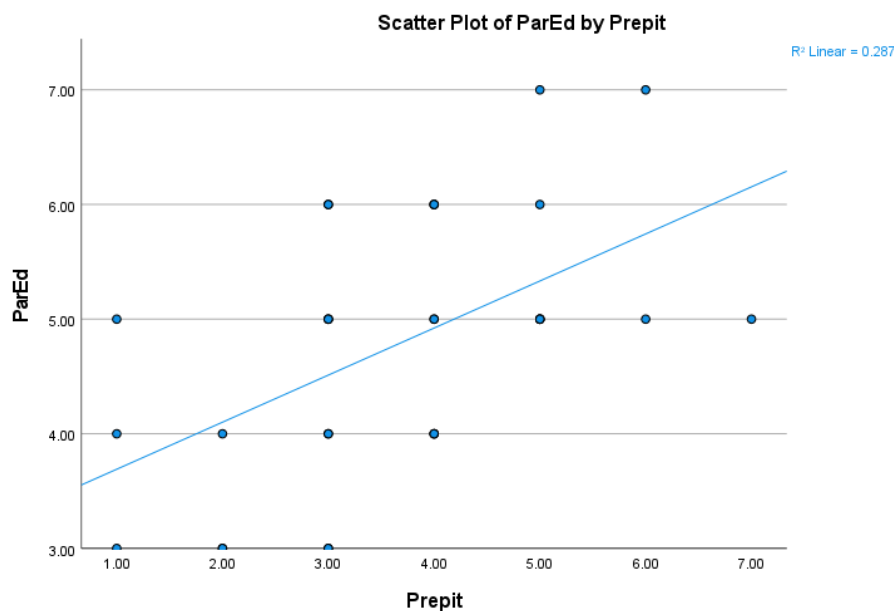


Figure 5. 6 Scatter graph of the relationship between parental education and number of risk reduction measures in school 1

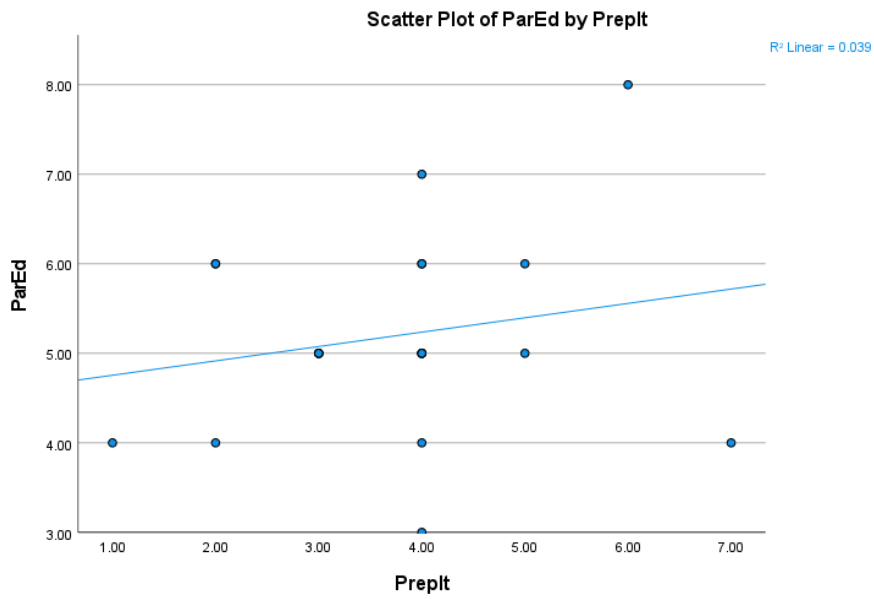


Figure 5. 7 Scatter graph of the relationship between parental education and number of risk reduction measures in school 2

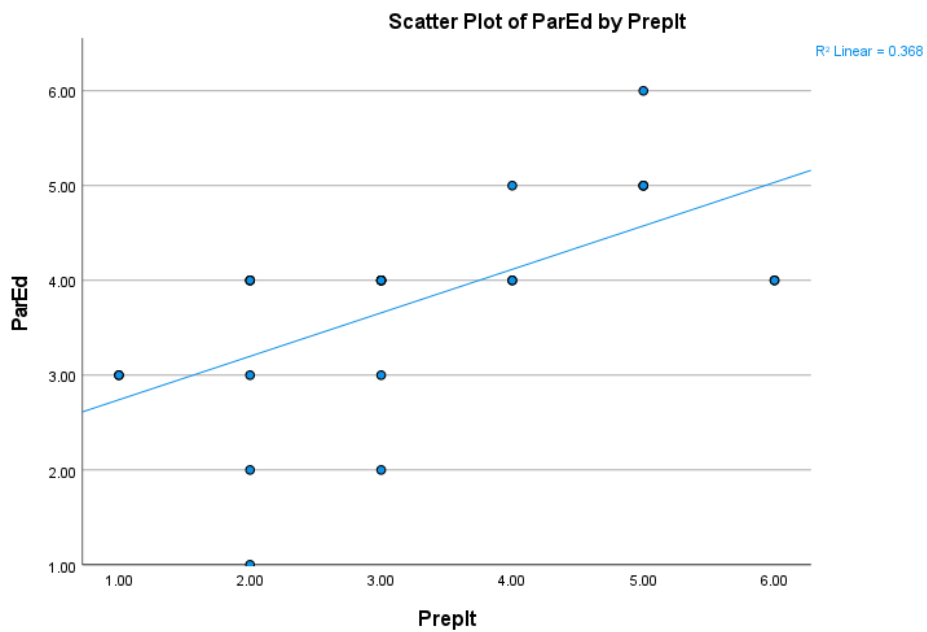


Figure 5. 8 Scatter graph of the relationship between parental education and number of risk reduction measures in school 3

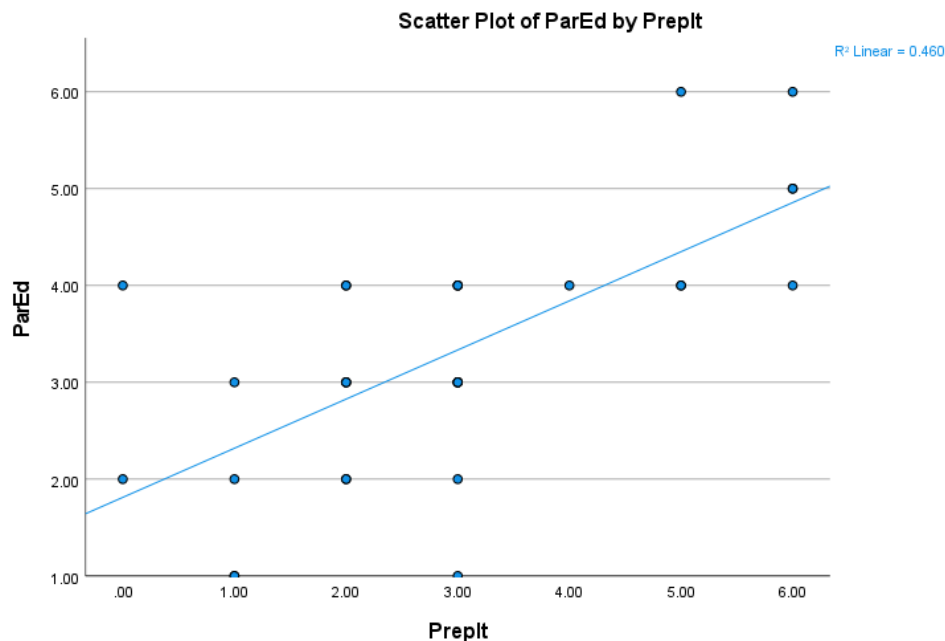


Figure 5. 9 Scatter graph of the relationship between parental education and number of risk reduction measures in school 4

5.7.1 A link between socioeconomic status and student DRR measures?

The extent to which the child and the family have home preparedness for disaster risk reduction has been linked to child enthusiasm for learning, emotional independence (Ronan and Towers, 2014), exposure to preparedness activities (Peek, 2008; Ronan et al, 2012; Amri et al, 2017), and an understanding of the hazard or the perception of risk (Ronan and Johnston, 2001). While the concept of preparedness for DRR has been extensively studied in the context of cultural and social factors in this study we aimed to find out whether economic factors were significant in the level of preparation. Therefore, we correlated parental education as a means of socio-economic standing with the number of items students had in preparation for a hazard related risk. The results from this study, taken from one fixed point in the longitudinal study, show that in three schools, 1, 3 and 4, that there were overwhelming positive correlations. These results are taken in the context that students had received little direct DRR education from their school and therefore that factors beyond education were a reason for their decisions to have items to prepare for DRR. **Table 5.38** gives the following p-values from the correlations; school 1 .002, school 3 .002 and school 4 .000. This suggests that the student socio-economic standing, determined by level of parental education,

has an influence on the number of disaster preparedness items. What it does not reflect is the extent to which these items would be useful and whether they are more relevant for one hazard, most likely hurricane. Further study is needed to explore this relationship to the wider school community. Questions remain over whether level of parental education alone is valid as a marker for socio-economic standing. Further work to understand the relationship between socio-economic background and level of home preparation is important. While it is possible to say that it is a factor, it would be useful to understand what role this plays alongside other factors. Further research on the exposure to named disaster events will also help us determine the extent to which experience of an event changes level of preparation.

5.8 A summary of student risk perception.

The perception of risk is fluid and changes over time (Lindell and Perry, 2000). Therefore, assessment of perception change is more suited to longitudinal perception than the common approach of understanding change after an event or after a mitigation measure is introduced (Matthew, 2003). This approach helps determine the extent to which an individual experiences 'disaster fatigue' or 'perception decay' (Peek 2008) or "memory decay" (Borque et al, 2016), where the perception of the disaster event wanes over time. This study investigated student perception change in a multi-hazard environment, over a 5-year period. This represented the student time during secondary school. This study is a first for risk perception with students over this period, and a first in a multi-hazard environment.

The study of risk has been defined in numerous ways, however, the common element in these definitions is the distinction between reality and possibility (Sjoberg et al, 2009). The study of an individual's assessment of risk is through risk perception. Such perceptions are subject to a range of influences.

Duffy, (2019) reminds us that perception is a personal trait that is multi-faceted and therefore looking for one direct causality can lead to over generalisation. The analysis of student perception suggests that student understanding of the hurricane hazard is better understood in comparison to the expert opinions. However, agreement with other hazards is not consistent with expert views over time. The perception of the hurricane hazard, despite being considered most threatening does change with respect to events. There is evidence of disaster fatigue after disaster events with

Tropical Storm Erika returning to normalised perceptions within 2 years. The longitudinal changes in student risk perception show evidence of how a disaster event can warped intensified perception of other hazards after a disaster event, linked to normalisation bias or the frequency heuristic. Students generally perceived geophysical hazards less after Hurricane Maria and in some cases after Tropical Storm Erika. This has implications in a multi hazard environment where two hazards are likely to occur close together. Over time the general pattern of hazard perception is consistent across most of the schools, and placement of hazards, while changing with individuals is consistent in mean values. This study also found evidence of perception variation in student locations, which has implications to produce educational materials.

However, with a consistent hazard, this study showed that students are perhaps subject to bias in their perceptions, especially towards hurricanes, while underestimating the less frequent and potentially disastrous larger magnitude volcanic eruptions or earthquakes. Students showed that their perceptions are mainly formed by their experiences and those of their friends and family, which was particularly evident after Tropical Storm Erika and Hurricane Maria. There is, however, a disconnect in student perception between the aftermath of disastrous events and intervening periods, where the importance of these threats is not considered as much. Schools and local authorities should look to develop programmes which help keep these perceptions near the forefront of their mind through more integrated bespoke disaster risk reduction education.

Chapter 6 – A qualitative assessment of DRR in Dominica

6.1 Managing DRR in Dominica

This section assesses the qualitative comments made in interviews with DRR professionals and seeks to understand the role of DRR management in the study period. All interviews were conducted between the period 2013-2018. To assess how DRR management has changed over the study period this section summarises events temporally in three sections:

- I. The role of DRR agencies in Dominica between 2013-2015.
- II. in assessment of Tropical Storm Erika to understand the role of DRR agencies in warnings, impacts and post Erika support.
- III. An assessment of Hurricane Maria to establish the role of DRR in managing the impacts of this event.

All information in this section has been anonymised and is based on either paraphrased or transcribed interviews which were coded inductively to answer pre-determined open-ended questions. All transcribed material can be found in Appendix F.

6.1.1 The role of disaster risk reduction agencies, 2013-2015

The findings shown here summarise the situation for both the Red Cross and Office of Disaster Management in the period up to 2015 before Tropical Storm Erika. Interview material was conducted with senior officials from each organisation.

Figure 6.1 is a chart showing the main DRR activities during the period 2013-2015 for each organisation based on face-to-face interviews with officials from the Office of Disaster Management and the Red Cross, the main (active) groups responsible for DRR activities in Dominica.

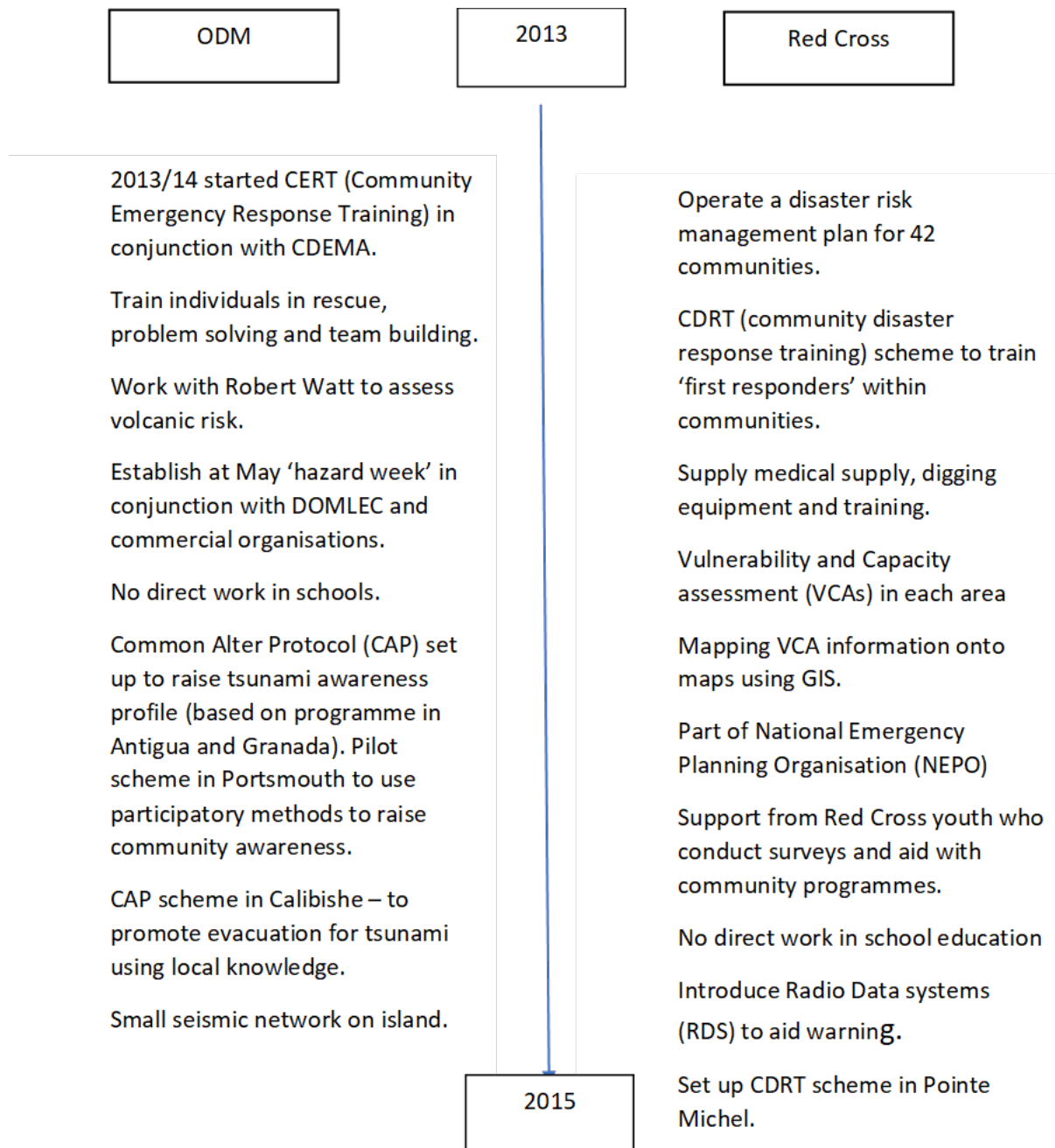


Figure 6. 1 Key DRR activities by the ODM and the Red Cross between 2013-2015 in Dominica (points in chronological order by occurrence).

Figure 6.1 shows that a key focus of both the ODM and the Red Cross were bottom-up approaches through CERT (ODM) and CDRT (RC). Both schemes ran independent of each other in different communities during the 2013-2015 period, highlighting the lack of coordination between agencies. In 2014 the ODM had set up a Tsunami Smart scheme (based on a CDEMA directive) which was part of the wider CAP scheme, to raise the profile of tsunami awareness in northern schools and communities, with Calibishe and Portsmouth chosen as pilot schemes. The small seismic network sought to improve the self-sufficiency of monitoring localised earthquake activity on and around the island. ODM schemes were all linked to wider regional schemes led by CDEMA or other Caribbean ODMs, while the Red Cross had the freedom to operate, independent of government interference, targeting communities within its network.

6.1.2 Thematic analysis of responses to Tropical Storm Erika

This section summarises the DRR response to events surrounding Tropical Storm Erika in 2015. The response is related to the interviews conducted with senior members of the government led ODM and the Red Cross, the two key players in managing this event. **Table 6.1** shows quotes from officials in the ODM and Red Cross in relation to themes coded from face-to-face interviews (Appendix F).

Table 6. 1 Thematic summary of the events surrounding Tropical Storm Erika based on accounts of leading ODM and Red Cross officials.

Themes	ODM	Red Cross
Warnings prior to evening August 27th.	<p><i>“ODM issued warnings for TS Danny one week before, but it shifted north”. “Tropical Storm Erika followed the path of Danny”.</i></p> <p><i>“The NOAA and Dominican Meteorological Office said there was no need for warning.”</i></p> <p><i>“Despite this ODM put out a warning to all heads of division”.</i></p> <p><i>“We received a phone call at midnight from a local resident who realised a belt of rain was approaching Dominica, predicting heavy rainfall at 7AM”.</i></p> <p><i>‘Based on this we issued a radio warning to be issued between 5:30 and 6:00AM advising people to move to higher ground”.</i></p>	<p><i>“Little warning was given in advance, though radio warning was issued early morning, but some areas had already been flooded by this time”.</i></p>
Impacts of the event	<p><i>“People killed in Petite Savanne came out to look at flooding and were caught by landslides.”</i></p> <p><i>“Road north of Canefield was blocked and bridges collapsed isolating the ODM in Jimmit”.</i></p>	<p><i>“Melville Hall (airport) suffered large amounts of damage”.</i></p> <p><i>“Road journeys to the north were not possible without 4 x 4”.</i></p> <p><i>“Roads collapsed from landslides and bridges were swept away”.</i></p>

<p>Organisation of EOC (Emergency operating Centre)</p>	<p><i>“Control was set up at the radio station”.</i></p> <p><i>“Protocols were in place for extreme events not torrential rain”.</i></p> <p><i>“We needed a larger EOC, so we moved to Red Cross”.</i></p>	<p><i>“ODM could not use Jimmit, as it was cut-off, therefore they ended up using Red cross as EOC”.</i></p> <p><i>“Lack of coordination between government departments and disaster response organisations”.</i></p>
<p>Post Erika support</p>	<p><i>“After 2 days the Dutch and British arrived to offer assistance”.</i></p> <p><i>“We delivered support to villages in need”.</i></p>	<p><i>“\$46 billion pledged, but only \$26 billion received”.</i></p> <p><i>“New homes built by the government in Dublanc and Petite Savanne is being rebuilt near Bellevue Chopin”.</i></p> <p><i>‘Many new jobs created in construction’.</i></p> <p><i>“Red Cross employed Mega V software to determine need. But there was replication of aid from ODM and Rotary leading to chaos”.</i></p>
<p>Reflective comments</p>	<p><i>“Problems with communication, especially getting messages to communities”.</i></p> <p><i>“Issue of local people lacking a serious attitude to the problem”.</i></p> <p><i>“Local contacts were inaccessible”.</i></p>	<p><i>“ODM did not share disaster plans with the local community....both organisations seem to work independently”.</i></p> <p><i>“Post Erika, changes in leadership of ODM have led to less contact between ODM and RC”.</i></p>

Table 6.1 quotes some of the events linked to Tropical Storm Erika from the two key DRR players. The lack of warning led to limited preparation. Protocols in place to deal with the situation were covered by the 2001 National disaster plan (**section 4.8**), but indications were that these were not appropriate for smaller scale rain events, without wind. The EOC response was hampered by the need to transfer location resulting from the blockages between the ODM location in Jimmit (20km north of Roseau on the west coast road), and central Roseau. Quotes suggest that advance warning was short-term resulting in people watching the unexpected events rather than finding safety,

leading to loss of life in some southern Dominican villages. Short-term responses led to the repair of key infrastructure, particularly with the building of Bailey bridges to replace collapsed bridges. Most roads were opened and functional within a month of the event. Organisation of aid proved to be a challenge with reported disharmony between different providers; the government organising delivery of items to affected locations, repeated by other organisations. It was suggested that a coordinated needs assessment was required. Key issues appeared to be a breakdown of communication between DRR organisations, a recognition that local people did not take the appropriate action and a suggestion of concern from other DRR agencies, that subsequent change in leadership within the ODM post Erika overlooked the need for strategic evaluation of the events, although contact with the ODM post Tropical Storm Erika made assurances that lessons were learned.

6.1.3 Thematic analysis of the response to Hurricane Maria

This section analyses responses of DRR individuals involved in the response to Hurricane Maria. The purpose of this analysis is to evaluate the impact and lessons learned from the hurricane. The analysis has been broken down into key themes to summarise the impact of hurricane.

- I. the warnings given,
- II. the immediate impact of the event,
- III. the response to the hurricane,
- IV. lessons learnt (including historical references)

All information is based on transcriptions found in Appendix F.

Warnings - Despite officials realising that Hurricane Maria had a track with the potential to intersect Dominica, there was uncertainty over the extent to which it would make landfall. Leaders of business on the island noted that the *“the head of the ODM said the storm would pass between Martinique and Guadeloupe and would not arrive till Tuesday”*. Despite this many commented that the government was aware of the risk as *“government offices were locked down from Sunday evening”* and the office of the Prime minister *“put out warnings (on Sunday) and declared schools should be shut” (local academic)*. However, the messaging about the extent of the magnitude was unclear on Dominica as *“Skerrit came on radio on Monday evening (but I did not listen as) they just told us to stay safe” (DRR professional in Roseau)*. Even once it was known that Maria was heading towards Dominica, despite there being regular warnings, *“ODM staff made warnings at DBS radio” (worker at DBS radio)*, there was uncertainty in the messaging about the strength of the approaching hurricane, *“messages told us it would be a category 3 not category 5” (local educator)*. Messaging was in reaction to the changing situation and *“CERT trained people received (text) messages”* and *“by 6pm reports told people in coastal areas to move”*. Despite this some of the DRR officials commented on the accuracy of the warnings, *“I know what (warnings) not to use, the government one is for Canefield only” (government official)*, while another commented that *“Met Office gave frequent updates, but I also use the NOAA, and these allowed me to make my own judgements” (local academic)*. It is clear from these statements that there is a disparity between the quality of information from local or government sources and those who choose to seek to gain their information from elsewhere. This can be surmised by one local who used European reports 24 hours before landfall who reported, *“radio reports (not Dominican) suggested the hurricane would enter*

the island from southeast corner and move across the island to leave in the north near Capuchin, which is pretty much the track it took” (local academic).

This analysis suggests that while the situation in the lead up to the hurricane was dynamic, and that there was an abundance of messages, mostly through radio transmission. The accuracy of the messaging was not clear and information about the escalating strength of the hurricane was not directly passed onto the local people, therefore, potentially increasing vulnerability and reducing the likelihood of appropriate preparation.

The short-term impacts - The impact of the Maria was unprecedented in recent Dominican history. This category 5 hurricane produced greater wind speeds than hurricane David in 1979, meaning old and young had not faced an event like this before. The number of reported deaths was “32 confirmed deaths and 30(ish) missing, (although these) numbers are not exact” (government official). One issue is that the death count may be in fact much higher if you include associated indirect deaths, as one official commented “people may have died from indirect effects, e.g., those that could not get insulin or other medication” (local educator). There was also the issue that people could leave the island as borders became more fluid. “Many left Dominica, as LIAT offered free flights and ferries offered a way out. No one accounted for those that came or left” (local academic). This problem was compounded by the inability to communicate with the outside world. In the lead up to the hurricane “Cable and Wireless stayed on until 9pm as I was able to post online” (DBS radio worker), and “power went down by Monday afternoon or perhaps it was the internet...I think they cut the electricity on purpose”. The signal to cut power was a damage limitation exercise however it increased the vulnerability of individuals who were isolated within their communities. There were isolated cases of phone signals to the outside, “Digicel was down, but you could link up with Orange on east coast” (local academic), but often people had to get to Roseau to broadcast messages across the island, “people walked from across the island to use radio broadcasts to tell each other levels of safety in each community...levels of death or injury” (local academic). For the immediate period Dominica was isolated, “Dominica was cut off – with most immediate action in Roseau” (government worker / DRR). But what caused this isolation? Many of the deaths and injuries occurred in smaller villages which were on steep relief or those living nearby river channels. “People in Coulihaut and Coulibistree, at Pointe Michel and Loubiere were killed by the water. The roof explodes and people go downstairs, then the river sweeps them away, they are killed by debris and swept to sea” (government official). “Many homes were lost in Castle Comfort due to property boundaries too close to streams – the government needs to rethink distances that are legislated” (local academic).

While water accounted for many of the deaths, the wind accounted for a great deal of damage. *“There was lots of water, but the main damage was wind” (local educator)*. One government official commented on the extent of the damage to properties; *“wind took off 95% of galvanise roofs”*. Local people were also surprised by the extent of the landslides and debris flows in rivers, *“there were mudslides but there were also tree trunks and boulders which had passed down the ravine – normally the ravine is not managed and has little water” (local educator)*, *“there were many landslides after Maria, the boulders were huge, bigger than a room in a house” (DRR official)*.

People’s expectation of a large magnitude event was not evident in the effects, as extensive material was removed from upland areas and redistributed in lowland areas near settlements. Fortunately, Dominica did not suffer a large-scale health situation, like Haiti after the 2010 earthquake, *“there were no outbreaks of cholera but there were outbreaks of gastroenteritis” (local educator)*. But one problem faced by people was the structural damage to property, as some people struggled in the aftermath as *“not all people were insured” (DRR official)*. One of the worst affected areas on Dominica was the Kalinago Territory. This isolated community on the east coast is geographically distant from the help provided by Roseau and the government. *“KT were affected badly with over 80% of all properties. Only concrete cast toilets were left standing in some areas” (local academic)*. The consequence of damage caused by Maria was the need for the activation of hurricane shelters which were often schools or churches. *“Some shelters did not fare well, as windows were broken onto people in the buildings” (local educator)*. Some people were forced to live in cramped conditions for several months and consequently *“shelters were treated with disrespect by some individuals” (shelter manager)*. While these shelters were open, students could not return to school affecting the ability for parents to continue with home repairs. Food was not an immediate issue as farmers *“had crops planted in June, those who had planted root crops, e.g., yams and dasheen, these were abundant”*. Despite this and an improvement in community spirit, *“some people took advantage of empty buildings (looting)” (shelter manager)*, with *“most people said they looted for food, but then some looted TVs and computers therefore a curfew was put in place” (government official)*.

Another issue for locals was cost. At a time when the impact of the storm increased the need for essential food, water costs rose: *“prices increased, coke went from 3EC to 10EC” (DBS radio worker)* and a similar issue occurred for data need: *“mobile phone use went up so cost of data went up” (local educator)*. The immediate response was difficult for the people of Dominica. There was a lack of connection between the physical impacts of the storm and its effects on the surrounding landscape. In cases reported deaths were a result of curiosity rather than a lack of suitable

preparation. The proximity of people to the secondary impacts of the storm meant that for those people vulnerability increased.

Reflecting upon response – success or failure? - Hurricane Maria was an unexpected event of the most extreme magnitude which had impact across the entire island. Its response reflects the National Disaster Policy (NDP) and the work of government agencies which were directly impacted by the storm. How did DRR officials evaluate the response in this context? Despite the function of government being directly hit the *“government issued briefings each day”* (government official) and *“utilities came on the radio to update about the services”* (DBS radio worker). In the days leading up to the hurricane and immediately afterwards the planned shelters were opened. One official commented *“shelters were designated as churches or schools, without checks to determine whether they were suitable”* (government official). However, shelter planning had not accounted for the reality as *“shelters were open for months, not weeks as initially thought”* (shelter manager). The role of the shelter management team was a challenge as one described *“shelter manager is a voluntary role, who had to monitor arrivals, set up rooms, deal with problems, manage peace and waste”* (shelter manager).

There was an issue of capacity after the hurricane. Like Tropical Storm Erika the ODM assumed responsibility for the Emergency Operations Centre. However, one DRR responder commented they had visited the *“ODM in Jimmit, but the building was locked up – the EOC had moved to Roseau”* (DRR official). This raises questions over the legitimacy of the operation in Jimmit which was initially designed to be away from Roseau in case of an extreme event. However, the response had immediate positives, *“Clearing of the roads was amazing, by October 20th I could drive my vehicle around the island”* (local educator) – as *“the government cleared the main roads while locals did connect roads”* (local academic). This served as an initial priority to ensure that relief could be mobilised from central Roseau. This maximised the use of the port in Roseau for relief from outside agencies, especially as one DRR official commented that *“after Maria the national organisation did not have the capacity”*. Outside help was received with *“the French brought in boat loads of supplies every week, so people could receive bread, water and supplies”* (government official) and *“Samaritan Purse and UNICEF provided temporary housing, tarpaulin, generators and psychosocial interventions”* (local academic). One local DRR responder commented that *“we had men from the UK who arrived with equipment to remove fallen trees”*. The clear focus was to improve supplies to needed communities across the island and *“for villages that did not have piped water, water trucks were sent to the villages, or people got water from springs – main supply was back on in a month”*

(local educator) and in rural areas *“aid provided, and support provided has been sufficient. Farmers have been supported”* (local academic). Yet despite this there was a commonly held feeling that *“in reality the settlements closer to Roseau were helped first”* (DRR official). With some locals not receiving insurance payments they resorted to using fallen material to rebuild. Clearly considering the circumstances and the universal impact across the island the speed of response was to be commended as infrastructure was reopened. However geographical disparity in recovery reflected local authority and geographical distance and in some areas electricity supply and permanent housing took over 12 months to take fruition.

Developing resilience in Dominica - After Hurricane Maria, the Prime minister made a pledge to *“to make Dominica the first climate resilient country in the world – this is our top priority”* (DBS radio worker). Considering this, one DRR official commented that *“I do not see how they (government) can keep the old policy (NDP) if they are to implement a new climate resilient policy”*. One suggestion was for a *“movement towards renewable power as a possibility”* (local government adviser). The relationship between DRR agencies is one aspect which needs to be addressed. One DRR official commented *“we will be here to stay, others (NGOs) do not need to plan long-term”* suggesting that there was a short termism linked to the relief input from some NGOs. Another official commented *“we will work with the ODM as part of NEPO. It has been suggested we can work with organising shelters, but we do not have the capacity for this”*. Clear understanding of the capacity and roles of each DRR is necessary for a coherent policy going forward. One DRR official commented *“what keeps me awake at night (hurricane season), we will not be as ready as we need to be, but we will be better than last time”* (government official).

Another major criticism has been the use of space leading to increased vulnerability. One local DRR respondent commented *“that after hurricane David happened 38 years before, (people coped) with winds up to 220mph, but did not have to comprehend this much water. The plantation land coast should not have been sold out (in Roseau, Coulihaut and Coulibistree)”* (local academic). Several commented on the quality and location of buildings; *“there is a problem with land use management - people build where there is space, but Maria took those houses”* (local educator). The implication was *“all future housing needs to be built by codes and structures, if not done properly it should be knocked down”* (local academic), while another commented on the *“need (for) conversations about traditional architecture”* (local academic) suggesting that these methods, were most durable, and even suggesting *“builders should ensure one room is concreted, like a bunker, with important documents stored within”* (government official). Another commented that there is a *“need to dredge*

rivers and remove pillar bridges, building suspension bridges which last for years. The government needs to enforce the rules” (local educator). Another point of contention is the use of shelters. One local commented “after hurricane David the government invested in schools as shelters, but this programme was not carried forward” (local academic). The view by numerous officials was reflected in “schools should not be shelters, government should build community shelters, managed by community leaders” (shelter manager).

Communication is a clear need for assessment in the future. The approach by the current ODM was largely top-down, however one DRR responder commented *“there is a desire for local people to reconnect and reorganise”*. It was felt the importance for *“people to heed the warnings – many thought it was just another warning and did not adequately prepare” (local DRR official)*. This may have been the consequence of the late warnings but still a hurricane is a serious threat suggesting a sense of complacency by some. Further to this the island was compromised by its decision to use just one radio source to broadcast. One official noted *that “during Hurricane David the radio transmitter operated on an AM central transmitter – you could stay in Virgin Islands and listen in. However, in the 1980s it changed to FM and Roseau was transmitting but others could not hear the signal” (local academic)*. This factor coinciding with the reliance on mobile technology left many isolated in Dominica.

The final lesson to learn was the issue of another large- magnitude hazard. Many DRR officials note *“the Caribbean was struggling to deal with one category 5 hurricane. A second put us on the edge. Another event, e.g., an earthquake, would have sent us beyond capacity” (regional DRR agency)*. The following quotes reflect the warnings issued by individuals:

“We should not forget earthquakes and volcanic eruptions. We should not rush concrete cast roofs, is engineering is not done properly, tremors may lead to rusting or collapse” (local academic).

“The country should focus beyond hurricanes, we are susceptible to flooding, earthquakes, volcanoes and fires” (local DBS radio worker).

“(other hazards) are the problem as minds are focused on the hurricane threat” (government official).

This reflects the constant reminder which is that while the regular threat of hurricane hazard exists, on multi-hazard SIDs the threat of the lower frequency higher magnitude hazards has the potential for a much greater impact as people are less aware and prepared for this eventuality.

6.2. The role of DRR agencies in managing disasters.

The Hyogo Framework for Action 2005-2015, through all priorities for action (UNISDR, 2005), and the Sendai Framework for Disaster Risk reduction, through priority 2 and 3, encourage the reduction of disaster losses through building resilience. On a national scale this is achieved through the work of government and participation by non-government organisations and local institutions. The UNISDR issued a report on *“Making cities resilient”* (UNISDR, 2015), outlining 10 essential steps to achieve this. However, achieving these essential steps is challenged by a lack of political will, budgetary constraints, and the building of trusted relationships between disaster risk reduction agencies (Amaratunga et al, 2018). Galliard and Mercer, (2012) show that successful Disaster Risk Reduction requires ‘inclusive’ collaboration between scientists, government offices and local community players, through bottom-up and top-down initiatives. However, this can be threatened by distrust between stakeholders, participation fatigue and poor institutional frameworks causing institutions to work at different scales in dissimilar directions (Galliard & Mercer, 2012). The National Disaster plan (NEPO, 2001) outlines the framework for emergency planning in Dominica (Figure 6.2).

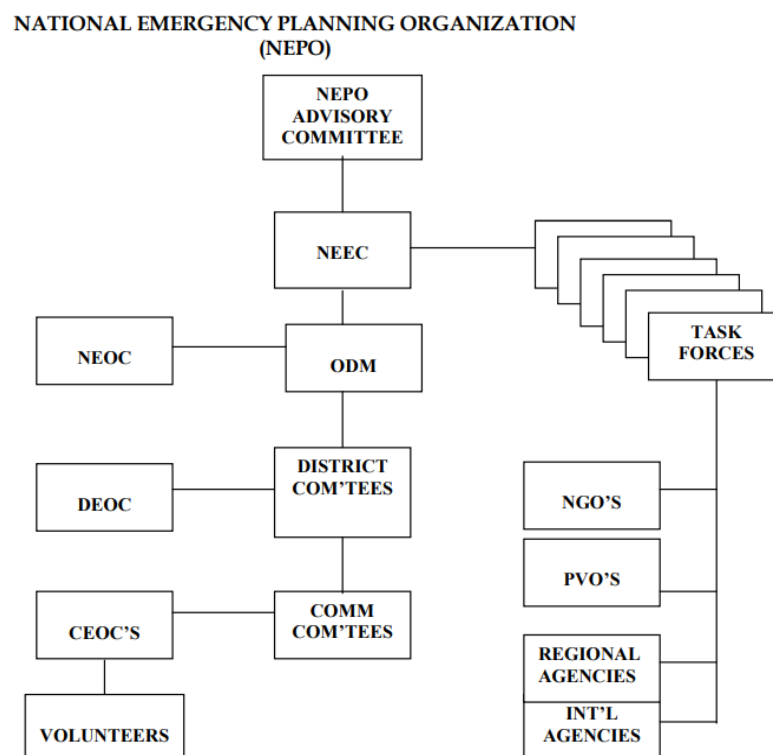


Figure 6. 2 Dominica National emergency planning organisation (NEPO, 2001).

The key players involved in Dominican Disaster Risk Reduction prior to Tropical Storm Erika, in 2015, were the Office of Disaster Management, who sit at the core of the NEPO structure, reporting directly to the national emergency executive committee, and the Red Cross. The qualitative assessments of the disaster risk reduction activities of these groups in this study show an attempt to integrate both bottom-up approaches and top-down approaches. In the study period between 2013-2015 the ODM set up CERT schemes (**Figure 6.1**) to develop community resilience, while working on a national scale through “hazard awareness week” to raise awareness in collaboration with commercial organisations to raise the profile of hydrometeorological hazards with the national public. The Red Cross also had a bottom-up approach through their long standing CDRT schemes designed to train a team of individuals in chosen local communities to respond locally after a hazardous event. They also conducted VCAs, for example in Ponte Michel (Red Cross, 2014), which worked regionally to develop community links through top-down organised training funded by the Red Cross organisation. While the National Disaster Plan (NEPO,2001) set out clear policy showing understanding of the local hazard, suggested mitigation actions and approaches, the practicality of these were never tested until Tropical Storm Erika. Pre-Tropical Storm Erika it was clear that the main bodies working in Dominica to provide DRR support faced the challenges outlined by Amaratunga et al, (2018) and Galliard and Mercer (2012). While there was political will, budgetary constraints meant, and a lack of communication and resource sharing meant that institutions were working on similar schemes (CERT and CDRT) in different locations.

The arrival of Tropical storm Erika gave limited notice and no warning as the main system had already passed Dominica in 2015 before the ODM realised that there was a threat of intense rainfall to the central and southern part of Dominica. As such limited warning could be raised as radio transmission services were unavailable until 6am on August 27th. As such it was not possible to put in place any of the pre-existing protocols set out by the National Disaster Plan. This inability to issue warning led to some deaths in local populations who watched the raging rivers and landslides rather than seeking suitable shelter. The location of the Emergency Operating Centre in Jimmit, the location of the ODM headquarters, was deemed unsuitable as it was cut off from the governmental infrastructure in Roseau. Therefore, it was transferred to the Red Cross building. However, the support between the two organisations was not collaborative and short-term response efforts across southern Dominica were organised separately. This ongoing lack of coordination, resultant from one organisation answering to government, while the other an international NGO, meant that some people benefitted from excess aid, while others failed to get what was needed.

During Hurricane Maria similar problems were encountered in the lead up to the event, which approached Dominica suddenly and made landfall with a much greater magnitude than was

anticipated. Key issues were faced again with the organisation of the EOC in Roseau rather than at Jimmit. However, despite limited accurate warning being issued, and the severity of the storm impacting the island at night, short term response was relatively rapid. Local CDRT and CERT trained community members provided relief within the community. A national approach to clearing infrastructure meant that the road network reopened within 2-3 weeks. Despite variation in areas water supply was back on for many within 2-3 months, while power supply took much longer. Considering the vulnerability of Dominica, the efforts of government and outside support agencies such as Samaritan's Purse and UNICEF have meant that Dominica has managed to find the path to recovery over the past 2 years. The government has decreed that Dominica will be the first climate resilient country and has released a Climate Resilience and Recovery Plan (CRRP, 2020) to with measurable targets on how it will achieve this. However, with a finance gap of 7-8 billion XCD and significant reliance on outside funding (CRRP 2020) the future management of DRR activities will be dependent on budgetary constraints (Grydehoj and Kelman, 2020). This review of DRR activities points to the need for continuing development of communication between DRR organisations, though the CRRP (2020) should help with this. Galliard and Mercer, (2012) identify stages for effective Disaster Risk Reduction (**Figure 6.3**)

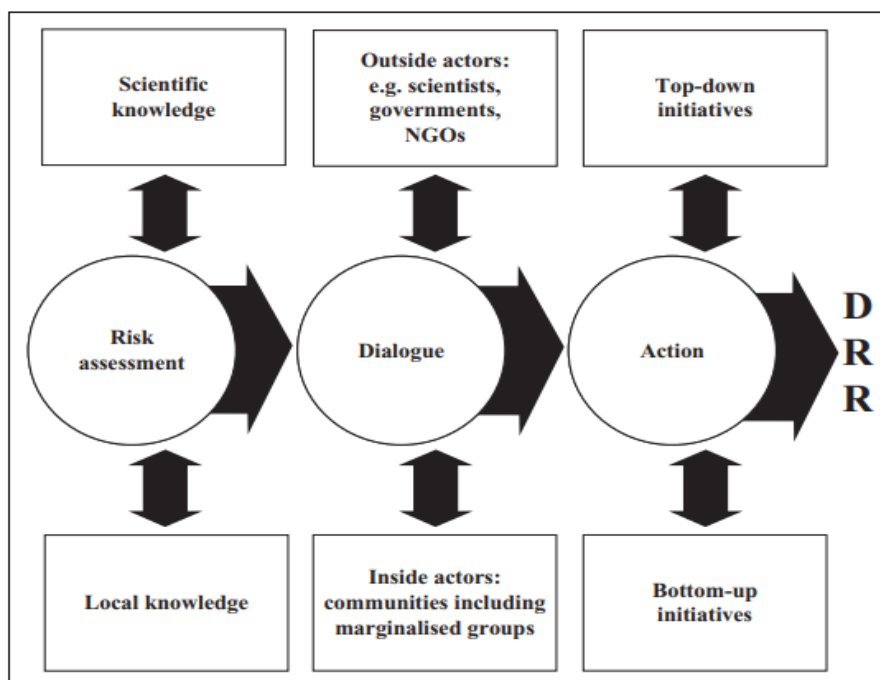


Figure 6. 3 Integrating knowledge, actions, and stakeholders for successful DRR (after Galliard and Mercer, 2012)

Dominica DRR management needs to focus on developing resilience within the local communities as well as the top-down measures it proposes. While it needs to account for the impacts of Hurricane Maria it must attempt to develop resilience towards the lower frequency higher magnitude hazard,

for example volcanic eruption or earthquake, which could affect large numbers of the population. Finally, as part of this preparation, it needs to act to develop clear warning guidance to give populations greater opportunity to respond.

While this study sought to assess the actions of the disaster reduction agencies, it was compromised by the change in personnel during the study period. The consequence of Tropical Storm Erika meant a change in leadership with the Office of Disaster management, who became less responsive to outside interviews after 2016. The Red Cross also changed leadership after Hurricane Maria and therefore it is difficult to make judgement about either organisation who have been dealing with the aftermath of Maria. Therefore, it is difficult to determine the true representativeness of the comments reflected in this work. However, cooperation between the DRR agencies needs to improve and moving forward, the CRRP report (Dominica government 2020) will provide a future benchmark for the success of these organisations in dealing with future, albeit climate related events. One benefit of these accounts is the development in understanding offered by the unfolding events of both disasters. These could provide an important benchmark for further or comparative assessment of these events in future studies.

Chapter 7 – Educational Analysis in Dominica

This chapter will seek to understand elements of the study directly concerned with student education and disaster risk reduction education. It is important to understand student education, i.e., what they learn and the methods by which they learn. Chapter 4 covers information which links to the education system and curriculum in Dominica. Therefore, the purpose of the first part of this chapter will be to assess the methods by which students learn, using information from the second PRISM activity. This will be important for understanding the preferences of the intended audience of disaster risk reduction information and packaging it in a way which the audience is receptive to. It will seek to understand the extent to which there are differences in preferred learning styles across the island or by gender. This information will be useful to disaster risk reduction agencies to ensure they produce and promote material to accurately reflect their different audiences.

The second part of this chapter will focus specifically on disaster risk education, i.e., education which aims to improve student understanding of disaster risk and may enable them to act. This section will assess the success of three different pedagogies identified by the UNESCO report in 2012 (Kagawa and Selby, 2012). This will help determine the student preferences to the pedagogies by understanding the impact each has on the student perception of multiple hazards. This is important for the future design of DRE curricula to ensure that both engaging and effective methods are used to promote student understanding. This will also include a review of different DRE resources (lesson materials) used to determine which were considered of greater use for student engagement and for practical use in a disaster risk situation. Again, this information is useful to help agencies or schools teaching DRE to help engage with students to improve the usefulness of the information communicated. Finally, this section focuses on the current state of DRE education in Dominica since Hurricane Maria.

7.1 A qualitative assessment of student learning preferences for DRR

This section data uses data from PRISM exercise 2 to establish an understanding of student preferences for learning about disaster risk. Only results for April 2016 – April 2017 is presented, because data for 2014 was incomplete and these values were not collected in 2018 due to time restrictions and the need to run the field classes.

Despite the original intention, exercise 2 was not conducted using PRISM. Instead, students were asked to rank their preferences for learning about hazards based on 8 categories: from i)

parents/guardians; ii) listening to radio; iii) watching TV; iv) researching the internet v) attending church; vi) while at school from teachers; viii) from information delivered by the Office of Disaster Management in Dominica, and xi) from information delivered by the Red Cross in Dominica.

In this section the following data is presented: i) group mean scores for each variable; ii) tests for statistical differences in distribution and median value by variable for a) location, b) gender and c) location of residence for each pupil (comparing the central area nearest the school, coastal areas outside the school and settlements in upland or river valley locations) using the same approaches as with PRISM exercise 1 data.

7.1.1 Understanding mean student learning preferences.

This section shows whether students differ (significantly) in their preference of a given variable. All testing for (ii) was completed using SPSS (**Section 5.7.1**). Testing of (a) and (c) was conducted using a Kruskal Wallis test and for (b) using a Mann-Whitney U test as this only had two variables.

Table 7. 1 Mean values in relative student ranking per variable (Exercise 2), by location (2016-17) (emboldened figures represent highest rank)

School 1	Parents	Radio	TV	Internet	Church	School	ODM	RC
Apr-16	3.3	4.8	3.6	2.2	6.8	4.1	4.6	6.4
Oct-16	4.0	2.5	2.9	2.5	7.2	5.5	5.0	6.6
Apr-17	3.8	3.4	3.8	2.1	6.9	4.7	5.2	6.1
School 2	Parents	Radio	TV	Internet	Church	School	ODM	RC
Apr-16	3.3	4.4	3.6	1.8	7.0	4.7	4.7	6.4
Oct-16	2.3	5.1	3.8	2.0	6.9	4.3	4.3	6.9
Apr-17	2.7	5.2	3.8	2.1	7.1	4.0	4.9	6.5
School 3	Parents	Radio	TV	Internet	Church	School	ODM	RC
Apr-16	3.1	3.9	4.2	2.0	6.9	3.1	5.5	7.1
Oct-16	3.8	4.2	3.4	2.0	6.8	3.9	5.0	7.1
Apr-17	3.8	3.9	3.9	2.0	7.1	3.1	5.0	7.1
School 4	Parents	Radio	TV	Internet	Church	School	ODM	RC
Apr-16	4.2	4.0	3.3	2.4	6.5	4.5	5.0	6.1
Oct-16	4.9	3.1	3.5	2.2	6.4	4.4	4.9	6.4
Apr-17	3.4	3.6	4.1	2.8	6.5	4.1	5.5	6.1

The results in **Table 7.1** show that students across all school's place preference to learning in a similar order. Use of the internet is consistently the most popular choice across all schools. Television is often the next most important choice for learning about natural hazards, though it is sometimes parental support. Of the technologies the use of radio is considered least important, ranking overall either 4th or 5th of the 8 choices. Students anecdotally commented that they receive this as an information source due to their parents using it. Technology occupies three of the top 4 ranks in all schools.

Education from parents is considered the next most important source of learning after technology. Students commented that their parents have experience, though these experiences often only related to hydro-meteorological events. School teachers ranked either 4th or 5th most important in most schools, except in school 3 where it was considered 3rd most important. The benefits of school as a learning resource became more valid as the students got older. The outside agencies e.g., the church, the ODM and Red Cross were all viewed with relatively low importance. The ODM was the most important of these 3 groups, with some students commenting about their messaging on the radio. All school staff reported that little (to no) work was undertaken by these organisations directly within schools or within lessons. Over time the importance of the scores is consistent. Only in school 1 did the value of the ODM decrease while the importance of the Red Cross improved. The church was not seen as an important source of information in almost any case.

7.1.2 Understanding student rank distributions for exercise 2

Figures 7.1-7.4 show the distribution of ranked values for exercise 2 data shown in box plots. The graphs use the following key.

■ Parents ■ Radio ■ TV ■ Internet ■ Church ■ School ■ ODM ■ RC

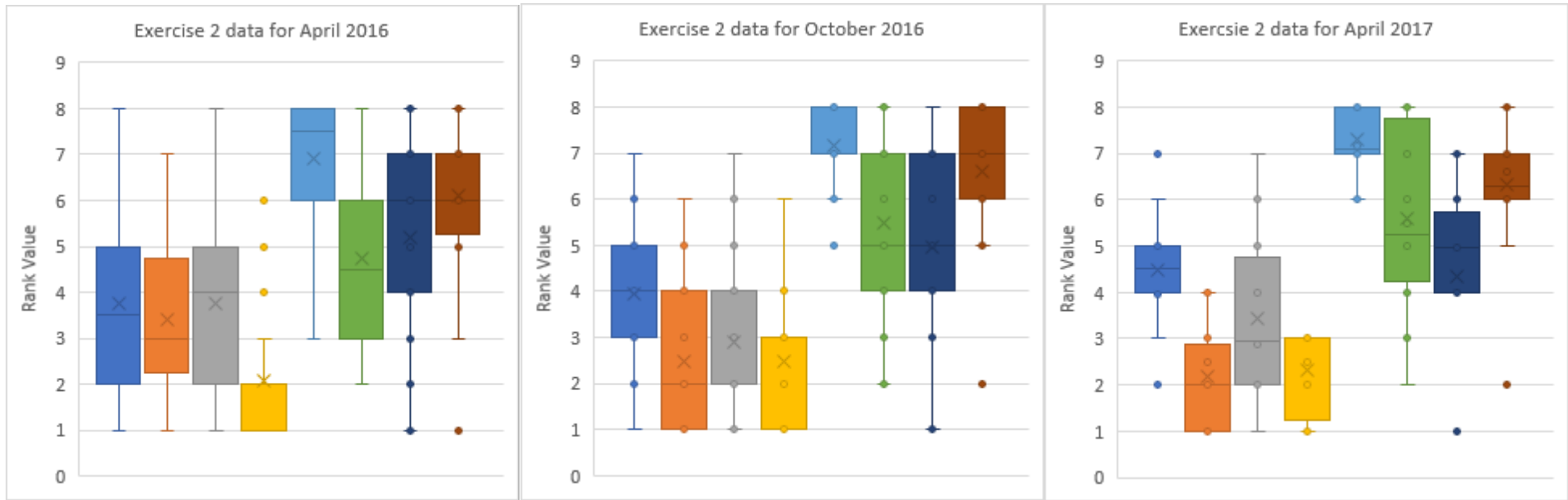


Figure 7. 1 Box plots showing Exercise 2 data for school 1, April 2016 – April 20 17

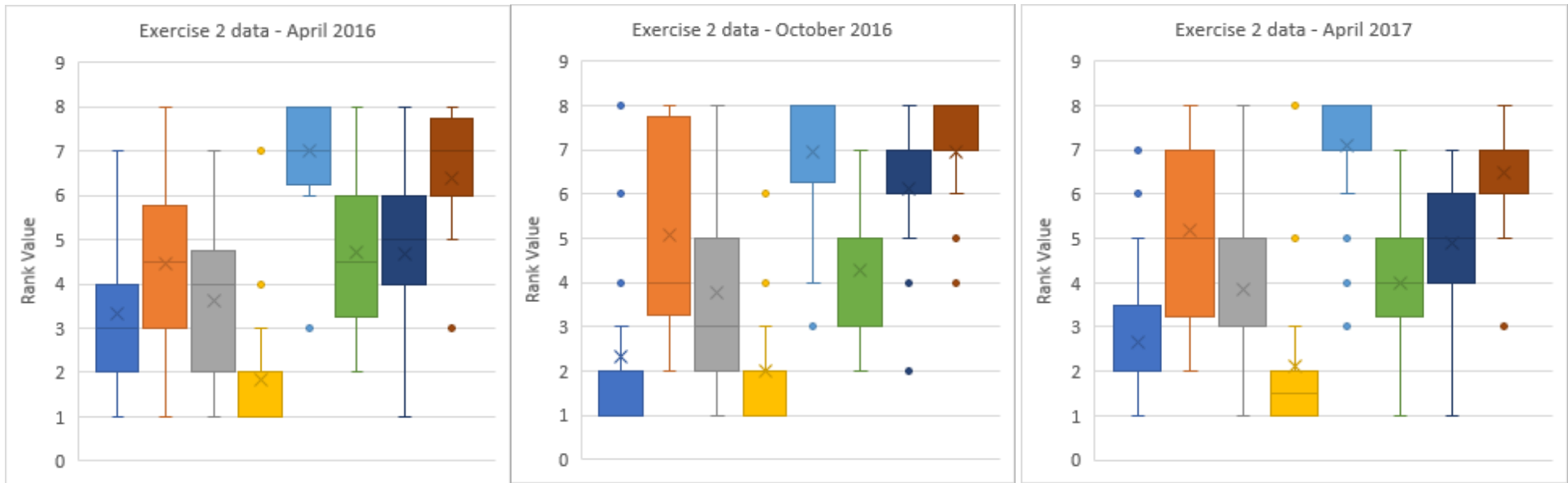


Figure 7. 2 Box plots showing Exercise 2 data for school 2, April 2016 – April 2017

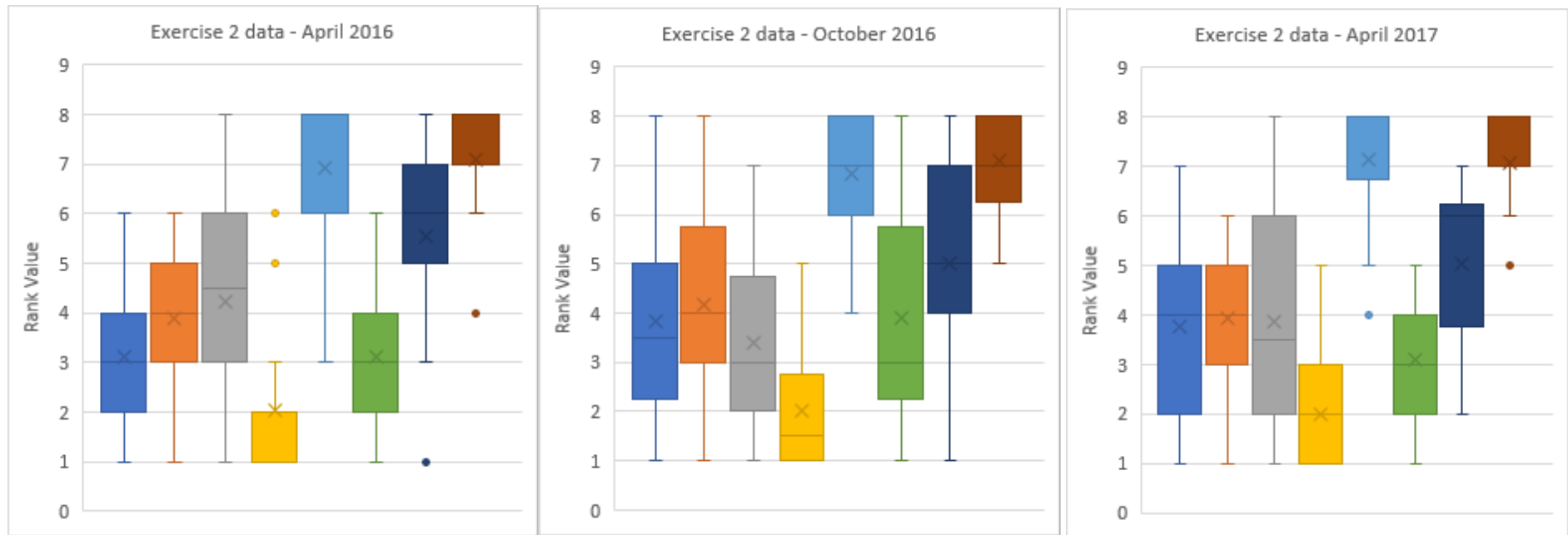


Figure 7. 3 Box plots showing Exercise 2 data for school 3, April 2016 – April 2017

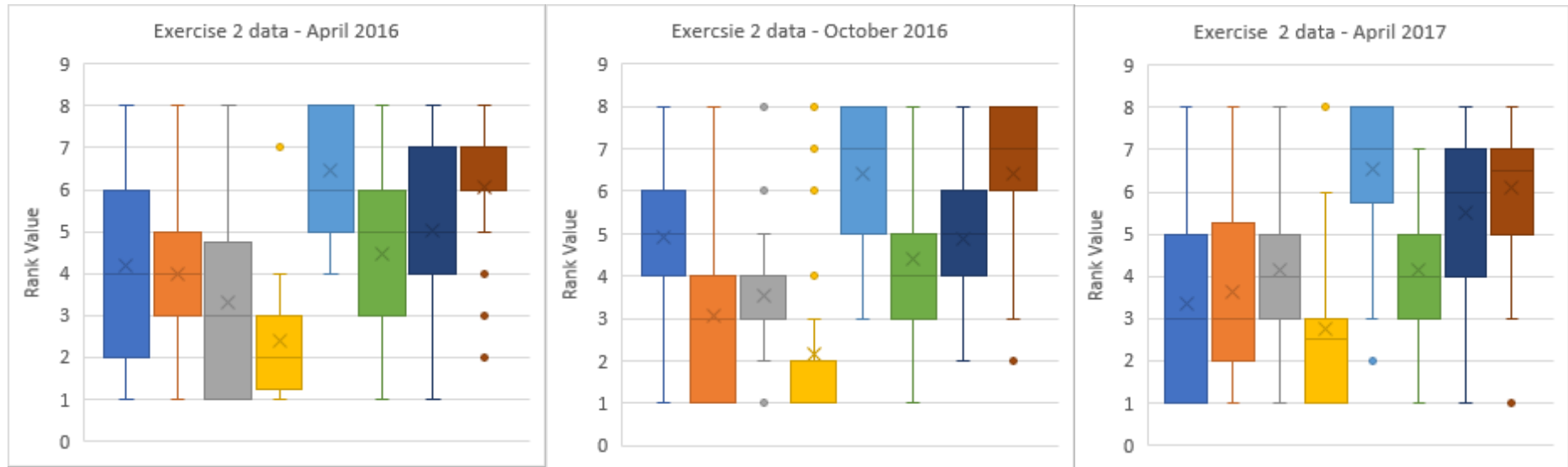


Figure 7. 4 Box plots showing Exercise 2 data for school 4, April 2016 – April 2017

Figures 7.1-7.4 show that the results for internet importance of the internet is always within the first three choices for all students. This highlights the importance of the internet as the most important way for students to receive new messages and to learn about natural hazards. The interquartile range (IQR) for TV was between rank choice 1-4. This pattern was consistent across school 1, 2 and 4 but less important in school 3. The distribution of values for radio varied by school. In school 1,3 and 4 the IQR was between rank 1-5 whereas it was less important in school 2, particularly in October 2016 and April 2017. The value of parents follows a similar pattern to the importance of television. Though in school 2 a much greater importance was placed on the parents with IQR ranging between rank 1-4 compared with 2-5 in school 1 and 1-6 in school 4. The value of schools draws a wide range of values, with some clearly seeing the importance with others adopting apathy, however, across all locations it holds an IQR between rank 2-6 in importance. The belief in the church and the Red Cross' importance can be seen in the limited range of ranks below 6. Students were consistent in their condemnation of these organisations as a learning tool. The ODM was valued slightly more with ranks between 4-7 and some isolated ranks below 4. Overall, the values show some consistency across the period.

7.1.3 Statistical analysis of student learning preferences for DRR

This section establishes whether these observed distributions in each school show any statistically significant difference. We have adopted the N_0 that there will be no significant difference between the categories for each data collection period. The results are outlined by year. Results, calculated using SPSS, show Intendent Samples mean test (IMST) to look for significant difference in the mean, and a Kruskal Wallis test (K-W) to test for significant differences across distributions between schools.

Table 7. 2 Tests for significant difference (IMST and K-W) for exercise 2 variables for April 2016 (figures emboldened show significant difference).

	Parents	Radio	TV	Internet	Church	School	ODM	RC
ISMT	.592	.661	.283	.506	.251	.024	.248	.606
K-W T	.371	.242	.400	.208	.218	.044	.332	.058

Table 7.2 shows that students' perceived ranks of learning preferences were similar for all categories except 'learning from schools' in April 2016. A pairwise comparison for the median test shows that the greatest differences existed between school 3 and 2 ($p=0.021$) and school 3 and 4 ($p=0.003$),

with little differences shown between the other locations. Similarly, a pairwise comparison for the K-W test shows a $p=0.016$ between school 2-3 and $p=0.013$ between school 3-4. There were no statistically significant differences between other schools. This shows that the choices made across the students in 2016 show remarkable similarity.

Table 7. 3 Tests for significant difference (IMST and K-W) for exercise 2 variables for October 2016 (figures emboldened show significant difference)

	Parents	Radio	TV	Internet	Church	School	ODM	RC
ISMT	.002	.017	.502	.044	.536	.254	.250	.562
K-W T	.000	.001	.302	.204	.293	.073	.122	.381

Table 7.3 shows that the October 2016 results shows more instances of variation than April 2016. In October 2016 both the median scores are significantly different for 'parent' and 'radio'. For the 'parent' category pairwise testing shows that significant differences occur between school 2-3 ($p=0.009$), school 1-2 ($p=0.002$) and school 2 and 4 ($p=0.000$). So, school 2 shares a different view to the importance of learning from parents compared to all schools. The pairwise scores for the K-W test also highlight the same statistical differences as the medians test for the 'parent' category.

For 'radio' the only statistically significant difference is between school 1-2 ($p=0.008$) and school 2-4 ($p=0.012$). Yet the K-W test comparing distributions shows a statistically significant difference between the distributions of school 1-3 ($p=0.009$), school 1-2 ($p=0.000$), school 3-4 ($p=0.045$) and school 2-4 ($p=0.002$).

The values for the median test for the 'internet' also show a statistically significant difference between school 1-4 ($p=0.017$), school 1-3 ($p=0.047$) and school 1 and 2 ($p=0.027$). This shows that in median value there are statistically significant differences between school 1 and all other schools for this period. Yet this difference is not reflected in comparing distributions.

Table 7. 4 Tests for significant difference (IMST and K-W) for exercise 2 variables for April 2017 (figures emboldened show significant difference).

	Parents	Radio	TV	Internet	Church	School	ODM	RC
ISMT	.169	.163	.583	.097	n/a	.149	.175	.506
K-W T	.242	.026	.726	.498	.499	.027	.496	.053

The results in **Table 7.4** show little evidence for statistically significant differences. In the median samples test, none of the categories showed a statistically significant difference, therefore indicating similar median values across all schools. For the K-W test to show differences in distribution only

radio showed statistically significant differences between school 1-2 ($p=0.005$), and 2-4 ($p=0.09$). Values for school were also statistically different but between school 1-3 ($p=0.003$) and school 3-4 ($p=0.38$).

Overall, the results for April 2016 to April 2017 do not show a great deal of significance difference meaning that students at each school had similar perceptions of the importance of the different categories for learning about natural hazards. As with Exercise 1, the following results look to see if there was a pattern of difference between genders or student location (centre of the town, outside of town in a coastal area or in an upland area or river valley) led to differences in order.

7.1.4 Analysing gender differences in student learning preferences for DRR

To conduct a comparison of gender using the student responses, Mann-Whitney U tests were calculated using SPSS to compare gender for each category position. Results are by year with p-value scores below 0.05 showing significant differences.

Table 7. 5 P-values for a Mann-Whitney U test comparing differences in variable by gender between school students at schools 1-4 (figures emboldened show significant difference).

	Parents	Radio	TV	Internet	Church	School	ODM	RC
A 2016	.019	.728	.949	.487	.436	.116	.877	.517
O 2016	.545	.887	.152	.341	.817	.491	.517	.437
A 2017	.737	.014	.625	.122	.984	.965	.396	.209

Table 7.5 shows that only two results show significant difference between April 2016 and April 2017. In April 2016 there was a significant difference in the importance of the 'parent' ($p=.019$) and for the category 'radio' in 2017 ($p=.014$). These differences are presented in **Figures 7.5-7.6**.

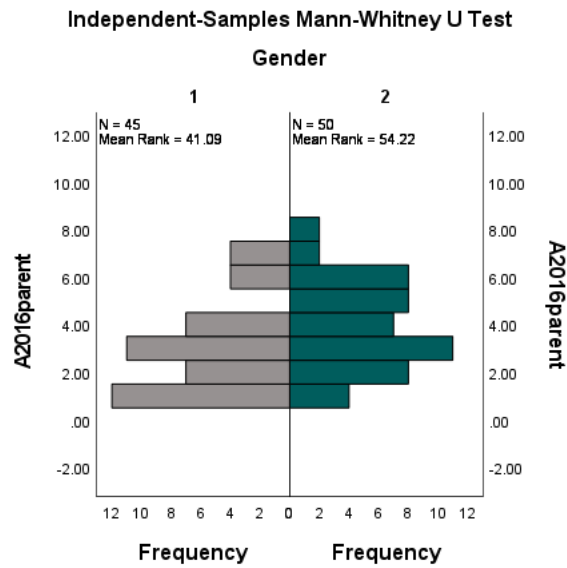


Figure 7. 5 Histogram to show the distribution for ‘parent’ variable between genders in April 2016 (male = 1, female = 2).

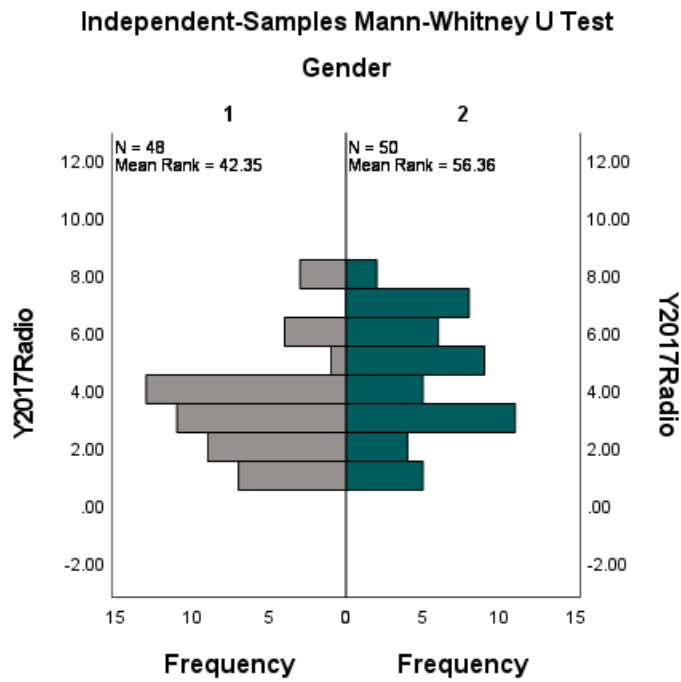


Figure 7. 6 Histogram to show the distribution for ‘radio’ variable between genders in 2017 (male = 1, female =2).

Figure 7.5 shows in April 2016 that male students had a greater distribution for ‘parents’ in rank 1 – 3 than females. **Figure 7.6** shows in April 2017 that males placed a greater importance on the rank

value of 'radio' compared to females. For all other categories, the data shows that there was little evidence of significant difference, suggesting that both male and female students place similar importance on the importance of these categories. This is important for designing a programme of resources as it suggests that boys and girls have similar learning preferences.

7.1.5 Analysing locational differences in student learning preferences for DRR.

Although results in **section 7.1.4** show little significant difference between males and females, this section looks to determine whether there is a difference in learning preference by settlement location. Here we use the same locational characteristics as in Exercise 1. Results show Independent Samples mean test (ISMT) to look for significant difference in the median values, and a Kruskal Wallis (K-W) test to test for significant differences across the distributions between student locations. Results are shown by data collection period in **tables 7.6-7.8**.

Table 7. 6 P-values to show significant difference (significant where $p < 0.05$) comparing student locations in April 2016 (figures emboldened show significant difference)

	Parents	Radio	TV	Internet	Church	School	ODM	RC
ISMT	.847	.799	.598	.045	.521	.425	.028	.236
K-W T	.269	.802	.634	.394	.123	.405	.105	.063

Table 7.6 shows in April 2016 similarity in learning preferences from the IMST and KW test. There were no significant differences in the distribution of values between the three location types. However, the IMST shows a significant difference between locations for the internet and ODM category. The differences in 'internet' score are centred around students in coastal locations who place a wider range in rank for the 'internet' category compared to other locations. P values between coastal location and city centre show $p = 0.032$ while coastal locations and upland locations have $p = 0.035$. Students from the Kalinago territory fit into the coastal locations and registered that they do not all use the internet frequently. For the variation in ODM category those in coastal locations placed reduced importance on the ODM compared to those in urban areas.

Table 7. 7 P-values to show significant difference (significant where $p < 0.05$) comparing student locations in October 2016.

	Parents	Radio	TV	Internet	Church	School	ODM	RC
ISMT	.149	.645	.397	.910	.180	.749	.140	.560
K-W T	.085	.827	.380	.979	.171	.626	.115	.403

The October 2016 results shown in **Table 7.7** indicate no significant differences in IMST and K-W tests for any of the categories in any of the locations. This suggests that students across these locations categorised the importance of each category similarly.

Table 7. 8 P-values to show significant difference (significant where $p < 0.05$) comparing student locations in April 2017 (figure in bold shows significant difference).

	Parents	Radio	TV	Internet	Church	School	ODM	RC
ISMT	.332	.882	.680	.435	n/a	.959	.829	.237
K-W T	.385	.470	.611	.083	.042	.776	.926	.508

April 2017 data from **Table 7.8** was like October 2016 with little significant difference between location and ranked variable. There is some evidence of significant difference in the Kruskal-Wallis test, as those in coastal locations ranked the 'church' higher in importance compared to the other two locations, but this result seems anomalous.

7.1.6 Summary of student learning preferences for DRR

There is a pattern of similarity in student perception of the importance of categories. There are isolated examples of difference, with the greatest amount occurring between schools rather than gender or student settlement location. The greatest differences occur between in the 'radio' and 'school' category. This is likely due to differences within families who traditionally use a radio for information and the perception of values the students place on their teachers as specialists to deliver information about natural hazards. The use of the internet is an important resource suggesting a need to place accessible and up-to-date information for independent learning and allowing students access to relevant internet material to allow them to collect a realistic outcome. The use of mobile technology has enabled the importance of TV and the internet. Help from DRR institutions is ranked as of lowest importance for the students currently reflecting their lack of engagement with schools.

7.2 Discussion of student learning preferences about DRR for multi-hazards

The focus of studies into student understanding of DRR themes relate mostly to how they perceive their risk in the context of the local environment, often related to one named hazard type. Few studies focus on the method by which students receive their understanding. This is important because educational programs assume that learning is centred around educational institutions and therefore devise programmes for schools. However, in this study we sought to understand the sources from which students perceive they have developed their understanding of natural hazards. This is important because if, for example, parents have the greatest influence, then work completed at school may not have a lasting impact on the student if they are receiving different messages from home. Therefore, we divided the sources of information into 7 sources relevant to the local student population in Dominica: parents, radio, TV, the internet, church, school, the Office of Disaster Management, and the Red Cross. In the lead up to both Tropical Storm Erika and Hurricane Maria, messaging was focused mainly through radio broadcasting and some television broadcasts as these are considered how most people will receive the messaging, particularly parents. Our results into the ranked importance of these sources to learn about natural hazards showed that student preference is via the internet. Television was second most important to students for their learning about natural hazards, while radio came in 3rd or 4th most important dependent on location. This In urban locations, such as school 1 and 2 students placed greater value in learning from their parents than school, while in the rural schools there was greater parity between the two. Radio was considered important however this is most likely a reflection of indirect learning via parental use rather than specific choice to use radio to learn. The disaster risk reduction agencies were ranked lowest, as useful, not because they were not giving messages about disaster risk reduction, but instead because their presence was not visible to the school students, therefore the perception that learning from them was at best indirect. Churches were also not considered of use by students, often ranking last as a learning source for information about disaster risk reduction and natural hazards.

These results are significant because they tell us that messaging regarding learning needs to be multi-faceted. Students receive information from a variety of sources and therefore messaging needs to reflect this. Assumptions cannot be made that radio broadcasting will be the sole means by which to reach the population, in the led up to a large event like Hurricane Maria. Learning resources therefore need to reflect this (Kagawa and Selby 2012). The internet allows students to be more independent in their learning. However, this information needs to be made to be accessible and current. At present the educational system in Dominica is dominated using textbooks. Greater diversity in resourcing needs to be made, however this will require teachers to have more subject specific training.

This result also shows that there were also no significant differences in how students learn dependent on their gender or the area where they live (e.g., coastal, urban, or upland locations). Some studies (Morioka, 2014, Lightfoot et al, 2020, Liu et al, 2020) suggested that there are learning differences in gender, however we did not find this to be the case. Our results show that the primary means of learning about hazards relates to direct technological methods. Indirect methods, via parents, teachers or other institutions need to work in collaboration with these direct methods. As we move into a technological adult generation this may be possible. However, blending a variety of ideas to reinforce the links with community, through song, dance and art are effective ways of building a link between child and adult learning (Back et al, 2009, Bird & Gisladdottir, 2014). Ultimately an effective learning environment for improved student awareness needs to blend community interaction with a blended learning approach through education (Petal, 2008, Selby and Kagawa, 2014). This needs to build on generic regional advisories and develop for the relevant use in, and integrating the involvement of, targeted Dominican communities (Wisner, 2006).

7.3 Analysis of educational measures for Disaster Risk Education

The results in this section focus on the extent to which educational methods, undertaken between 2016-2018, were effective at changing student risk perception. This will be achieved by comparing mean SHS perception values before and after educational sessions to determine which had the most overall impact per school by assessing the differences. These values are shown in **figures 7.7-7.10**.

Individual student perception changes will be presented on a schematic PRISM board as vector diagrams to show trends in a class perception to assess how perceptions changed through directional changes on the PRISM board. These will show the extent to which individual students made changes between each session. Sensky and Buchi (2016) hypothesized that the angular position relative to self may reflect optimism or pessimism towards a change, this will be an opportunity to reflect on this. This section will also present results on the percentage of students who made changes to individual hazards because of each session to enable comparison between each school. In addition to assessing the impact of the educational session, through the changes outlined above, this section will analyse the use of the resources from session 2 to determine their benefit for use in DRR education. To what extent are resources engaging or useful?

Lastly, data from session 3 will be analysed to assess how fieldwork has an impact on student decision making for DRR. These results are presented using maps to show the spatial variations in **Figures 7.11-7.13**.

7.3.1 Using mean SHS values to show educational impact.

Figures 7.7-7.10 show mean student change to SHS values over the three teaching sessions (S1-S3) in the period 2016 – 2018. Hurricane Maria is shown on each graph to indicate its occurrence between sessions.

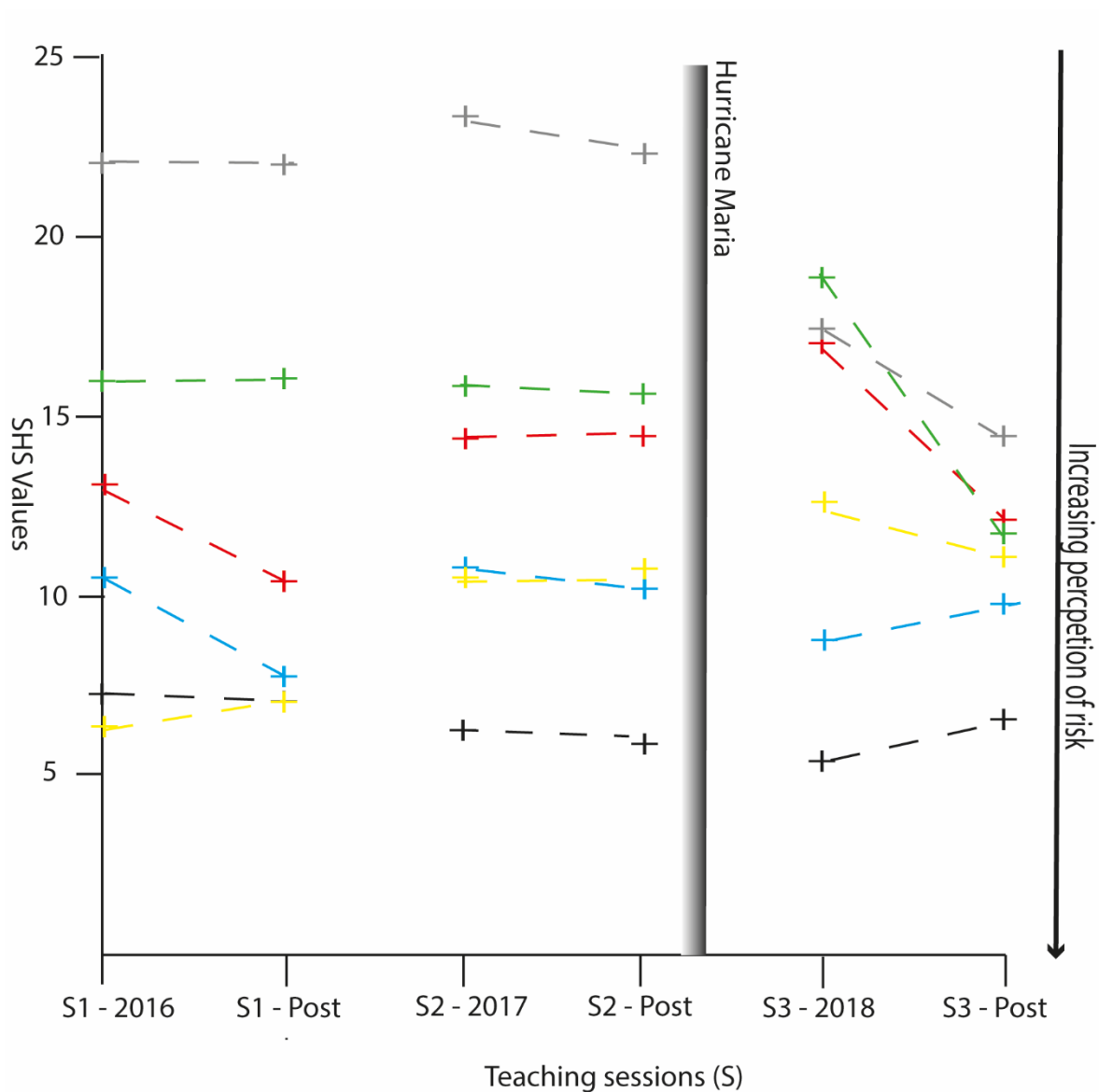


Figure 7.7 Changes to average SHS values for different hazards, before and after teaching sessions 1-3, in school 1. Notes = Colours – Yellow – Landslide, Black – hurricane, Blue – flood, Red – Earthquake, Green – volcanic eruption, Grey – tsunami

Figures 7.7-7.10 show the change to mean SHS values for each hazard (PRISM exercise 1) resulting from each teaching session. Results show similar trends across each of the schools. Session 3 had the greatest impact of all sessions in changing PRISM position. In school 1,2 and 4 all the geophysical hazards show an intensification of perception after session 3. Volcanic risk shows the greatest change in session 3, moving closer to “self” by an average of 5cm. Earthquake risk intensifies in school 1 and 2 by 3-4cm, but less in school 4.

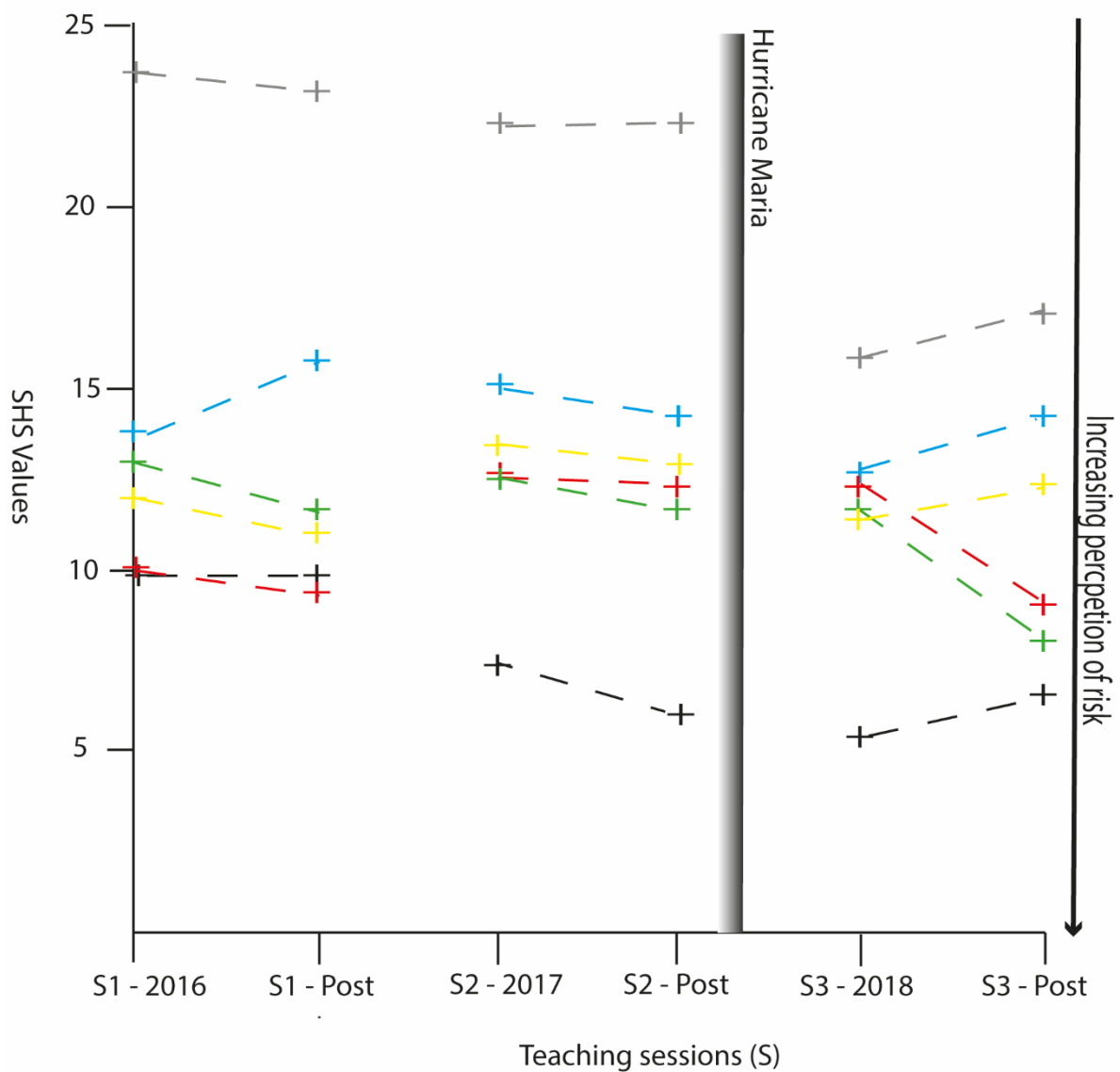


Figure 7. 8 Changes to average SHS values for different hazards, before and after teaching sessions 1-3, in school 2. Notes = Colours – Yellow – Landslide, Black – hurricane, Blue – flood, Red – Earthquake, Green – volcanic eruption, Grey – tsunami

However, school 4 shows a greater intensification of the tsunami risk after session 4, increasing by 6cm towards “self”. Only in school 2 does the tsunami risk decrease in intensity, moving away from “self” marker. The hydrometeorological risks show a different pattern. Hurricane risk perception is still considered most threatening after fieldwork, but in all schools the effect of session 3 fieldwork was to move perceptions of hurricanes back to 2016-2017 levels. Session 3 changes show that flood risk perception moves away from “self” after the fieldwork in schools 1 and 2 but intensifies in school 4. Landslide risk intensifies slightly in school 1 and 4 but reduces in school 2 after the fieldwork. Across most of the sessions, 3 shows the greatest movement for most of the hazards.

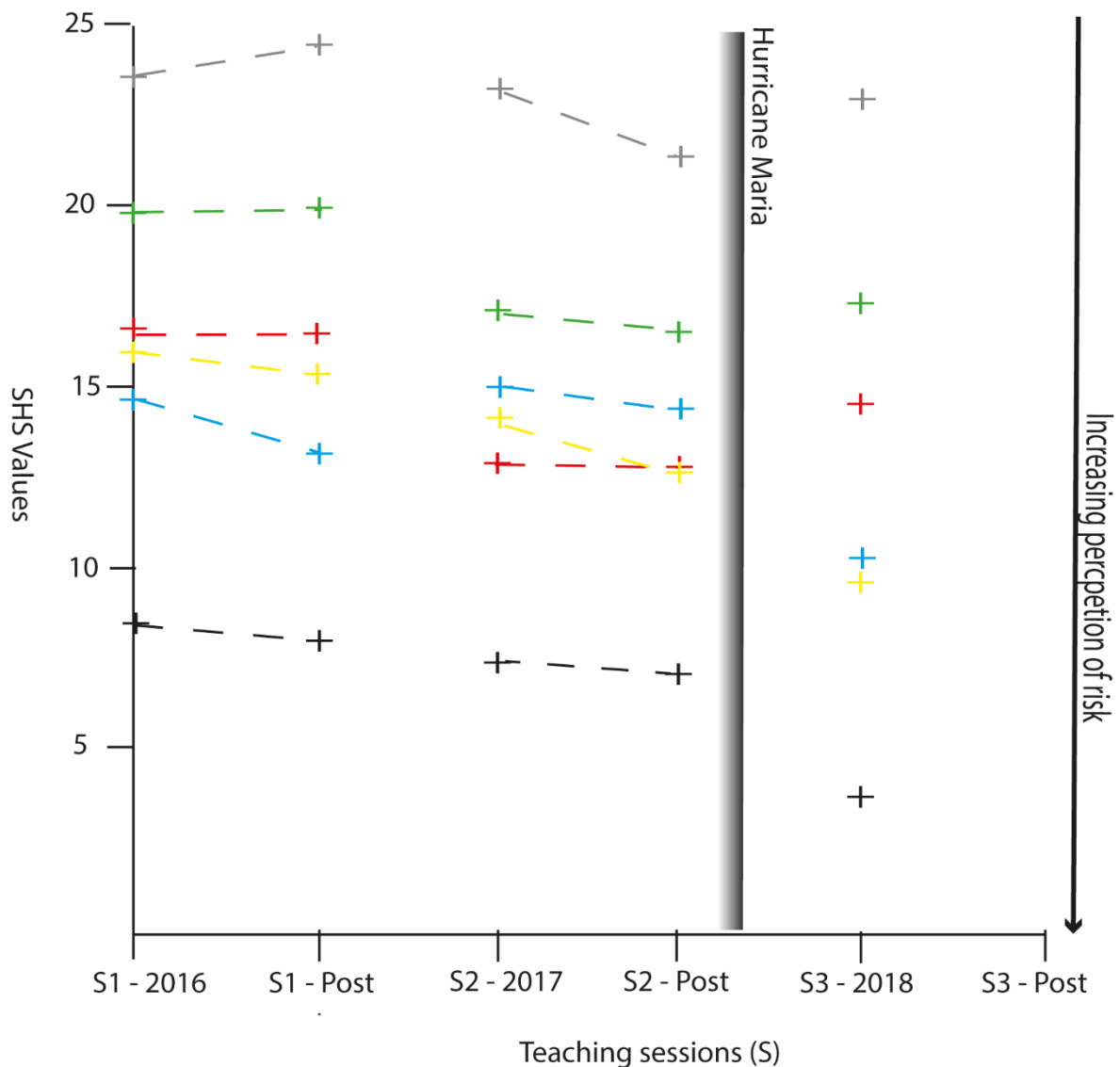


Figure 7.9 Changes to average SHS values for different hazards, before and after teaching sessions 1-2, in school 3. Notes = Colours – Yellow – Landslide, Black – hurricane, Blue – flood, Red – Earthquake, Green – volcanic eruption, Grey – tsunami. Note – session 3 note completed by school 3 students.

Figures 7.7-7.10 show that session 1 has some evidence of impact on mean SHS values. The greatest impact across the 4 schools is on the flood risk, with greatest intensification of perception in school 1 and 3 but a large reduction in perception in school 2 (Figure 7.8). Session 1 had limited impact on school 4, other than a minor change to the perception of landslides. Generally, the geophysical risks showed limited change, except in school 1 whereby earthquake perception (Figure 7.7) moved towards self. Landslide values also showed some movement away from “self” in school 1 but toward “self” in school 2. Session 1 did not generally change the order of students perceived risk before and after the session.

Results comparing change from session 2 also show a limited change in the order of risk perception in all schools. Session 2 also had the least impact on changing mean perception scores.

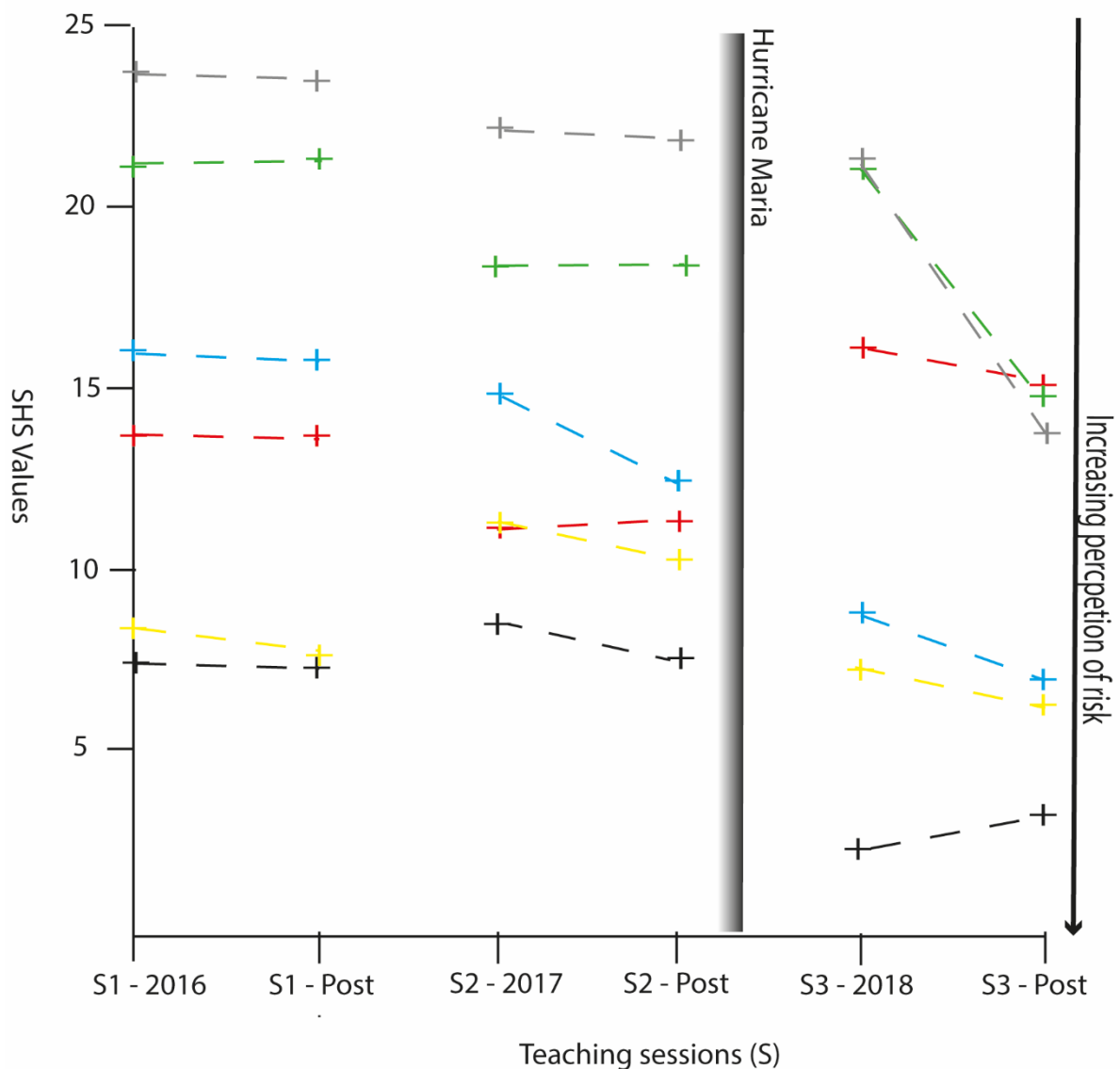


Figure 7. 10 Changes to average SHS values for different hazards, before and after teaching sessions 1-2, in school 4. Notes = Colours – Yellow – Landslide, Black – hurricane, Blue – flood, Red – Earthquake, Green – volcanic eruption, Grey – tsunami. (Session 3 only completed by 6 students).

In all cases after session 2, average SHS scores had limited change after the session or showed slight movement towards 'self'. Session 2 had the greatest impact on school 4 (**Figure 7.10**), showing relatively increased intensity in the perception of hydrometeorological hazards, with flooding showing the greatest change. Above average changes were noted for hurricane risk after session 2 in both school 4 and 2. All of the session 2 changes could be within error.

Table 7.9 shows significant differences (2 tailed t-test) and effect scores (Cohen's d effect score >0.5) in changed perceived scores because of educational sessions. School 1 and 2 include all session, school 3 and 4 only include session 1 and 2 comparisons. Session 3 results are omitted for school and 4. School 3 did not take part in session 3 while school 4 had limited participants.

Table 7. 9 The statistically significant differences ($p < 0.05$) and effect scores (> 0.5) comparing change in SHS values after each educational session.

School 1		Hurricane	Flood	Earthquake	Vol. Eruption	Landslide	Tsunami
Session 1	P=value		0.005	0.04			
	Cohen's d		0.59				
Session 2	P=value	0.012	0.012				
	Cohen's d						
Session 3	P=value			0.002	0.000	0.034	
	Cohen's d			0.69	0.82		
School 2		Hurricane	Flood	Earthquake	Vol. Eruption	Landslide	Tsunami
Session 1	P=value		0.002				
	Cohen's d		0.95		0.51		
Session 2	P=value	0.028					
	Cohen's d	0.57					
Session 3	P=value			0.023	0.05		
	Cohen's d			0.55			

School 3		Hurricane	Flood	Earthquake	Vol. Eruption	Landslide	Tsunami
Session 1	P=value						
	Cohen's d						
Session 2	P=value		0.027			0.020	
	Cohen's d					.51	
School 4		Hurricane	Flood	Earthquake	Vol. Eruption	Landslide	Tsunami
Session 1	P=value						
	Cohen's d						
Session 2	P=value	0.47	0.01			0.12	
	Cohen's d		.69			.51	

Table 7.9 shows that there were impacts on student perception from each session, though this varied by school. Session 1 had least overall impact, mainly impacting the perception of flooding in school 1 and 2. Statistically it had no impact in school 3 and 4. Session 2 had an impact across all schools most significantly in school 4. It only had an impact on hydro meteorological hazards. Session 3 had a much greater impact on the perception of the lower frequency geophysical hazards, particularly earthquake, and volcano but less so on tsunamis. The significance of these results suggests, in agreement with **Figures 7.7-7.10** that the fieldwork session had a significant impact on changing the perception of students, however the statistical significance was not evident from **Figures 7.7-7.10**.

7.3.2 Evidence of educational impact.

This section shows vector plots to compare the impact of sessions on perception change by showing plots representing movements across the PRISM board. **Figures 7.11-7.13 (a-c)** show vector plots to represent the changes in volcano, hurricane, and flood after each session. Arrow distance represents the extent of change, therefore longer arrows resulted in greater change. Dots represent no change in perception after the educational session. Results are shown for session 3 first as this was deemed to have the greatest impact. Session 2 and 1 are shown in subsequent sections for comparison.

7.3.2.1 Session 1 – Interactive methods.

This section assesses the impact of session 1. **Table 7.10** shows the impact in terms of percentage of students who changed their perceived values after session 1.

Table 7. 10 Percentage of students with changes to their original PRISM values after education session 1 for hurricane, flood, tsunami, and landslide

School	Hurricane	Flood	Earthquake	Volcanic	Landslide	Tsunami
1	15%	38%	23%	23%	23%	23%
2	0%	69%	13%	25%	25%	6%
3	17%	25%	13%	4%	13%	13%
4	0%	3%	0%	3%	3%	0%

Table 7.10 shows session 1 had the least impact overall on student perception changes across all hazards. School 1 students were impacted most by this session with at least 1 in 5 students changing their perception of each hazard because of the session. The impact was mixed in school 2. It had a huge change in the perception of flood hazards, but little impact on hurricane and tsunami perception. Tsunami and hurricane showed the least change overall, while flood and landslide showed the greatest change in students' perception. Overall school 1 and 2 students gained a greater amount from the session. School students from school 4 found this session least useful in changing their perception of hazards.

7.3.2.2 Session 2 – Surrogate methods

Figure 7.11 (a and b) show the vector changes for the hydrometeorological hazard perception changes for School 2 and 4. Presentation of flood and hurricane hazard were chosen as examples as they showed the greatest average movement. The vector diagrams show represent school 2 and 4 students whose perceptions changed by the greatest amount for these hazards in session 2.

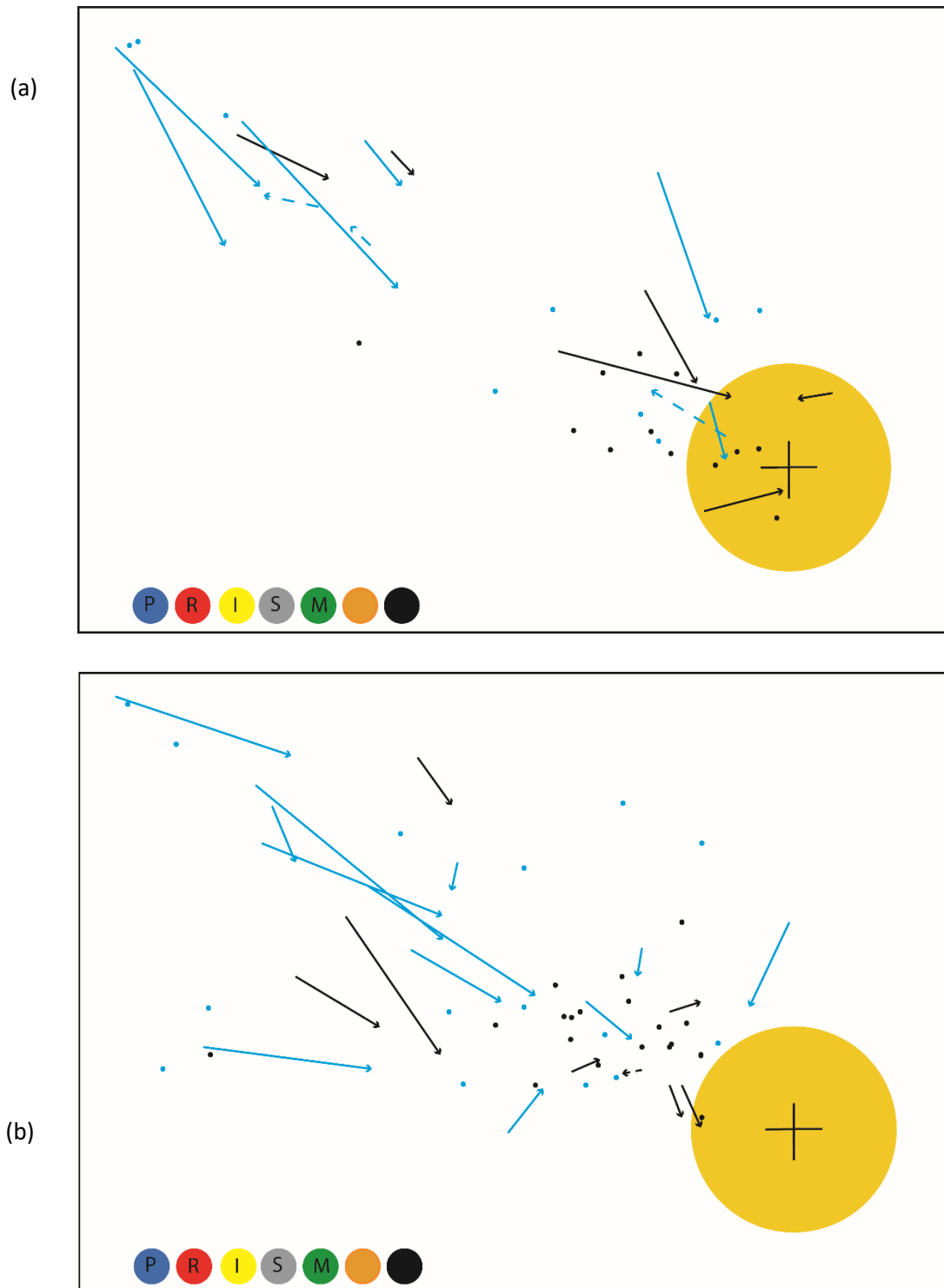


Figure 7.11 (a-b) Vector diagrams showing SHS movements for the hurricane (black arrow) and flood risk (blue arrow) hazard before and after session 2 for (a) School 2, (b) School 4. Notes = Dots represent no change. Dotted lines represent a reduced perception in hazard risk.

The vector diagrams in **Figures 7.11 (a) and (b)** show less movements in comparison to **Figures 7.12 (a-c)**. This suggests that this session by comparison had less impact on changing the student perceptions, although the statistics in **Table 7.10** do not support this. The perceived change in

hurricane risk, moves towards 'self' for all but one student. Relative movements starting closer to 'self' are smaller than those which begin further away. However, 66% of students in school 2 chose not to change their perception of hurricane hazard after session 2 while the 71% of students chose not to move their hurricane perception disk placement after session 2. This session therefore impacted on approximately 1/3 of students, in comparison to session 3 which led to 100% of students changing their perception scores.

In school 2, 50% of the students changed their perception of flooding due to the session, while 42% did so in school 4. This session therefore had a greater impact on the perception of the flood risk than the hurricane risk. The direction of movement in both selected schools here highlights how many students kept their change in perception within the diagonal. Though there were greater vertical movements from school 4 students.

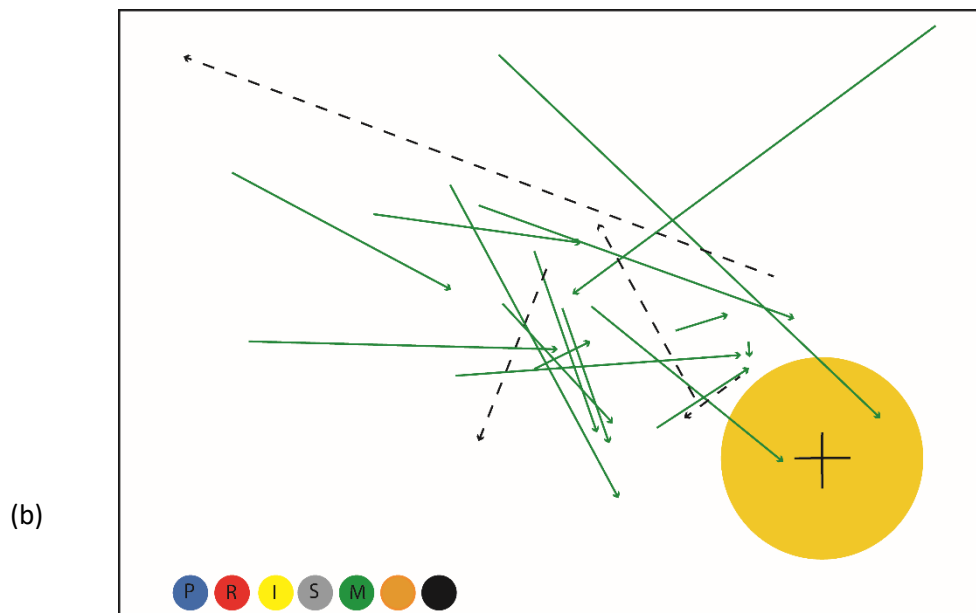
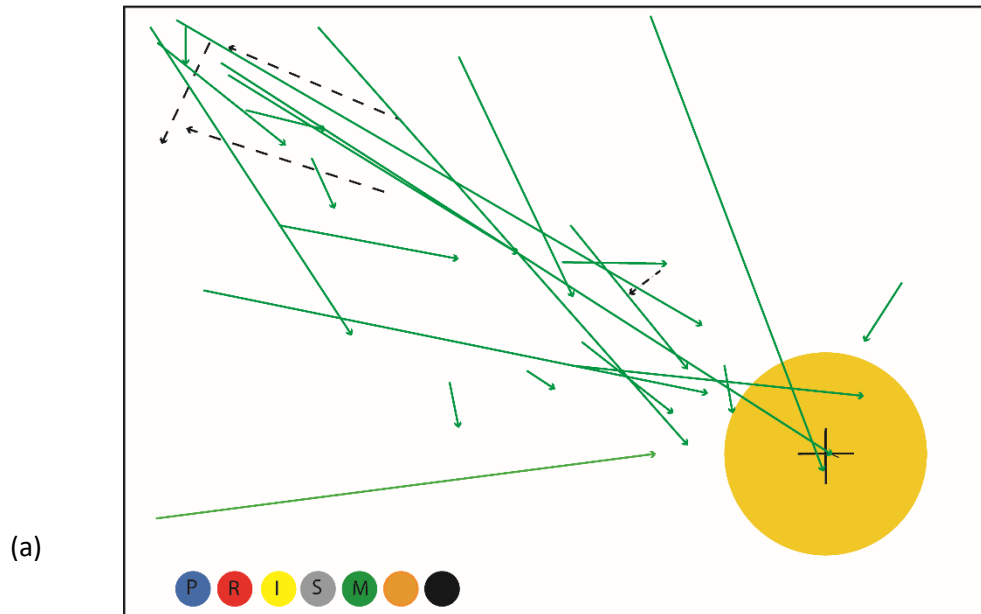
Table 7. 11 Percentage of students with changes to their original PRISM values after education session 2 for hurricane, flood, tsunami, and landslide.

School	Hurricane	Flood	Earthquake	Volcanic	Landslide	Tsunami
1	37%	60%	43%	44%	27%	50%
2	33%	50%	50%	50%	50%	45%
3	17%	25%	0%	13%	21%	21%
4	29%	42%	18%	18%	44%	25%

Table 7.11 shows that session 2 had the greatest impact on perceived flood risk across the 4 schools, with 60% of students from school 1 changing their disk positions (supported by **Table 7.10**). The geophysical risk perceptions changed more because of session 2 in schools 1 and 2 compared to schools 3 and 4. Except for flood risk perception, session 2 had a minimal impact on the percentage of students from schools 3 and 4 who changed their disk positions. The session had the least impact on school 3 with changes in risk perception impacting on average 1 in 5 students; no students changed their perception of earthquake risk after this session. Session 2 had the greatest impact on school 2, with an average of 46% of students changing their perceptions during this activity. Hurricane perception was often the least changed perception after this session.

7.3.2.3 Session 3 – Fieldwork and decision making.

Figures 7.12 (a-c) show the changes in SHS values for the students (schools 1,2 and 4) who participated in the fieldwork programme from session 3.



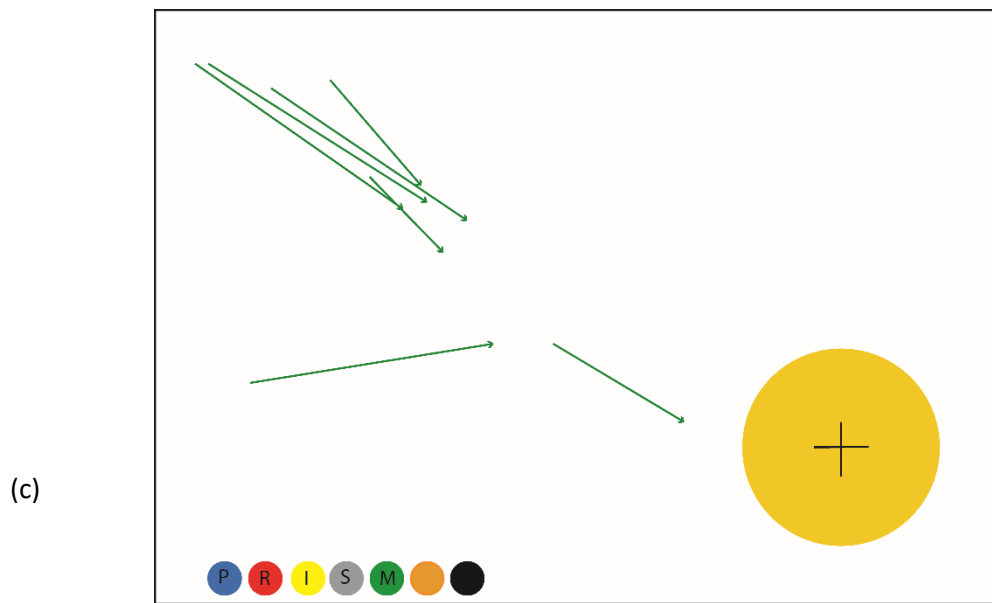
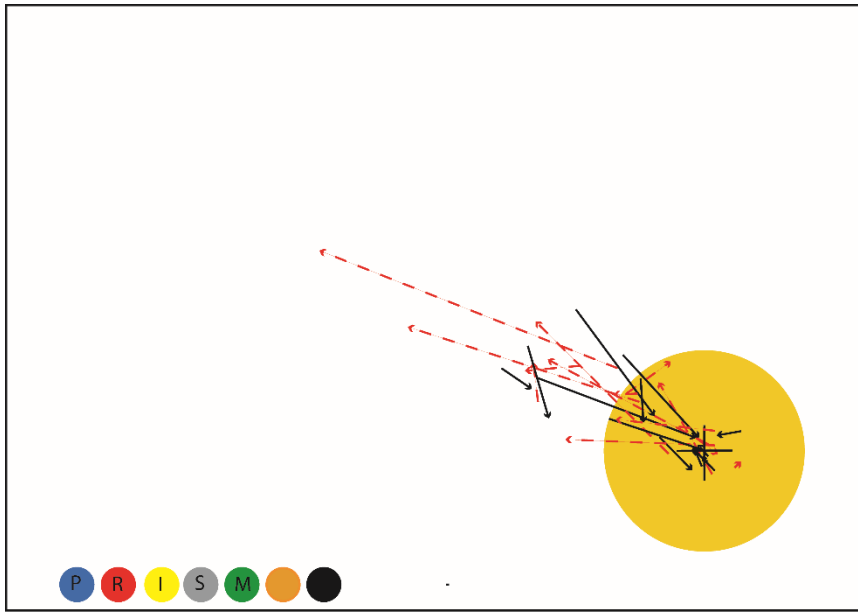


Figure 7. 12 (a-c) vector diagrams showing SHS movements for volcano hazard before and after fieldwork from session 3 for (a) School 1, (b) School 2 and (c) School 4. Notes = Green arrows show perception moves intensifies towards self; black dotted arrows show reduced perception of hazard risk.

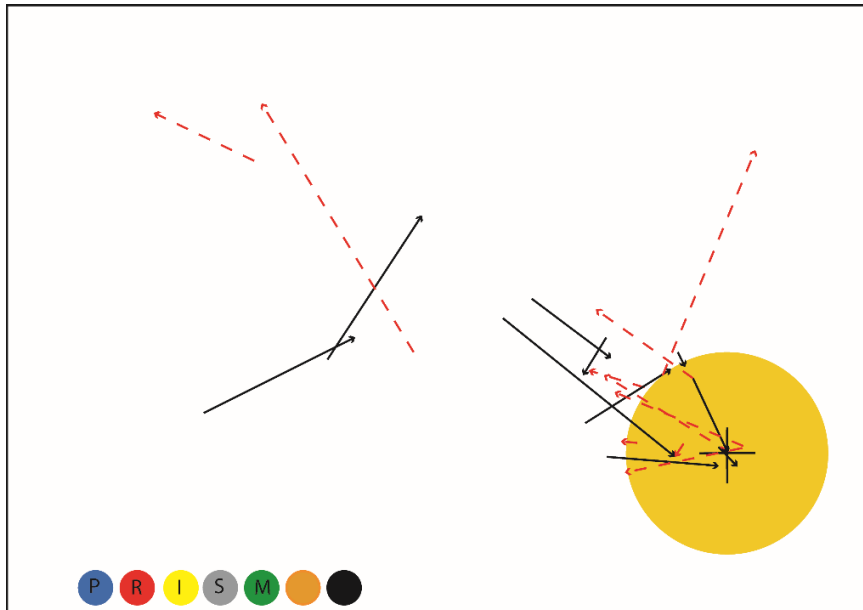
Figures 7.12 (a-c) show the impact of the fieldwork exercise for volcanic perceptions in 3 schools. Most notably arrows indicate the extent of the movement towards 'self' for most students. Only 4 students in school 1 and 2 showed movement away from self. Many of the movements towards self are larger movements (over 4cm) indicating a clear change in perception associated with this teaching. Most movements follow the long diagonal, however, in school 1, 10 of the students show a vertical movement across the board and 9 students from school 2 have a similar pattern indicating that not all perceive the use of PRISM along the diagonal axis. This may link Sensky and Buchi (2016) hypothesis that the PRISM board positions allow for an indication of optimism or pessimism when changing perception. School 3 has a small sample and most of them follow the diagonal trend.

Figures 7.13 (a-c) show the contrasting impact of fieldwork on hurricane perception (after Hurricane Maria).

(a)



(b)



(c)

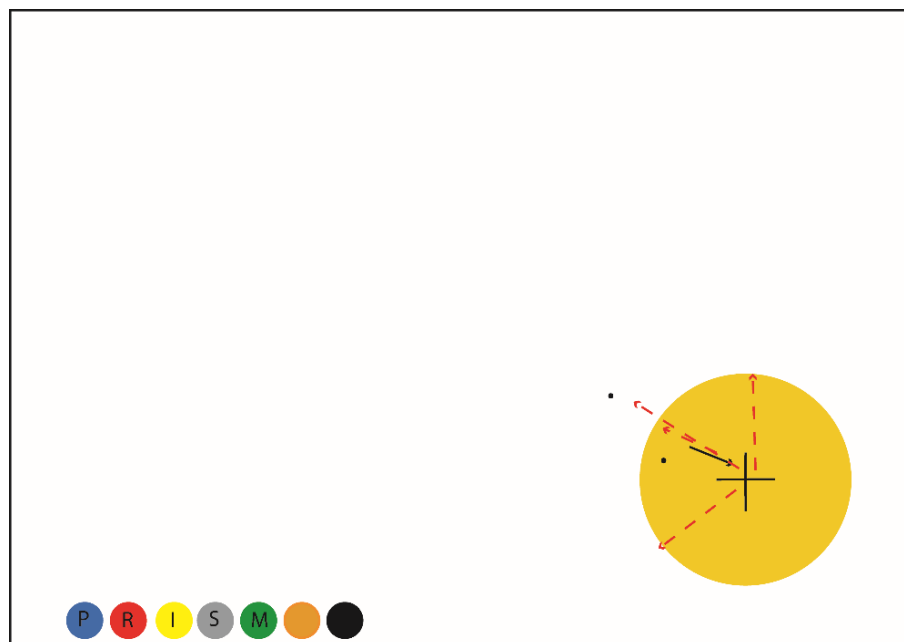


Figure 7. 13 (a-c) Vector diagrams showing SHS movements for the hurricane hazard before and after fieldwork from session 3 for (a) School 1, (b) School 2 and (c) School 4. Notes = Black arrows show perception moves intensifies towards self; red dotted arrows show reduced perception of hazard risk. Dots represent a student whose perception was unchanged after session 3.

In comparison to **figures 7.12 (a-c)** the SHS movements for hurricanes are smaller compared to volcanic risk perception. SHS values are also closely located around 'self' indicating the number of students who perceive this as a higher impact hazard. While fieldwork did cause a change in all student values in school 1 and 2 there were 2 students in school 4 who did not change their perceptions. There is a balance between movements towards and away from 'self', though some of the movements away (reduced perceptions of risk) are greater than the largest movements towards 'self'. This may reflect a resetting of hurricane perceptions post Hurricane Maria. In school 1 almost all the arrow directions are along the diagonal, however in school 2 there were 8 students with a vertical orientation to the arrow, and 2 in school 4. Small movements in hurricane perception may account for the existing intensified perception of this risk, therefore are small movements more significant than larger movements for volcanic risk?

7.3.3 Student decision making to improve DRR, from session 3.

Part of session 3 required students to identify 'safe zones' on a map for 4 named hazards in their school location. After session 3 fieldwork they were asked to repeat this exercise to see if the teaching format had changed their perspective. **Figures 7.14-7.17** show the students results for school 1 and school 2 for both hydrometeorological (hurricane and flood) and geophysical (volcanic

and tsunami) hazards. Coloured dots represent the hazard safe zones prior to the session, and black dots represent locations after the session(a)

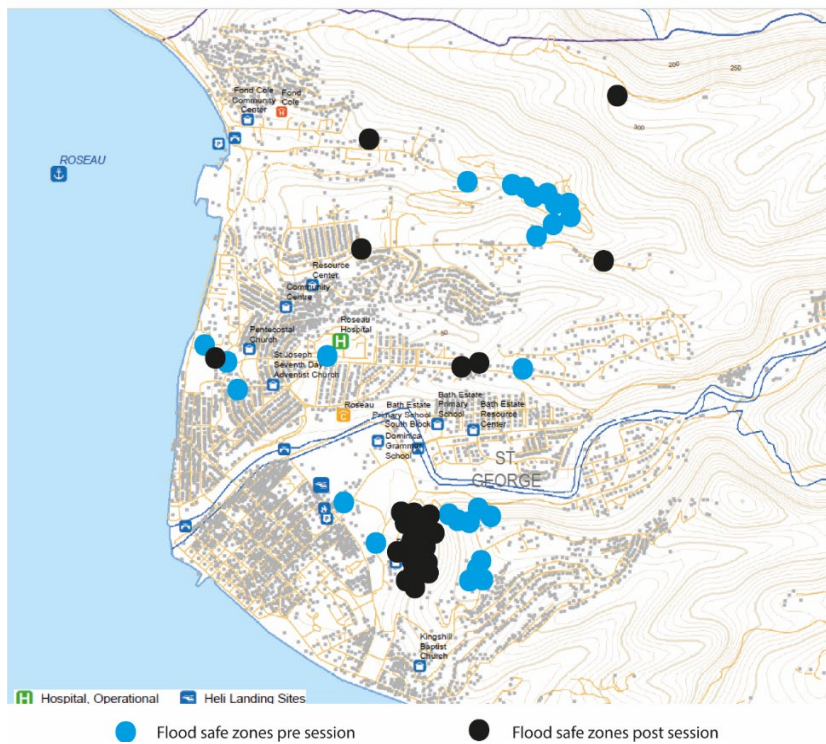
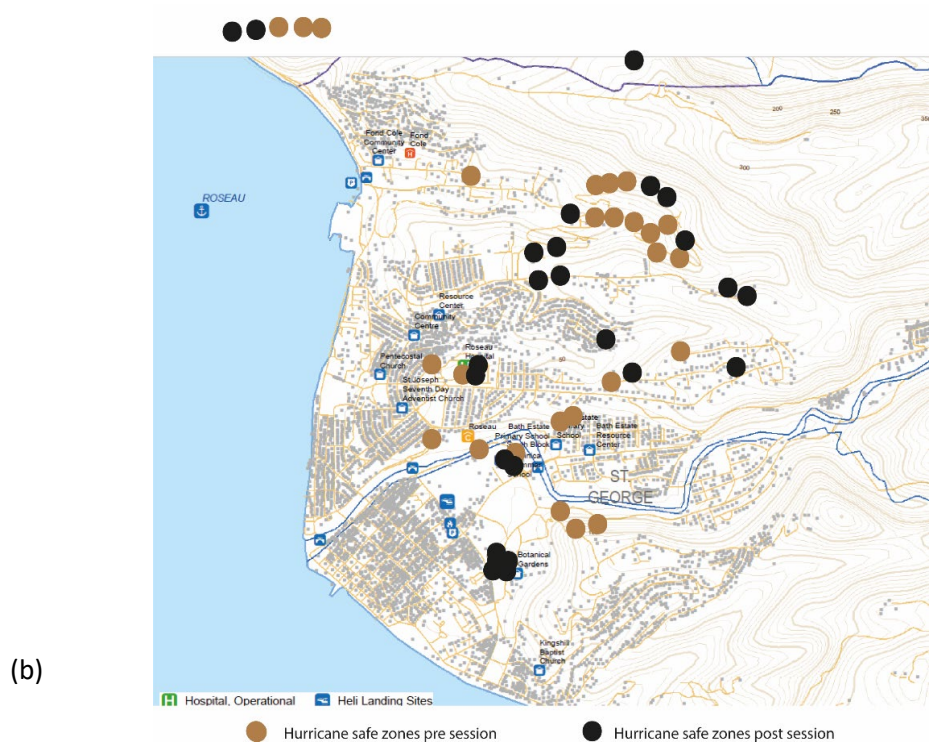


Figure 7. 14 Dot distribution maps showing change in perceived 'safe areas' in Roseau for hydrometeorological hazards (hurricane (a) and flood (b)) before and after session 3 fieldwork participation, in school 1.

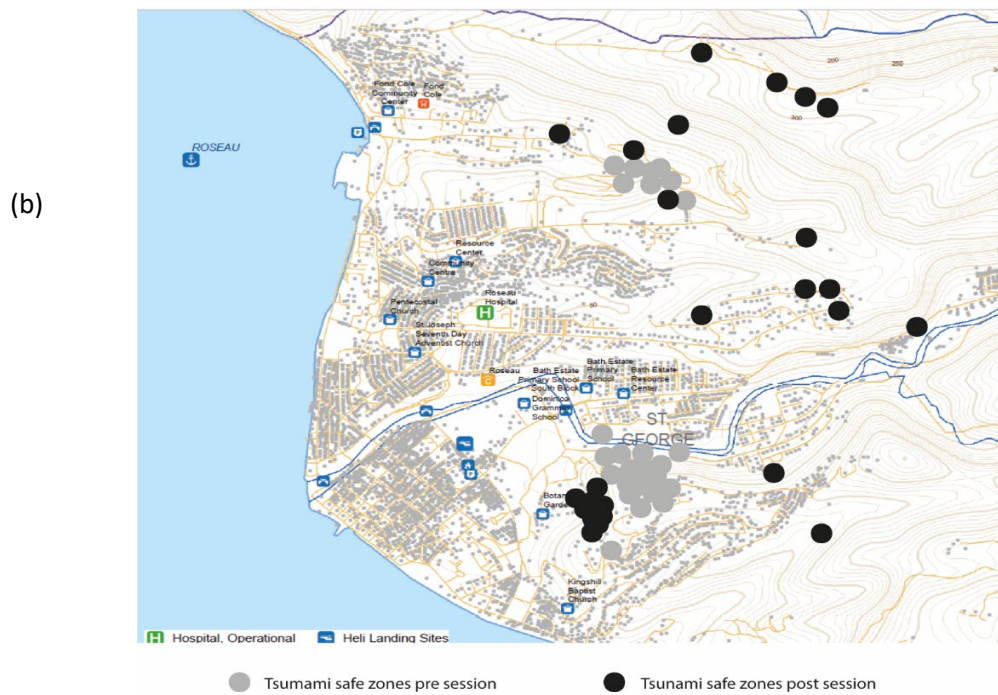
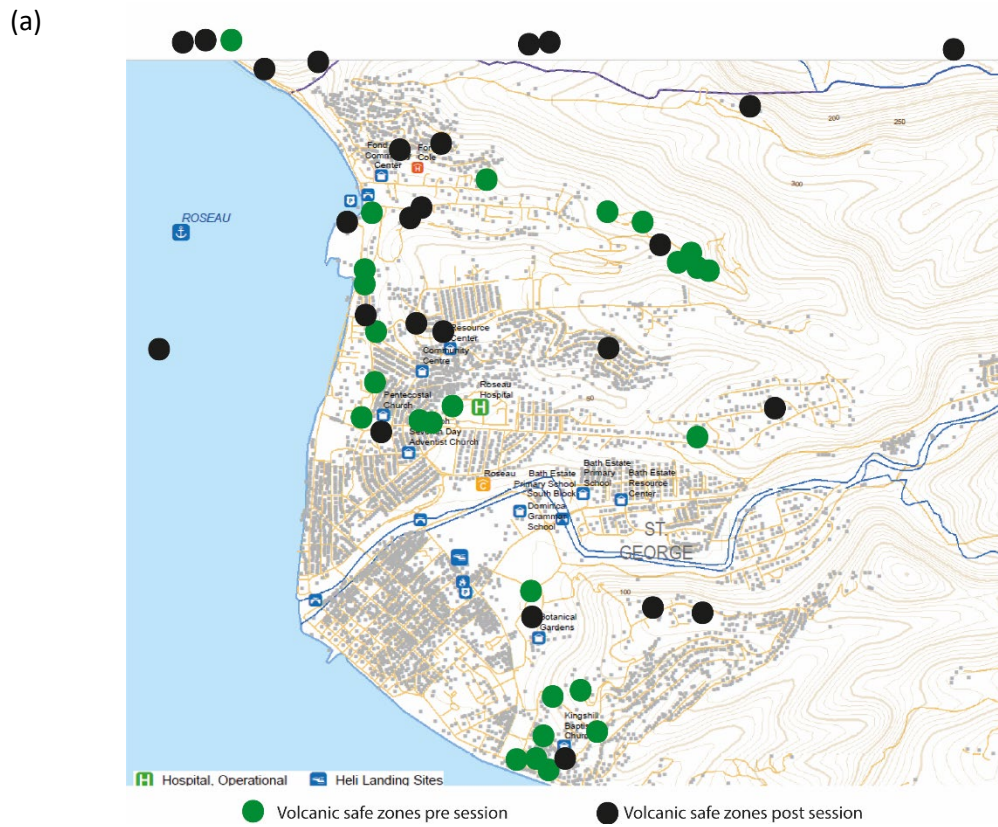
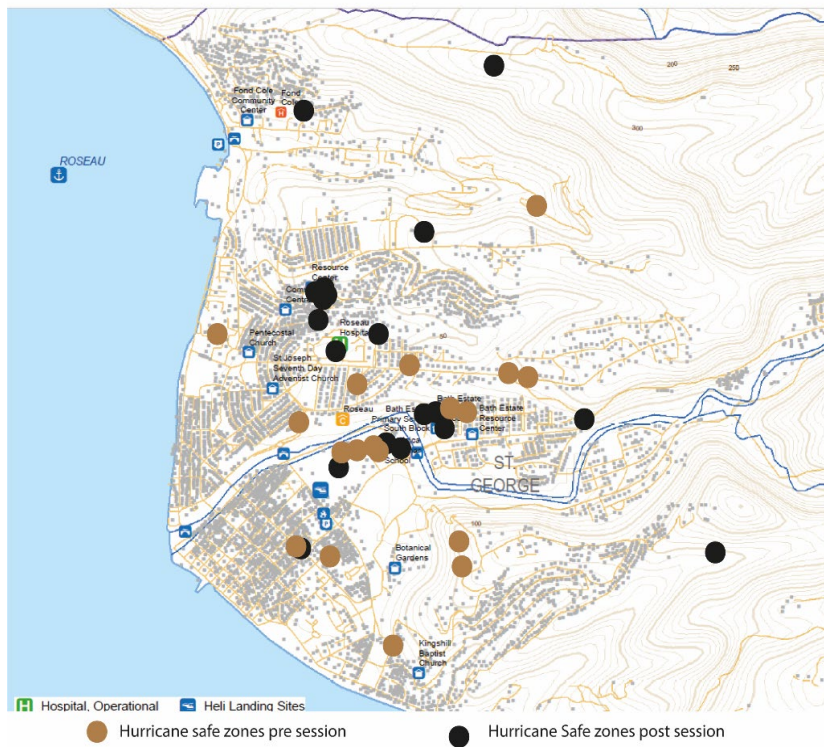


Figure 7. 15 Dot distribution maps showing change in perceived 'safe areas' in Roseau for geophysical hazards (volcano) (a) and tsunami (b) before and after session 3 fieldwork participation, in school 1.

(a)



(b)

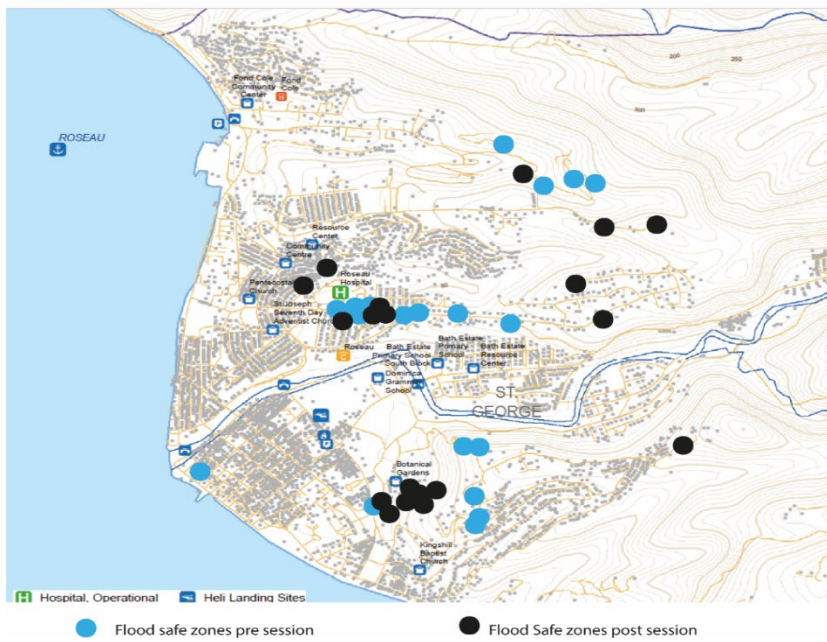
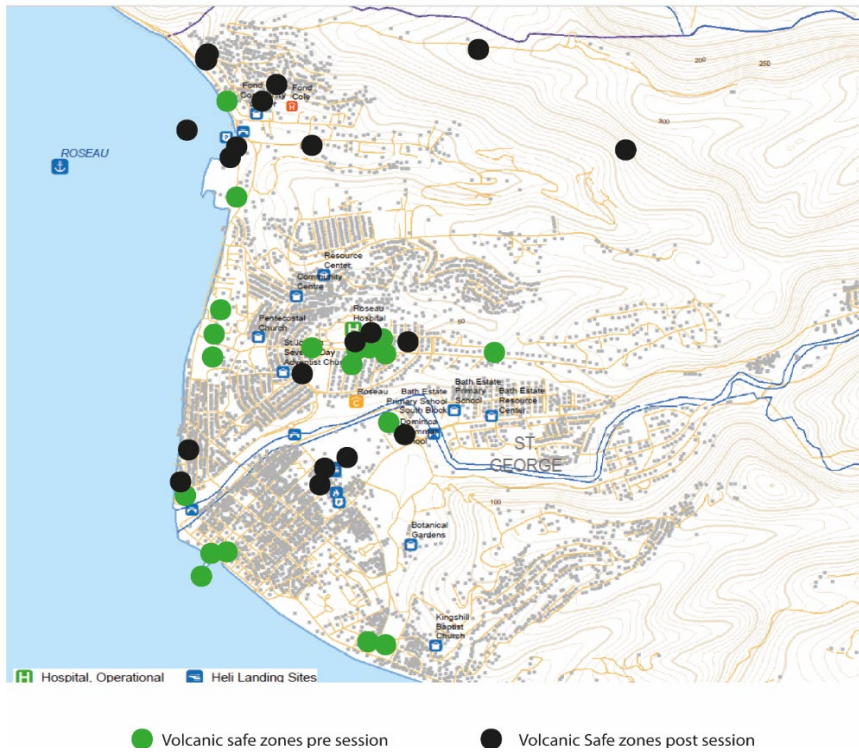


Figure 7. 16 Dot distribution maps showing change in perceived 'safe areas' in Roseau for hydrometeorological hazards (hurricane (a) and flood (b) before and after session 3 fieldwork participation, in school 2.

(a)



(b)

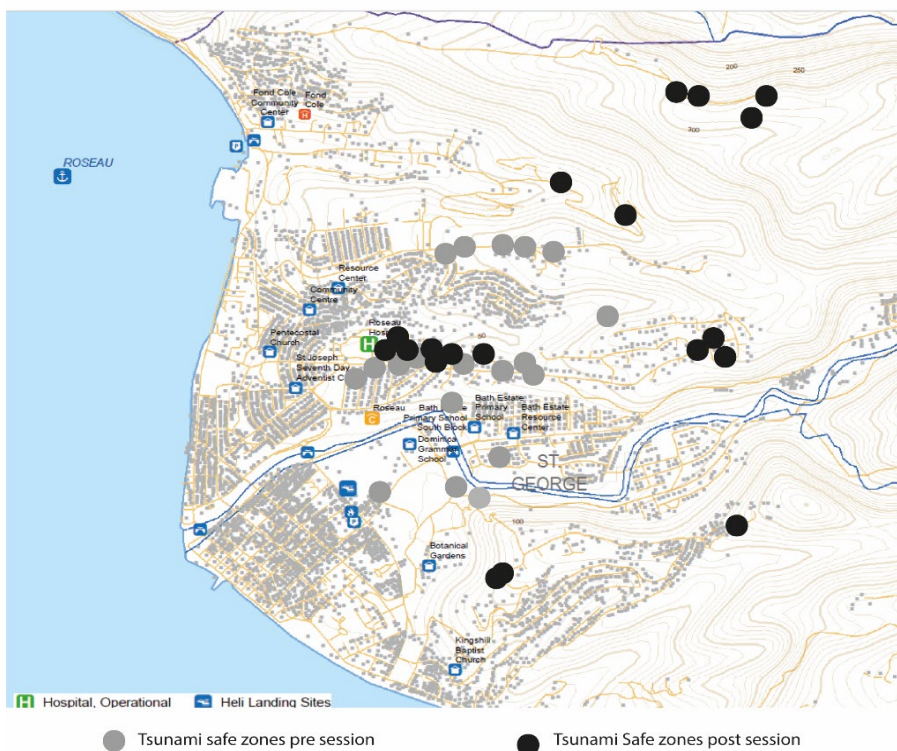


Figure 7. 17 Dot distribution maps showing change in perceived 'safe areas' in Roseau for geophysical hazards (volcano) (a) and tsunami (b) before and after session 3 fieldwork participation, in school 2.

7.3.3.1 Results for School 1

Hurricane – there are two distinct groups in the pre fieldwork grouping shown in **figure 7.14 a**; one to the north of Roseau in the Stockfarm suburb, and elevated ridge away from the river; the second around the river near to the existing shelters. After the fieldwork there is a similar grouping of student placements to the north, though some have come closer to neighbourhoods and the hospital. Fewer students chose the shelter near the river, instead opting for the school building as an alternative, despite this building suffering some damage in Hurricane Maria.

Flooding – **Figure 7.14b** shows that students opted for higher land in the pre-fieldwork selections. They chose the Morne Bruce area behind the botanical gardens, which had easier access. Others had opted for areas within town or the Stockfarm ridge. After fieldwork there were two significant groups, one in the botanical garden and in the elevated area of Stockfarm. Fewer decided to stay in the urban area adjacent to the river.

Volcanic – **Figure 7.15a** shows that students spread their volcanic safe zone results prior to the fieldwork. Many opted to stay within town, to the north of the Roseau River but near to the coast. The other placements were focused nearer to Kings Hill, south of Roseau. After the session, the spread of safe zones was still diverse, however, fewer placed disks to the south of the River Roseau, with a greater number opting to choose the area north of Roseau towards Canefield. Fewer people opted to stay in the downtown area of Roseau, only those staying opting to choose Morne Bruce as higher ground.

Tsunami – **Figure 7.15b** shows that students opted for higher ground before and after the fieldwork, suggesting they understood relative safe locations to escape from a tsunami. Pre-session, students mainly opted for Morne Bruce hills or the raised area around the Stockfarm suburb. After the session there were a greater number finding the northern upland areas of Roseau as safe, however, some opted to go further north than previously chosen.

7.3.3.2 Results for School 2

Hurricane – **Figure 7.16a** shows similar results pre- and post-fieldwork. Pre-fieldwork several students had opted for central locations within Roseau near the hurricane shelters, especially the one at Dominica Grammar school. However, after the session fewer decided to stay closer to town, with more seeking the higher space or shelters away from the town centre and the river.

Flood – **Figure 7.16b** shows that pre-fieldwork, the students opted to locate at either location with higher ground (Morne Bruce / Stockfarm) or nearer the hospital. Post fieldwork there was still a preference for locations on higher ground, but also near the botanical gardens, in the open space suggesting an understanding of safe zones for floods.

Volcanic – **Figure 7.17a** shows that volcanic hazard produces the least consistent results. Pre-fieldwork students were spread throughout locations within the town and along the coast. After fieldwork fewer opted to stay nearer the centre, though some did opt to call the emergency service locations as safe zones and the hospital. A greater number of students opted to travel north to away from the river, along the coastal district near the port. The vast majority had opted to travel away from the southern side of the Roseau River which faces the PPVC.

Tsunami – **Figure 7.1.7b** shows that pre-fieldwork many students had opted to seek safety from areas around Goodwill and the hospital, though a small number had opted to stay near the river hurricane shelters. Post fieldwork there was a movement away from the centre to areas nearer the hospital and areas on higher ground and therefore this was well understood.

7.4. A discussion of educational methods, 2016-2018

The importance of education in DRR has been growing in the past 20 years. Yet in that time the emphasis has been on encouraging the development of CCDRR as a unique part of DRR. This has led to advances in the development of psychosocial methods (Peek, 2008), the development of CCDRR in curriculum (Ronan et al, 2016) and the establishment of guidance for integrating CCDRR in the community (Benson and Bugge, 2007, Selby and Kagawa, 2012). However, there are few examples which have effectively established the impact of integrating these methods with student groups over time.

This study tested three such methods outlined by Kagawa and Selby in the UN guidance on CCDRR in education. Until now no studies have looked at the impact of these studies on multiple hazard perception and none have been conducted in a longitudinal context. However, some recent studies (Haynes and Tanner, 2015, Ronan and Towers, 2014; Ronan et al, 2016; Cadag et al 2017, Wilmshurst, 2017, Pfefferbaum, 2018) suggest that a participatory approach has more effective results. Therefore, assessing the educational impact of the session will determine their effectiveness.

7.4.1 Impactful educational approaches to DRE

The choice of educational methods in this study were based on the UNESCO recommendations (UNESCO, 2012, Kagawa and Selby, 2012), for education in disaster risk reduction. All methods chosen were designed to differ from the 'normal' teacher-led class-based approach employed in Dominican schools. The methods chosen were designed to be distinct from each other to be able to understand their impact; an interactive group task, a surrogate learning approach and a field-based decision-making exercise. Impact was determined by measuring using PRISM perception scores about relative hazard risk before and after the session. Looking at mean changes in SHS values in **Figures 7.7-7.10**, despite students not being able to participate in school 3, the other schools showed significant changes in perception scores because of the fieldwork. This is confirmed by **Table 7.9** which shows that the most significant differences in perception were attributed to the fieldwork session, for the geophysical hazards, volcano, and earthquake, with p values of 0.002 and 0.000 in school 1 and 0.023 and 0.05 in school 2. Cohen's d effect scores for school 1 of 0.69 for earthquake and 0.82 for volcanic eruption indicate a significant relationship, despite the relatively small sample sizes. However, one must question the extent to which the fieldwork had an impact on the less well understood hazards because of the experiences that students had regarding Hurricane Maria. Discussions with school staff showed that Hurricane Maria consumed student's thoughts in the months after the disaster up to the fieldwork session in April 2018. This may therefore mean that the fieldwork task was correcting the bias presented by Hurricane Maria. The fieldwork may have simply addressed the lack of local knowledge associated with the potential impact of these hazards. The PRISM vector diagrams in **figures 7.12 (a-c)** show the individual changes in perception associated with the fieldwork for volcanic hazards. Impact of change in perception is clear with most students choosing to move their disk placement towards "self" and by a significant distance. Such movements were not evident in **Figure 7.13 (a-c)** looking at the impact of fieldwork on hurricane hazard or in comparison to session 2 changes shown in **Figure 7.11 (a-b)**. Fieldwork in this case has had the most impact of the sessions in changing perception but has a greater impact on infrequent hazards. It would be valuable to understand the impact of the fieldwork on student learning over time, to determine whether this had a continuing impact on student perception in the time beyond the study session. This ties in with the pedagogic theories of Kolb (1984 & 2005, and Burt and Thompson, 2020) who underline the importance of fieldwork and experience in developing curiosity in learning.

Session 2 did have an impact on student perception. **Tables 7.10 and 7.11** show that there were more changes in SHS placement because of session 2 indicating it had a greater impact on student

perception than session 1. However, session 2 had a variable impact spatially, with school 1 and 2 being impacted greater than school 4 and a limited impact on school 3. Even within each school the impact on the perception of individual hazard was different. In school 1 and 2 it changed a greater number of perceptions of flood and tsunami compared to hurricanes. It seems likely that the likely change on hurricanes would be small as this is a well understood hazard, whereas there is greater remit to change perception of the less frequently occurring hazards. However, these results present a greater problem for DRR educators. The variability of success in impacting student perception of different hazards suggests that different approaches need to be used for different student groups with different hazards. This suggests that the commonly used, one size fits all approach is unlikely to have the same success across all schools. It also suggests that the methods need to challenge the local understanding. A student who is subject to the same hazards repeatedly becomes accustomed to them, and potentially complacent. The benefit of the fieldwork method and decision-making exercise is that it used student understanding in a locally applied context allowing students to make decisions based on new local knowledge. This suggests that DRR programmes need to adopt a local approach to maximise impact in student populations.

7.4.2 The issue of hazard frequency for DRE

Johnston, Ronan and Standring, (2004, 2014) show that student awareness of known hazards, in this case earthquake protocol, was good. However, there was a continuing need for education to address the different types of hazards faced in the community. This study emphasised this point. In Dominica, the hydro-meteorological hazards are more common in frequency. However, student perception does not account for the scale of such events, instead the magnitude framed by the student perception is based on the experience they or their family have experienced. Qualitative comments in **section 5.5 (Tables 5.19-5.23)** support this as direct experience linked to a named event was the most quoted reason for disk placement on the PRISM board. Many of these experiences linked to named storms/hurricanes serve as a reminder of the potential impact. Failure to experience or indeed name past seismic events, coupled with their irregular spatial experience across the island mean that, for example students do not associate with these events in the same way as hydrometeorological. **Figures 7.7-7.10** show the PRISM values taken before and after each teaching session, underlining this point as the hydrometeorological events are often those with the lower PRISM values, therefore perceived more of a risk to the individual. There are isolated cases where earthquake perception was relatively positioned are greater risk, e.g., in school 2 students in April 2016, but this reflects their experience of a seismic event near the island near that time. The

position of tsunami and volcanic perceived risk to students was more often placed with greater distance from 'self' indicating lower perceived risk. However, this does not account for the lack of risk by these hazards. Indeed, a large volcanic eruption in the vicinity of school 1 and 2, where most active volcanoes are located, e.g., PPVC or Morne Watt, would be devastating on a scale not experienced by these students. Equally a tsunami would have a profound impact on all the school students, were they in school, as all of the schools would be in the path of a tsunami were it to make landfall in each location, with the exception of school 3. Visiting the schools and assessing the curriculum confirmed that the only hazard taught in a relatively local context was a hurricane. While geophysical hazards were in the curriculum, for those opting to study geography (on average 27% of students in the schools studied), they were often taught in a generic context with no reference to local situations. This raises the concern that future, large magnitude events would have a significant impact on school students, and communities, as there is no allowance made for this education.

7.4.3 The use of fieldwork and decision making in changing behaviour.

Fieldwork develops a deeper understanding of methodology and data by developing an emotional and intellectual response to the learning, personal to the individual (Kolb, 1984, Guinness, 2012). Burt and Thompson, (2020) suggest that fieldwork develops an inner curiosity to understand the world around us, akin to a survival mechanism, through an inductive process. Our fieldwork teaching exercise was entirely participatory and allowed students to assess their understanding of perceived safety zones in the Roseau area through direct exposure to sites around the area. **Figures 7.11-7.13** are dot distribution maps showing perceived safe areas before and after the fieldwork exercise. Looking at each of the figures, the impact of the fieldwork can be assessed. For flooding, in both cases the post fieldwork site selections were clustered and generally at greater distance from the river. If anything, the fieldwork taught students that they do not need to travel far with a flood, instead congregate at a location which is high enough above the river. No student was located near to the river after the exercise which suggests they improved their understanding. Equally for tsunamis there were less students located near to the river, with the post fieldwork selections at suitable heights above sea level or distances from the coast. For the hurricane, many students opted to locate either at home or in shelters before fieldwork. However, post fieldwork discussions focused on the suitability of some of the shelters close to the river. For this reason, in school 1 students opted to be further from the river, however, in school 2 this message was not as clear. The impact of fieldwork shows students generally locating away from the centre of the valley, which may be an avenue for pyroclastic material, with others opting to get away from Roseau. Many also

recognised that possibly no local site would be safe. These results indicate, for students from school 1 and 2 that the fieldwork had some benefit to their understanding of safe locations. However, it is not possible to determine from this whether student preparation would be improved. Equally, without further study of wider school populations it is difficult to assess whether the impact of fieldwork was just in Roseau or would indeed transfer to other areas? What this exercise underlines is the importance of fieldwork in DRR education for determining locations of safe spaces in their own towns. These exercises are often overlooked through class-based exercises. They also show that DRR preparation needs a variety of tasks in preparing safe spatial awareness, as well as preparing their home, or their reactions to different events. While fieldwork has the obvious problems of safeguarding and teaching training / trip leader training in local geomorphological evidence, it is an overlooked tool in the DRR education and needs to be integrated for all students in their education, not just through Geography lessons.

7.5 Evaluating DRE resources from Session 2.

We have seen that session two had some impact in changing student perception of student. During the session, a surrogate teaching strategy was used (Kagawa and Selby, 2012) showing students a range of resources designed to change their understanding of hazards. This section assesses the student responses in evaluation of the resources used to determine their engagement and use. **Figures 7.18-7.20** show the student evaluations of most engaging resource (**figure 7.18**), their perceived resource with greatest use for DRR (**Figure 7.19**) and their perceived resource with greatest use for community DRR (**figure 7.20**).

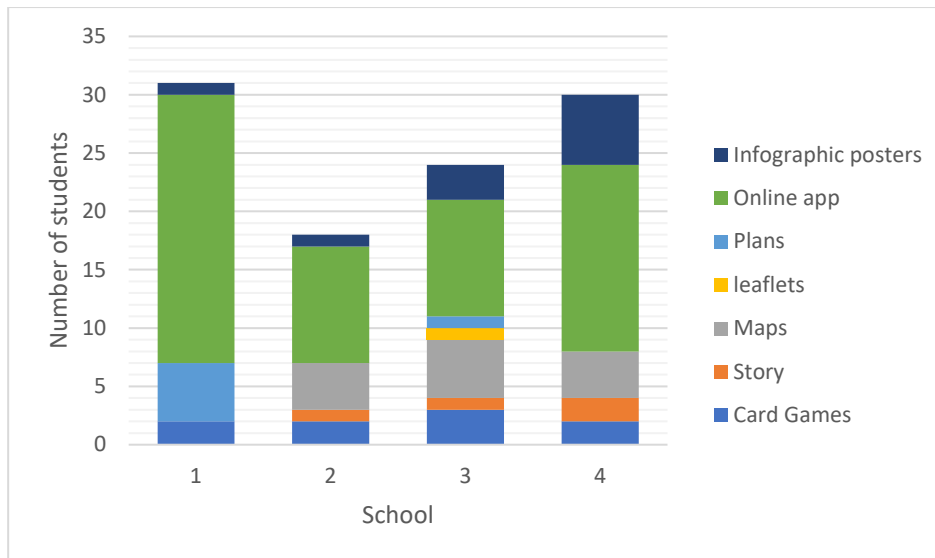


Figure 7. 18 Bar charts showing the student most engaging resources used in session 2 in schools 1-4.

Figure 7.18 shows that the students in all schools enjoyed the use of the online app (game) as a method of learning. Use of (hazard) maps was a consistent favourite among students in schools 2-4 but not so in school 1. Infographic posters were considered engaging by at least one student in all the schools. Traditional leaflets and use of plans did not gauge the student interest in the way that other methods did.

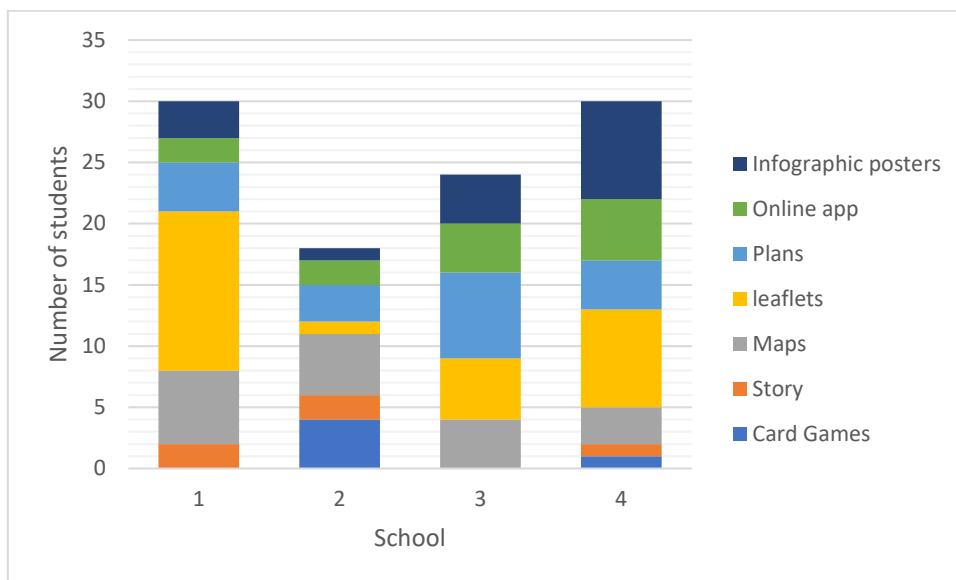


Figure 7. 19 Bar charts showing students (schools 1-4) choice of resource perceived useful for DRR.

Figure 7.19 shows that student choice of resources considered useful for DRR useful had greater variation than the engaging methods. In school 1, 3 and 4 infographic posters and leaflets were the most useful way to learn about a hazard. Disaster plans and maps performed consistently well across all schools. The online app considered most engaging by students was not considered equally useful for learning about a hazard, although it was considered 3rd most useful in school 3 and 4.

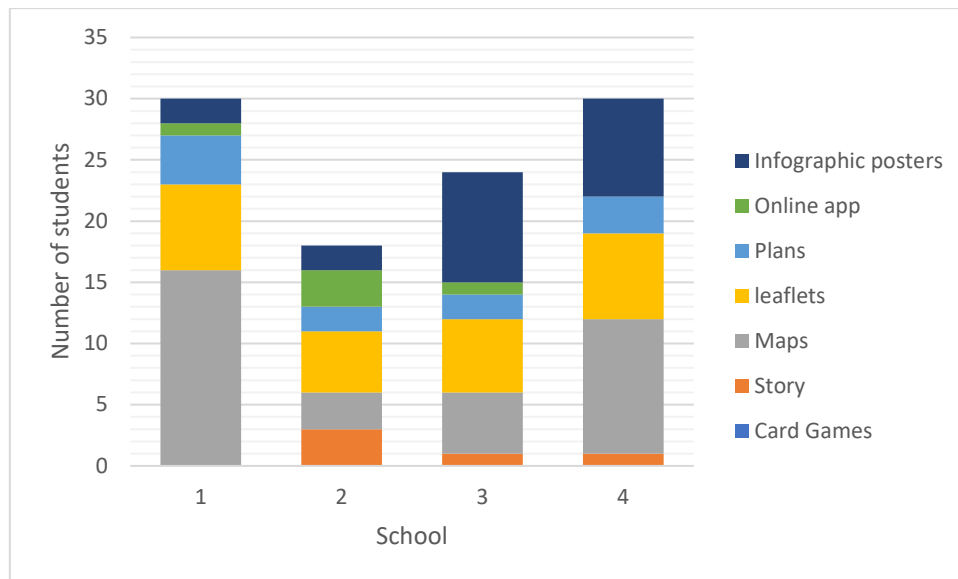


Figure 7. 20 Bar charts showing the resource students perceived useful for DRR in their community.

Figure 7.20 shows that two resources stood out as being most useful for DRR in the community: the use of leaflets and maps. Infographic posters were deemed useful for the community in schools 3 and 4 but less so in school 1 and 2. School 2, a private school, believed their community would gain benefit from online games which may reflect the level of access to technology, yet none of the respondents in school 4, which has mainly indigenous and lower income families, gave online apps as a valuable method. Plans had some benefits across all schools.

7.5.1 Qualitative analysis of DRE resource evaluation from session 2

In addition to the selections made in Figures 7.18-7.20 students were asked to comment on their opinion of each resource as a tool for disaster risk reduction. Figures 7.21-7.24 show tree plan diagrams designed to reflect the student perceptions of the resources for use in DRR, after session 2. Student comments were coded, and categorised and figures 7.21-7.24 represent these opinions. Students were able to offer more than one comment as they were asked to complete the evaluation for each resource, hence the total number varies for each resource. Figures 7.21-7.24 show the number of responses within a category by area and value given in each box represents the percentage of students who gave that response from each school. The number given in each corner of a coloured box represents the resource number:

- 1 - Card Games (Top Trump volcano cards and disaster game)
- 2 – Story book about tsunami and earthquake hazards
- 3 – Hazard maps showing spatial variation in risk for multiple hazards
- 4 – Hazard leaflets used by the Office of Disaster Management in Dominica
- 5 – Multi – hazard disaster plans produced by the Red Cross Dominica.
- 6 – Earth girl app – online application designed to scenario plan earthquake and tsunami risk
- 7 – Infographic posters designed to inform people about spatial risk associated with a named hazard

Figures 7.21-7.24 show tree diagrams summarising student evaluations of resources in session 2 in schools 1-4. Each of the resources is represented by a colour (and number). The size of each box represents the relative importance of the reason.

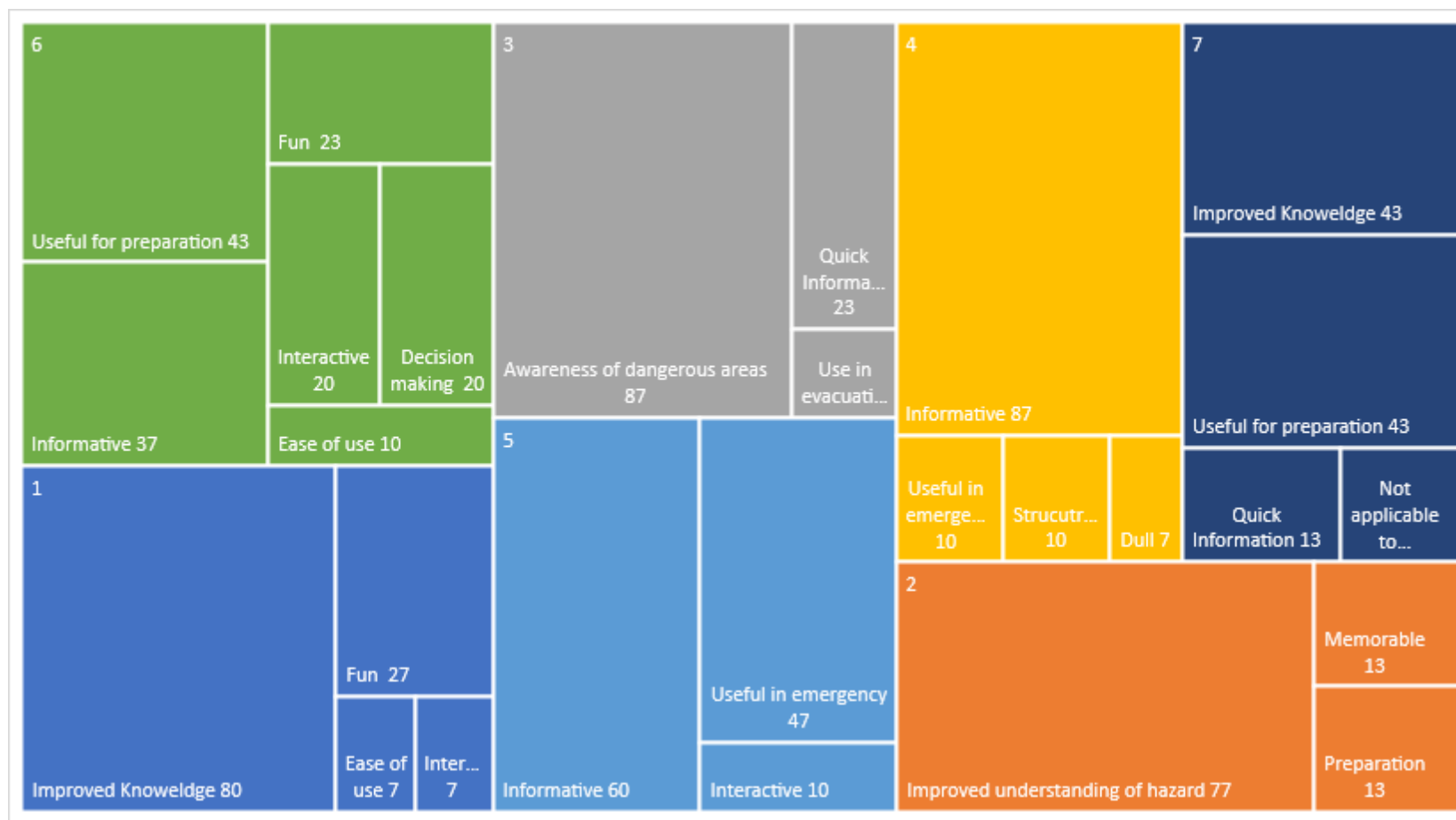


Figure 7. 21 Tree diagram showing the percentage of themed responses in resources evaluation after session 2, at School 1.

(Numbered boxes 1-7 are represented by the following resources key– 1 Card Games, 2- Story Book, 3 Hazard maps, 4 – Hazard leaflets, 5 – multi-hazard disaster plans, 6 - Earth girl app , 7) Infographic posters).

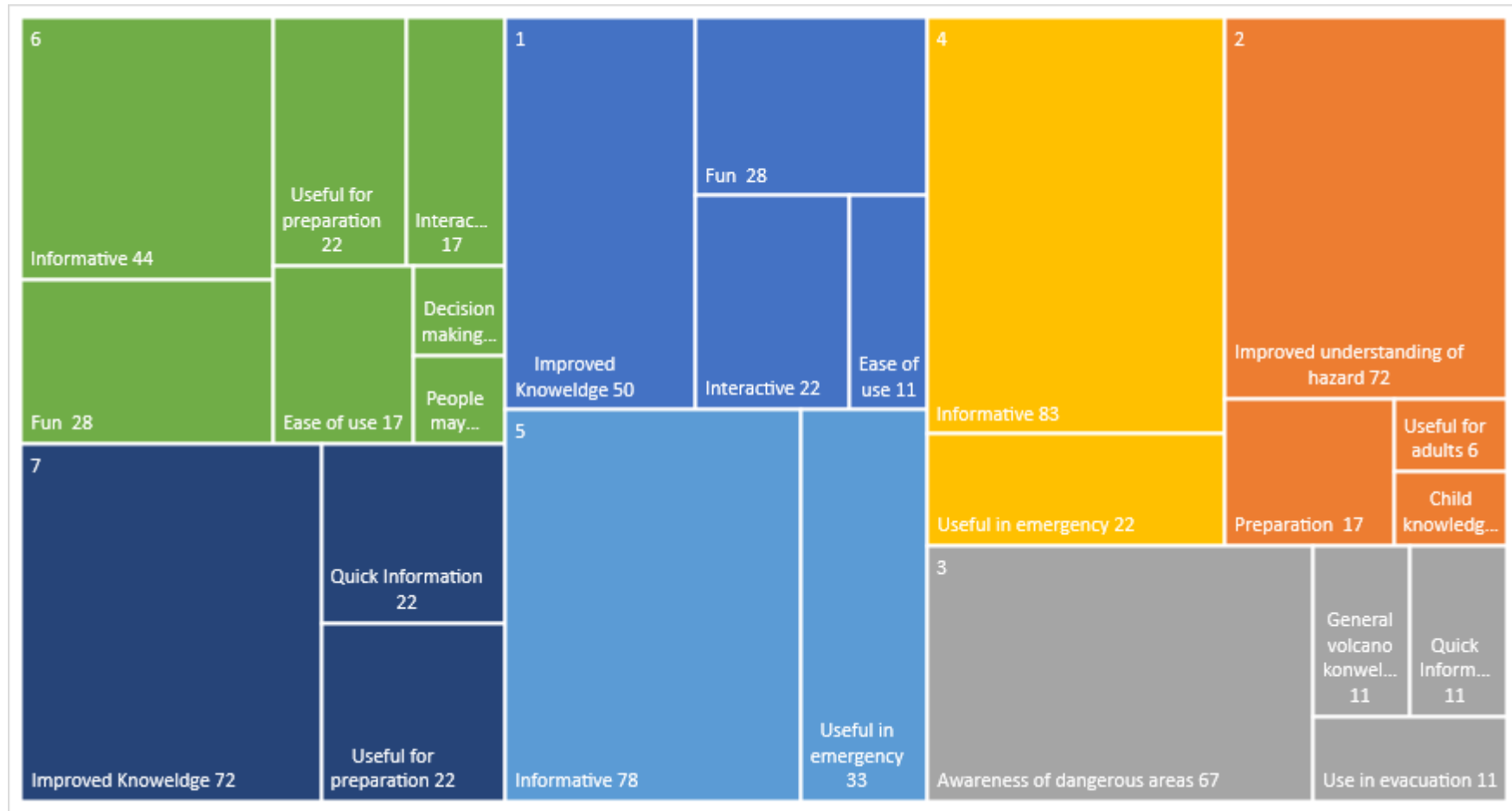


Figure 7. 22 Tree diagram showing the percentage of themed responses in resources evaluation after session 2, at School

(Numbered boxes 1-7 are represented by the following resources key– 1 Card Games, 2- Story Book, 3 Hazard maps, 4 – Hazard leaflets, 5 – multi-hazard disaster plans, 6 - Earth girl app , 7) Infographic posters)

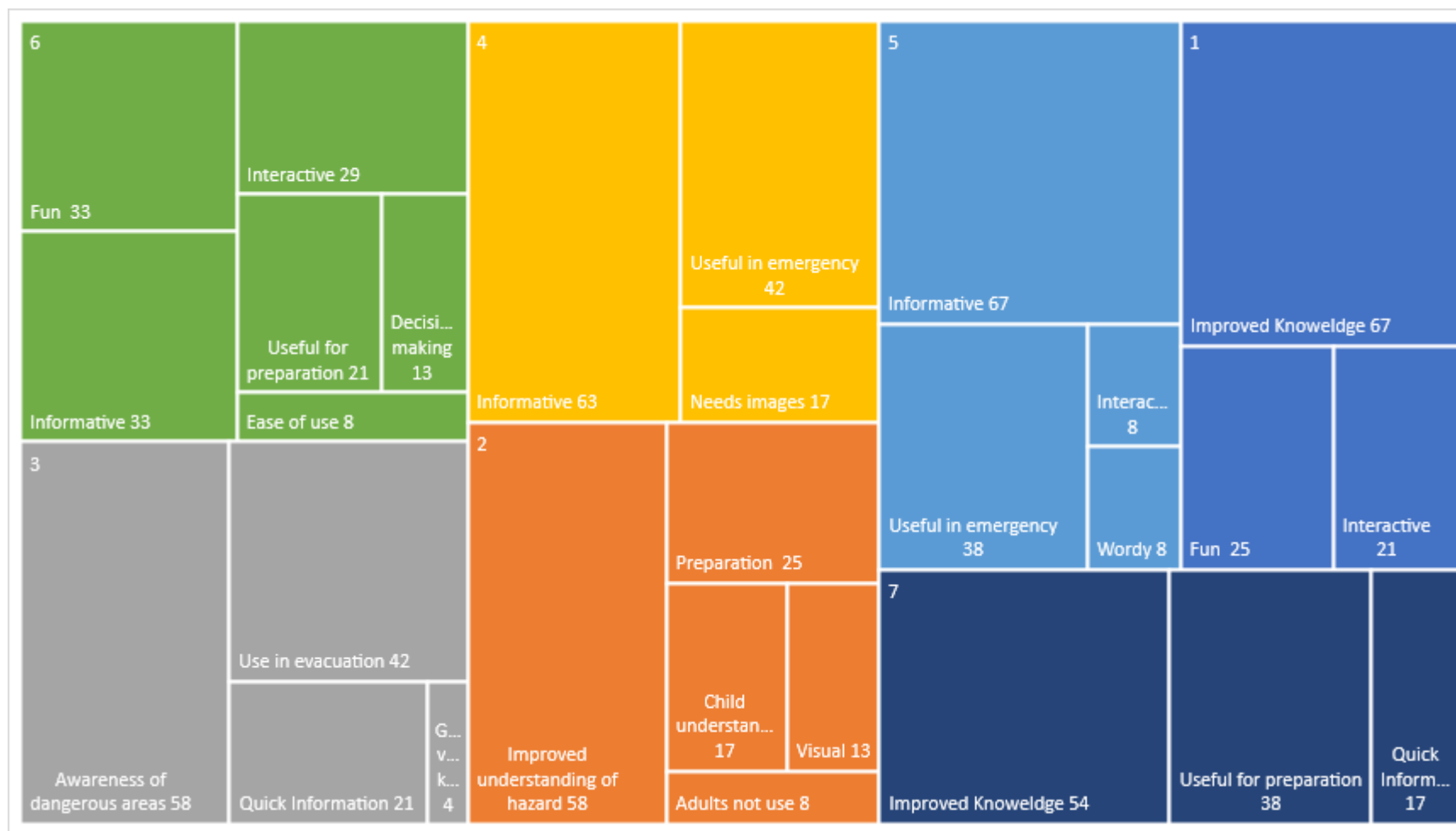


Figure 7. 23 Tree diagram showing the percentage of themed responses in resources evaluation after session 2, at School 3.

(Numbered boxes 1-7 are represented by the following resources key– 1 Card Games, 2- Story Book, 3 Hazard maps, 4 – Hazard leaflets, 5 – multi-hazard disaster plans, 6 - Earth girl app , 7) Infographic posters).

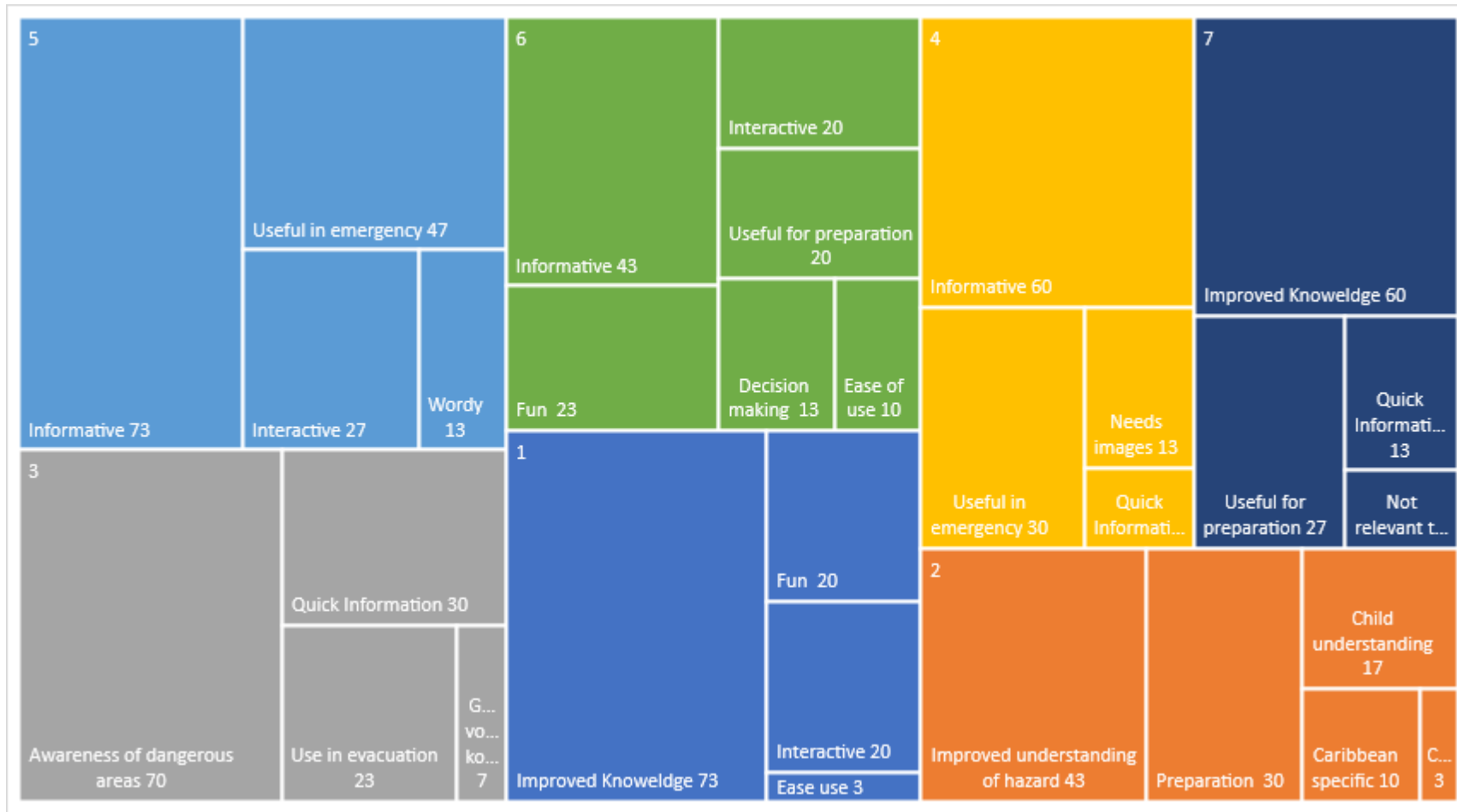


Figure 7. 24 Tree diagram showing the percentage of themed responses in resources evaluation after session 2, at School 4.

(Numbered boxes 1-7 are represented by the following resources key– 1 Card Games, 2- Story Book, 3 Hazard maps, 4 – Hazard leaflets, 5 – multi-hazard disaster plans, 6 - Earth girl app , 7) Infographic posters).

7.5.2 Quantitative analysis of DRE resource evaluation

Figures 7.21-7.24 show the reasons (%) given by students, within a given school, in their evaluation of the resources as a tool for learning about the hazard in the context of Disaster Risk Reduction. The following is a summary of these findings by resource:

Resource 1 – Card Games (Top Trump volcano cards and Disaster Game).

Students across the 4 schools commented overwhelmingly that this method improved knowledge. In school 1 80% of students gave this reason while the least citing this reason as school 2 on 50%. The next most popular comment on this was how fun this method of learning was with between 20-25% of students commenting on this across the 4 schools.

Resource 2 – Story of Earthquake and tsunami in Caribbean (CDEMA)

The most cited comment for this resource was the improvement in understanding of the hazards featured in the story. School 1 and 2, 77% and 70% respectively commented on the information. Whereas only 58% of students in school 3 and 43% of students in school 4 commented on this. In all schools, between 13-30% of students commented on the use of this resource as a tool for hazard preparation. In school 3 and 4 17% of students felt this was a more appropriate resource to help children learn, though 2 students in school 3 commented that adults may not use the story as a tool to prepare. 10% of students in school 4 commented that this was appropriate as it was Caribbean focused and 13% of students in school 3 felt that it was beneficial because it was visual.

Resource 3 – Hazard / Geology Maps of Dominica.

The overwhelming feeling across the 4 schools was that this resource gave an improved spatial awareness of the locations which were safe (58-87%). Students felt that the information provided was “*quick*”, enabling a ready visual representation of risk level in each area. They also commented that this could be useful for evacuation purposes (11-42%).

Resource 4 – Leaflets about different hazards (ODM).

Students believed that this resource was useful for “*information*” (60-87%) and would be purposeful in an emergency. However, there were a significant minority of students, particularly in school 3 and 4 who felt that the leaflets were “*too wordy*” or “*lacked enough pictures*”. Two students in school 1 even commented that the leaflets were “*dull*”. Though three students in school 1 felt that the information presented in the leaflets was structured in a useful way.

Resource 5 – Disaster Plans (Red Cross)

The majority in each school (60-73%) felt that these plans were informative and could be very useful as a checklist in an emergency. Students in three of the schools commented that these were interactive resources and could be used with the family group. However, students in school 3 and 4 felt that this resource was wordy and needed a greater balance of images to make it more appealing.

Resource 6 – Earth girl game (tsunami / earthquake hazard simulation)

Students across all schools gave the widest number of comments for this resource. The key reasons given were that it was “fun” or “interactive” and therefore engaging. Students felt that through the simulations they could learn about the hazard and therefore it served as an alternative way to learn information. In this context they thought it was useful as a tool in an emergency, as they could learn from it. However, a small minority questioned the applicability to real-life situations. Though in school 1,3 and 4 between 13-20% of students felt this was a great tool to help them make decisions.

Resource 7 – Infographic posters (of volcanic and landslide risk – USGS)

This resource produced similar results to the hazard maps (resource 3). Most students in all schools commented that this resource was informative and showed where the hazard could impact. Some (13-27%) commented that this could therefore be used in emergency situations. Between 13-22% of students in all schools like quick access to information, with one student in school commenting that “these would work well as posters in villages”.

7.5.3 Qualitative analysis of decision making.

School 1 – a variety of reasons were given for the placement of safe zones for hurricanes, in a time recently post Hurricane Maria. 38% of students commented that they should locate away from the Roseau River, while 31% suggested a location away from the coast. 24% of student’s commented that the location chosen was safe in Hurricane Maria therefore would be a safe location for the future. Though 23% of students suggested “higher ground”, though this was not clearly distinguished and may have been about an elevated area of the island or away from rivers or the coast.

For the flood risk 54% of students justified their choice of position away from the water or the river while 58% justified their choice as being on higher ground. 23% of student’s commented that location away from the sea would be best for less flooding, while 24% of students commented that their choice of area had not historically flooded, therefore, would be a suitable choice.

For volcanic risk 54% of students commented that their selection of site was away from their perception of the volcano. However, many of these sites were in areas that were geographically distant, and they had not accounted for previous deposits. 15% of students commented that higher ground around Roseau would be suitable to be safe from volcanic eruptions, with only 4% giving the reason that they were away from the interior of the island or away from *"lava' deposits"*.

Tsunami risk was collectively understood by students with the majority (88%) giving higher ground as their reason for placement and 38% specifically mentioning being far from the coast.

12% of students mentioned that Roseau was not safe from the effects of any hurricane, while one student within the group understood that Roseau was not safe from pyroclastic flows.

School 2 - The reasons for perceived safety were more wide ranging in school 2. For hurricane safety zones, students gave a variety of reasons. 25% of students commented that locating in existing shelters was safest due to their solid construction, while the same number opted to locate away from water or in a high location away from runoff.

For flood risk, 85% of students opted for higher ground, with 15% suggesting that their choice was *"far enough"* away from the river or that they should be *"on a slope so that water runs off"*. One student commented that they *"should not locate on a slope due to the threat of landslides"* with another suggesting they should *"locate away from a steep valley"*.

Volcanic risk safe zones gave a range of reasons for safety. 40% commented that their location was in a place where the volcano could not reach, while 30% located near the coast so they could evacuate. 10% of students opted for locations which were *"higher"* to be away from the effects of the eruptions, while another 10% of students commented that they needed to be out of the valley *"away from the lava"*. One student mentioned that *"Roseau had no volcanoes"*.

Like school 1, there was greater agreement over the tsunami risk. 95% of students commented that their decision to locate was on higher ground, with 10% commenting that they were away from the coast. One student opted to stay in their own house believing that it would be safe from a tsunami.

15% of students in school 2 commented that anywhere near the river (e.g., near Bath Estate) was not safe, while 20% of students suggested that nowhere in Roseau was safe from a volcanic eruption. 15% of students also made the recognition that existing shelters near the river became flooded after Hurricane Maria.

7.6 A discussion of effective DRE resources.

After the 2005 World Conference on DRR in Kobe, there has been an increase in efforts to produce new resources for use with students, e.g., textbooks, games, and websites. However, few of these approaches have been systematically conceived or scientifically evaluated. There has been therefore little study of the effectiveness of such material for use in DRR. Often these are produced by scientific experts, field practitioners, non-governmental organisations, or internal organisations, with little consultation with educational specialists. As such, little thought is spent on the usefulness of the information produced and the context in which it will be used, with little account for variation in learning style, pedagogic approach, or audience. Instead, such resources are designed to build knowledge of disasters, reduce risk, or develop risk capacity. Petal, (2008) outlines the importance of three key areas for resource development for DRR education. Firstly, understanding should derive from a range of stakeholders and experience but ultimately be relevant to local people. Secondly, limit the academic vocabulary, simplify visuals, and plan a sequential approach using positive outcomes as examples of practice. This will allow the user, the student, to assess evidence and make balanced judgements, while encouraging parent to child communication. Lastly, she outlines the need for fun. Few studies have been made into specific examples of resources as there are few academics with the pedagogical knowledge, scientific understanding, and locational knowledge to understand what is relevant for a given group of students. This is where longitudinal studies have their advantage as researchers can work with and adapt to the intended audience. As an academic researcher and educator of 20 years it has been possible to devise a programme of education which has touched upon these principles. The second teaching phase enabled students to assess a series of existing DRR educational resources designed to improve student understanding of a range of hazards relevant to the Caribbean region and Dominica. **Figures 7.18-7.20** show the disparity in student opinion between what was essentially engaging and what was useful. Computer based applications, such as Earth girl, used to improve student understanding of tsunami risk, were considered most engaging. Despite this, leaflets, infographic posters and use of plans were chosen as useful for learning about hazards in Dominica. However, there was variation in the opinion of engaging and usefulness across the different school locations. These results highlight the challenge for the creators of resources; how relevant are they to the local audience? School 4 and school 3 students come from rural settings, where internet availability may be irregular, or where family connections and community bonds are stronger. Therefore, popularity of storytelling is considered more important, whereas in urban settings such an approach may be considered childish and therefore not used within the community. Equally engaging the community using infographic hazard maps or plans are considered more important in communities with

active disaster and village councils compared to students in urban areas who are inclined to follow government guidance. This underpins the challenge for development of educational resources and educational approach – it needs to be different across geographical areas. Resources made in university campuses’ away from the desired target have generic appeal. However, there is a need for local scale input which has a locally relevant bespoke design, is engaging and accommodates a range of learning needs. This study underlined this need and agreed with Petal, (2008) that resources need to be simple, visual, engaging, fun but locally relevant. Student comments in **Figures 7.21-7.24** highlight how our choice of resource covered a range of these needs but varied dependent on location and circumstance, for example the students commenting that the Hazard map of Dominica could be useful for evacuation purpose, or that infographic posters would serve a good visual on community notice boards. It is clear that no one resource holds the key to being effective as it is dependent on purpose and situation. However, using the example of WASH, that several measures which promote the same message is clear to help change behaviour (Gautam et al, 2017)

7.7 Qualitative assessment of education in Dominica since Hurricane Maria

This section assesses the impact of Hurricane Maria on the educational system in Dominica. The hurricane had a large impact on the education of students. The following analysis reflects leading figures within schools (principals) and government as well as the views of those brought into help improve the educational response to hazards in Dominica after Maria.

Schools were shut on the Monday before Maria hit. Reopening occurred for *“some schools reopened in late October with students back in November, but some schools still had families staying in them (as shelters)” (government official)*. While this was the initial reopening, normality did not return until April in 2018 for many students, as staggered return meant that the whole school opening was delayed. Staff commented that *“students were not helped by our teaching of hazard prior to the event”*. They also noted *“schools suffered damage to roofs and structural damage” (school principal)* as well as fluctuations in numbers on roll as some had left the island. Despite this one principal noted *“we allowed students from other schools to temporarily register” (school principal)* allowing access to education. In the immediate return with the help of international NGOs UNICEF and IsraAid *“the ministry organised 3 days of non-teaching when students returned as psycho-social support” (school teacher)* so that students received coping mechanisms to deal with their experiences.

Since reopening the government has worked with IsraAid and UNICEF to improve the access to DRR in education. Officials from these groups noted *“we organised a pilot scheme in schools to get students to*

assess the impact of natural hazards in their school". School principals noted that this involved face-to-face training involving both staff and students. As a result of this *"schools had to complete a DRR booklet and submit – all 73 schools must do this....to assess their own vulnerabilities"* (government official). NGO officials noted that *"we aim to come up with tailor made (DRR) scenarios for each school"* through *"school staff developing DRR with children, creating (a) student led initiative"*.

The NGO aim was to *"develop DRR in education through either "infusion" or by adding another topic (subject) in the curriculum"*, with students having *"engage(ment) at 3 times in their education, at 3-5 years, 4th grade and 3rd form"*. While these changes have yet not been enacted it will be interesting to see how teachers, who lack formal subject training, cope with either of these approaches, especially as neither NGO will be on the island to see the end of the scheme they have started. An initial interest was cited by the government, but the measure will be the long-term sustainability of the scheme. While other NGOs on the island maintain that at present, *"they do not have direct plans in schools for DRR"*.

7.8 A summary of messages about DRE education in Dominica.

This study has highlighted the importance of education in preparing a population for impending disasters. The educational system in Dominica allows college trained graduates to enter the teaching profession without a university education or postgraduate teaching qualification. The school day is one inherited from post-David society after 1979 in which students in state educated institutions study between 8am-1pm. In this framework students follow a state organised curriculum which until 2018 had no specific requirement to teach about natural hazards in Dominica. Students would study social studies in form 1-3 and if they selected Geography as a CSEC subject they may cover the impact of natural hazards in generic form. Schools varied in their approach to this application and some interested staff would develop this into the curriculum. The limited input from the Office of Disaster Management, the Red Cross and local emergency services meant that regular DRR input was rare and dependent on local enthusiastic teachers. Small scale governmental approaches such as the *"Tsunami smart"* scheme was piloted in schools in a bid to develop a bottom-up educational culture towards hazards, however these were not sustained. Schools bore the brunt after Hurricane Maria. Some used as shelters were out of action for months after the event and others were damaged resulting in reduced capacity for students. Although education resumed within two months in the most progressive schools for exam classes, many were without full time education until April 2018. Teachers became psychologists to help with the return of students, while principals were continually pressured to reopen

schools. On reflection some teaching staff believed that the education system had not prepared the students for Hurricane Maria. The situation since Maria has seen IsraAid and UNICEF have worked with the Ministry of Education to develop a scheme to help them achieve what Hart, (1999) proposed as the fundamental for success in DRR education, a student-centred approach. As of late 2018 IsraAid had succeeded in setting up vulnerability assessments and providing training to staff which would be disseminated to school students. Plans to introduce DRR into the curriculum either as a taught subject, or through cross curricular studies were suggested, with the aim of developing a student-centred approach (Benson and Bugge, 2007, Peek, 2018). However, the ongoing problem with NGO initiatives in SIDS is the lack of sustainable support to ensure that the scheme is a success. As of 2020 (Scotland, 2020, pers. comm) this scheme has not developed beyond the vulnerability assessments set up in the 2018-2019 academic year. In Dominica there is still a need to change the culture associated with DRR education to develop the student-centred approach outlined by numerous past studies (Benson and Bugge, 2007; Duffy 2014; Ronan et al, 2016; and Amri et al 2017). This programme needs not only to develop frequent DRR inputs into the curriculum but needs to develop a local perspective which engages with the community, which needs to come from government, but implemented at a local scale. This study does not attempt to outline a framework for educational change in Dominica, but it underlines the importance of approach to engaging students in a bespoke DRR curriculum. Government should seek to develop a DRR education curriculum with those who have experience of education and teaching, rather than just those who work in disaster risk response.

Chapter 8: Recommendations and conclusions

This chapter addresses some of the key achievement of this study and identifies areas for future development. The focus of these future recommendations is broken down into three parts i) using PRISM and ii) improving DRE. This is followed by the conclusions of the study.

8.1 Recommendations for future research (PRISM)

8.1.1 Improving the use of PRISM for risk perception.

Risk perception can be measured both qualitatively and quantitatively with differing merits(Sjoberg, 2000). Qualitatively it seeks to understand a subjective assessment of negative uncertainty (Sjoberg 2009) but quantitatively it measures probability, for example, an earthquake of a magnitude will have probability of 1 in 10-year return. Using a quantitative approach it is possible to scale the likely risk return from low to high. PRISM data quantifies the risk level based on the SHS measurements on a scale from 0-27.5. Calculation of risk can be quantified by experts to provide likely scenarios for a given return period.

While this study has provided one of the first longitudinal studies of student risk perception and compared them to local expert perceptions the design of the PRISM board may be further improved accounting for probabilistic risk. This would require constant reassessment by local experts to account for temporal changes in risk. **Figure 8.1** is a revised version of the PRISM board to include zones to represent the frequency of hazard risk. The inclusion of zones would allow users of the board to categorise their disk placement based on their perception of frequency. This would help ensure that disk placement is standardised on the board for all users. This approach may allow for improved consistency between users based on their relative perceptions of risk.

This revised version of the PRISM board (**Figure 8.1**) would indicate to respondents' levels of risk allowing consistency in disk placement tests by inter-rater reliability tests. This could be compared with the existing results from SHS disk placement to determine the extent to which respondents see the likelihood of frequency and return.

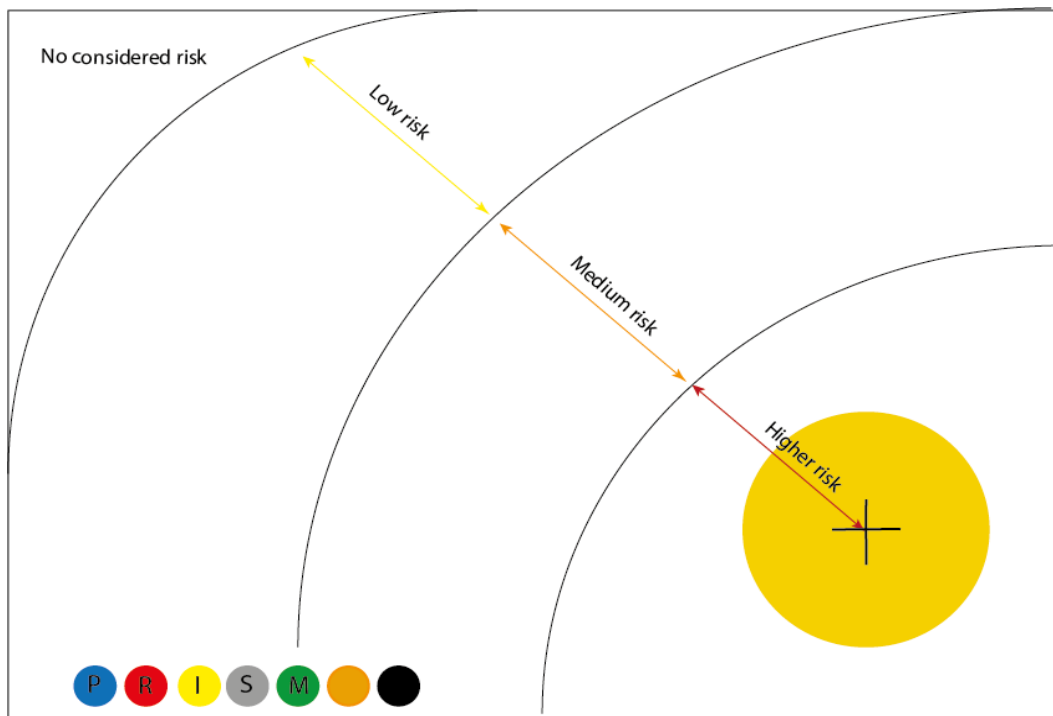


Figure 8. 1 Proposed alterations to the PRISM board.

8.1.2 Use of the SHS distance values?

In this study we have taken the SHS distance to represent a metaphor for risk. The greater the distance from self, the lower the perceived risk. This has shown itself to be a valuable tool and allows for a relative scaled approach in understanding multi-hazard risk as it allows for direct comparison between risks, unlike traditional tools i.e., Likert scale modelling, which can act in isolation. The representation of risk, however, could be considered problematic because an increase in SHS value results in a decreased perceived risk which can confuse the user (although it did not during the study). Using reciprocal values to show SHS distance would give smaller values for lower risk and would allow for greater risks to have higher values. **Table 8.1** shows an example of the respondents PRISM SHS values.

Table 8. 1 A comparison of SHS values with reciprocal values to show perceived risk for hazards.

Respondent	Hurricane	Flood	EQ	VE	Landslide	Tsunami
SHS score	3.6	3.1	7.9	6.6	4.8	19.3
Reciprocal	27.8	32.3	12.7	15.2	20.8	5.2

Calculating the reciprocal using $1/n * 100$ gives a score which reflects the level of perceived risk. Flood values show a higher score of 32.3, which allows for an easier understanding of increased and decreased

perceived risk. Reciprocal values would therefore scale from 100-3.63. One consideration would be for values under 1. A reciprocal of 1 SHS would be equal to 100, yet a reciprocal of 0.5 would be 200. Below SHS scores would exponentially rise, creating difficulty for graphical plotting. Therefore, one solution to this would be to define fixed boundaries for PRISM score calculations so that any score between 0.1-0.99 is rounded up to 1. Using this would make the concept of SHS scores easier for the public to understand.

One other consideration for the use of SHS values is to improve the understanding of how the data is scaled. It is assumed that the SHS values follow a linear scale, like Likert scale modelling. How can one be sure that in a Likert scale from 1-5 that the difference between 1 or 2 is the same as 3 or 4. Or is 2 twice 1? The use of this scale assumes linearity. Equally, with PRISM, how can one be sure that disks placed closer to self-have a greater meaning than those placed further away. Does a PRISM SHS score of 1 represent 1/10 of the risk of a PRISM SHS score of 10? Equally if a student moves a disk placed closer to self by 2cm, will this distance have a greater significance than a 2cm movement of a disk placed towards the edge of the board? Buchi et al, (2002) discuss the nature of 'SIS' PRISM data to determine whether PRISM distance values increase arithmetically or logarithmically. To test whether this is the case testing the SHS raw data using a logarithmic scale may help determine this. SHS data could be recalculated to analyse the pattern using a logarithmic scale. Using $(SHS + 1)_{\log}$ would give a value placed close to the self-marker with a lower score e.g., $SHS 0.6 = 0.204$. However, a disk placed at SHS 6 would give a log score of 0.845, increasing at a lower rate. Further study applying this approach would allow for an improved understanding of how the data is scaled. Although the current value of the PRISM method is the combination of the quantitative values with qualitative values, helping understand the justification of disk placement, which again allows for both relative comparison and explanation unlike Likert scale modelling.

8.1.3 Revised shape of the PRISM board

PRISM technique has shown that it can assess perceptions of an individual or a group accounting for the influence of multiple factors on the board. The findings in this study suggest that a large proportion of participants use the long axis space rather than the vertical or horizontal axis, from self. This calls into question the extent that people account for the angle from self. It also questions whether participants use this technique as a linear scale bar. The evidence from this study does not support the second assertion. However, to understand the dynamics of the PRISM board would be of use in further research. Firstly, the shape of the PRISM board could be further tested to test the significance of the angular position (Sensky, 2013, Sensky and Buchi, 2016) shown in **figure 8.2**.

One proposal is to test an arcuate shaped board (as in Figure 8.1). This new board will eliminate the tendency for respondents to place their disks along the diagonal axis. The arc will have a longer diagonal axis, with a shortest vertical perpendicular axis. This will determine whether angle 'self' is a consideration in disk placement, without the visual bias of the long diagonal. Therefore, eliminating the varying length on the board will enable the researcher to concentrate on the extent to which angle is significant.

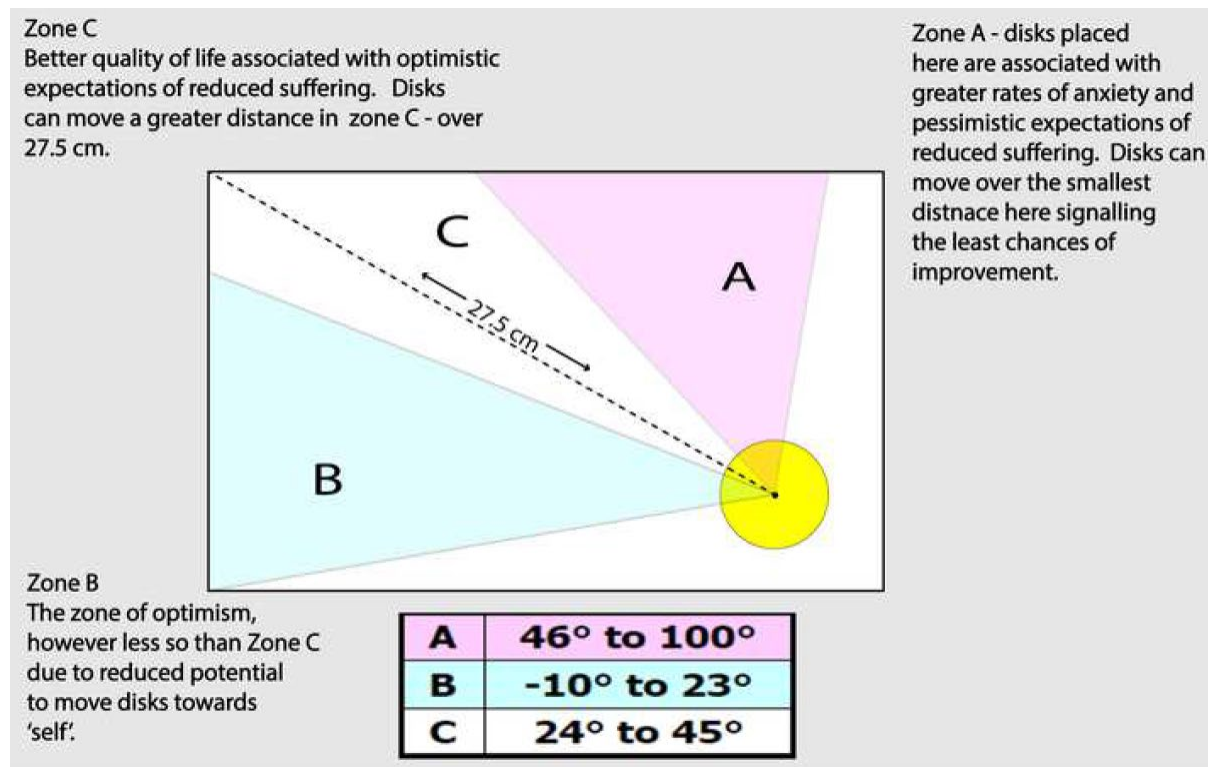


Figure 8. 2 Suggested link between angle and psychological state of respondent (after Sensky and Buchi, 1999, 2016)

Additionally, to test this, in the questionnaire section of the survey, respondents will be asked 'how they feel' about the position of each disk, in addition to asking why a disk was placed in a particular place. This should reinforce the potential link between board position and psychological perspective of the disk placement.

8.1.4 Technological developments in PRISM.

While the use of PRISM has shown itself to be an effective and accepted tool to measure risk perception, the use of magnetic boards and paper (and stickers) to conduct the study is cumbersome. Sensky, (2013) shows the development of an app called iPRISM to track movements linked to perceived suffering. This method provides a basis for an app which could be developed to measure risk perception.

To validate this application for use in risk perception studies the following recommendations are made:

- This would need to have moveable disks.
- SHS values automatically calculated along with angles.
- A recording package to capture respondents' viewpoints.
- A time series marker which captures disk placements, time between disk placements (to test whether thinking time is less with known risks?)
- A supporting database which allows for the capture of SHS values, angular data.
- Security features to ensure that data is anonymised and encrypted to store personal data.
- The ability for respondents to conduct successive exercises.
- The ability for the programme to remember an individual (through an account login) for longitudinal surveys.
- Open-access software application which can be used on mobile phones and allow for a citizen science approach.
- Organisation of the data in a format readily accessible to existing statistical packages such as SPSS for ease of analysis.

During this study collaborative work has taken place with the computer science department at the University of Portsmouth however, further work is needed. The use of a computer-based format would alleviate the need to conduct timely post exercise measurements and improve the accuracy of placement. It would allow studies to be conducted with increasing regularity after initial use, or independently. This study has provided a longitudinal perception of multi hazards which has not been achieved by other studies before. However, a computerised approach would allow for more regular risk input and create a detailed time-series of risk were it available as a mobile application.

8.2 Recommendations for future research (improving education and DRE)

8.2.1 Improvements in student sampling and sizes and controls

This study was one of the first in risk perception to conduct a 5-year longitudinal study of changing student risk perception, relative to disastrous events. The nature of this timeframe meant that student sign up was dependent on participant agreement to be part of the entire study. Schools acted as a focal point for this study allowing repeated contact with the same group of students. However, the study was restricted to small samples based on the impositions placed locally by the Ministry of Education and school principals. This meant that the student sample reflected between 31%-100% of a cohort within a given school, affecting the ability to conduct reliable control groups. Conducting PRISM surveys with

two simultaneous groups would allow for direct comparison between the use of teaching approaches. While some attempt to differentiate between respondents who studied Geography and those who did not were made in 4th and 5th form scores, further study could consolidate the initial results gained in this study with two major focuses:

- I. To what extent do the students who study geography have a clearer perception of the perceived risk compared to those that do not. Conducting this across an entire student cohort would give more representation and show the extent to which local teaching needs to better meet the needs of DRR education.
- II. To what extent do teaching methods on disaster risk reduction compare with those who are not given that teaching. This approach could be conducted ethically so that all students have basic input from outside speakers or organisations. However, while one group would receive no further information the second group would have specific disaster risk reduction lessons. This approach could be conducted during a week per year over 3-4-year period to determine the extent of the differences.

These approaches could be conducted simultaneously across schools across a geographical area (to include other Caribbean islands or SIDS) to assess the impact of DRR education and resourcing further.

8.2.2 Development of student understanding of risk

The longitudinal nature of this study allowed for an insight into student understanding of risk and the links between them. This is valuable information which enables identification of student gaps in understanding. For example, after 2017, students from School 1 showed an intensification of perception of hurricanes, and flooding however, not landslides despite the link between these hazards. The same students, after 2017 show a decreased perception of risk for both volcanic eruptions and earthquakes, but not tsunami, a secondary hazard linked to the former. These examples are not, however, consistent for all school students. For example, in School 3 students, after 2017 recognised an intensification in the hurricane hazard. In this case the pattern for flood and landslide mirrored the change in hurricane perception. This indicates variability in understanding between the primary and secondary hazard, despite the recognition by students that hurricane, flood and landslide events occurred simultaneously.

Further study could take place to understand the extent of linked understanding between hazard risks. A control group could be taught about local hazards in a standard way, while another group could be taught a session which specifically gives insight into the links between groups of hazards, while a third group could experience these links in the field. After each session, students would be asked to revisit

their original PRISM placements. They would also be asked to complete a story to explain the impacts of a large event. This task would give the students the opportunity to report back their understanding of the links between the hazards.

8.2.3 Educational DRR

Research funding creates a need to understand impact so that studies justify their worth. Educational DRR requires teaching. The delivery of the message is important, in that the same message can be delivered differently. It is important for educators to understand pedagogical theories to be able to adapt their style to the audience. This study was unique in that it explicitly used educational pedagogy to formulate teaching approaches to improve awareness in a context of DRR. However, this study identified that DRE could be inconsistently delivered if the educator has little experience within a classroom or community, or by an NGO officer who may not have educational experiences. Therefore, those responsible for delivering DRE need interaction with teaching professionals to understand the audience, and therefore should adapt their delivery to match. The resources used in delivering the DRR message are produced by experts, organisations. These are designed for repeated use. Rarely are resources designed for the specific location in which the DRR education is delivered. Equally there is limited quantitative assessment of whether the resource is fit for task. This study has shown that effective resourcing can have an impact on the student awareness of local hazards. Further research needs to take place to determine the extent to which resources are financially viable and reach the audience. This is possible with online resourcing which can assess the number of visits. However, the effectiveness of DRR resources needs assessment to determine whether they are useful for their intent.

There is a great amount of academic focus on studying hazards and disaster risk but considering this there is a disjointed and limited effort in targeting improving the school student awareness of localised disaster risk reduction. This study has set a standard in promoting the need for longitudinal data sets to appreciate the temporal nature of disaster risk perception. It has also provided an alternative method, PRISM, which would be viable for use with school students and allow for a consistent approach between locations or within populations. This study has also highlighted the need for a conjoined approach to improving DRE in educational institutions and has set out to understand how effective different approaches among different student groups. This could provide great value for collaboration on effective DRE and set the basis for making disaster risk education an important inclusion in future DRR frameworks.

8.3 – Conclusions

The HFA and SFA (UN 2005, 2015) set targets to promote DRR to reduce the impact of disaster risk on vulnerable populations. The Sendai framework aimed to promote an understanding in disaster risk; to strengthen disaster risk governance; to invest in DRR for resilience and to enhance disaster preparedness. This involved accounting for local and specific characteristics of disaster risk and engaging all of society in multi-hazard environments. Understanding the difference between perception of experts and laypeople to calculate the disparity helps develop gaps in understanding and awareness and devise appropriate measures to promote resilience in the population. This is important at a time when global climate change, with a rise of 1.5°C-2°C could trigger climate related disasters and increase the existing 4 billion people that live in areas of water stress (World Bank, 2019).

The Caribbean, made up of several SIDS, is a vulnerable region subject to increased climate hazards. The region could be subject to adverse impacts on agriculture, infrastructure, and tourism with the increasing likelihood of more frequent tropical cyclones in a world with 2°C increase in temperature (World Bank, 2014). These countries often lack the resources to tackle global scale problems and need greater inter-island co-operation (Kelman, 2010).

Dominica, one of the Windward Islands in the East Caribbean is a vulnerable country. The IMF reports that between 1980 and 2017 Dominica is the 4th most vulnerable Caribbean country (CRRP, 2020). It is the only Caribbean country with a significant population of the indigenous Kalinago people. Since 2015 it has been impacted by Tropical Storm Erika and Hurricane Maria which cost Dominica 90% and 226% of its GDP (CRRF 2020). It is projected that Dominica will be subject to 1.0°C-3.5°C heating, 30% reduction in rainfall events, an increase in wind speeds between 2-11% and a sea level rise to 1.4m (CRRP, 2020). Considering this Prime Minister Skerrett has vowed to make Dominica one of the first climate resistant countries in a bid to build back better from the impacts of the 2017 Hurricane Maria. Successful DRR should be part of this pledge to improve local awareness of future risks.

Dominica is a multi-hazard environment. As well as the annual threat of tropical cyclones, it has 11 potentially active volcanic centres, one of the highest concentrations per unit area. Its situation on the LAT puts it at risk from both seismic and tsunami-based risk. The steep topography, along with the 365 rivers means that it is subject to landslide and flood events. Understanding how the population of Dominica perceives these hazards is critical to developing effective DRR measures and building resilience.

Wilkinson et al, (2018) suggests after recent climate shocks a need to build resilience to multiple hazards, which will involve inclusion of a range of stakeholders in decision making. Dominica has a

youthful population, with 21.41% below 14 years old, and a further 13.15% between 15-24 years old (CIA Factbook, 2019). The young population of Dominica has a right (Matthew, 2003) to be involved in the future of the country as a stakeholder in DRR, through developing their perceptions of disaster risk in a multi-hazard environment and better understanding how to use education to improve awareness of disaster risk, so that they are better informed for building resilience in the community (Pfefferbaum et al, 2018, Wisner et al, 2018).

Recognising that there are relatively few studies which have looked at student perception over a longitudinal period (Ronan et al, 2001), and understanding that existing methods of perception data collection are limited in understanding student perception due to language barriers (De Vaus, 2002), organisation (Borque et al, 1997) and short-termism (Bird 2009), this study aimed to use a novel approach to understanding risk perception, PRISM, to assess student perceptions of multiple hazards in four contrasting locations across Dominica. Using these perceptions of hazards, it would be possible to determine the effect of educational sessions designed for DRR.

The use of PRISM designed by Buchi and Sensky (1998,1999 & 2016) has success in understanding patient suffering in a clinical context. However, the potential for its use has developed beyond a clinical context, with Zimmerman et al (2013) using it to assess the perception of hazards while travelling. A few recent studies (Parham et al, 2015, Yildiz et al, 2002, Bodas, 2020) have further developed the method for use in a disaster risk context, with the benefit for understanding student risk perception of its simple construct and low reliance on test heavy survey methods, which may be subject to bias (Hawkes et al, 2009). Despite altering the approach to PRISM to follow (Rumph et al, 2004), allowing group data collection, this study found that PRISM was quickly understood by all students, allowed an evaluative approach to perception by giving students the opportunity to alter their beliefs, and allowed students to convey their perspectives to justify their perceptions. This was particularly significant as it allowed the participation of SEND and EAL students. Cronbach's alpha scores confirmed the reliability of the method, however, future inter-rater calculations, using Fleiss kappa may allow confirmation of the inter-rating scores given by Buchi and Sensky in validation of the study. While this study confirmed the use of the board was well understood to collect relative student perceptions, the rectangular board design creates some potential issues of anchoring data therefore future recommendations include testing a board redesign to minimise this impact. This study confirms that while PRISM is not a replacement for conventional qualitative assessments methods, **it serves as an alternative allowing more effective determination of relative perception** compared to conventional scales e.g., Likert. Despite this, this study highlights the **value of using PRISM with children**. It showed children's **quick understanding** of the method, **relative consistency of its use** throughout the longitudinal study and how **effective they could communicate their views without being restricted by complicated academic text or**

misinterpreting the question. The use of PRISM in this context therefore has great potential for use in both local communities with people of different socio-economic background and between different countries, especially as the **method is not restricted by language.** This will allow for a consistent method of analysing perception which moves beyond the use of traditional questionnaire. This was a key finding of this study and endorses that this method could be applied for future perception studies with children. Further development of this method as an online application will allow greater use within disaster risk communities.

This study aimed to understand how student perceptions in a multi-hazard environment changed over time, as previously studies largely focused on changing perception directly after a hazard or after a mitigative measure. **This is a unique element of this study which sought not only to track the change in perception but to understand how different events affected the trend of changing perception and the inter-relationships in trends between different hazards.** This study sought to grasp the factors which influenced changes in perception. The advent of two disaster events during the study period changed the original perspective of the study, however, allowed the opportunity to understand the impact of such events on perception. Despite the constraints of a small sample size and the need to adapt the study to changing circumstances due to two disastrous events, **this study was able to gauge differences longitudinal perception trends in contrasting locations.** This study found that **student perceptions were dominated by a primary risk, e.g., hurricane risk.** This message was reinforced by actions of the DRR community, personal experiences of annual hurricane season and experiences of family and friends. **Frequently experienced secondary hazards, such as flooding and landslides were also perceived with importance,** while potential geophysical hazards were not considered relatively threatening. This study found evidence that **students had knowledge linking hazards,** but this information was used more after disaster situations compared to intervening times. Suggestion that students had a poor link between primary and secondary hazards could not be confirmed like in the study by Solana and Kilburn (2003), but this study showed there was a need to encourage students to promote their understanding of links between hazards. **This study underlined the relationship dynamics of hazard risk perception between periods between and directly after a hazard event.** This highlighted that the **impact of a major event can lead to significant changes, either positive or negative, of the perception of the less frequent events.** This was particularly evident in the relationship between hydrometeorological and geophysical risks and merits further study to understand the potential disconnect between frequently and low frequency hazards.

This study showed that student perceptions of Dominican hazards varied from experts, except for hurricane hazards. Students based their perception ratings on their own experiences while the experts had the benefit of perspective and probabilistic outcomes. **Students often expressed their views in the**

context of the past events, rather than likelihood of future events. This gap in perception understanding is something that education could but currently does not address.

This study also recognises that student perceptions were also subject to bias. Confirmation bias (Kahneman, 2012) linked to the threat of hydrometeorological hazards results in the perception of geophysical events being underestimated. The longitudinal element of the study showed that after Tropical Storm Erika, **student perception of hydrometeorological hazards** were impacted, and perceived as greater risk, though were **subject to normalisation bias after 1-2 years** confirming evidence of disaster fatigue (Borque et al 2016) in student perception. Again, this has great significance for the understanding and awareness of the low frequency, potentially high magnitude geophysical events.

This study also provided evidence **that student perceptions are spatially variable and subject to gender difference.** It was evident, for example that **coastal locations were consistently more aware of flood or hurricane risk and the potential for tsunami compared to inland locations.** The evidence for these relationships was inconsistent but would merit further study to better understand this difference. This finding has significance in the context of raising student awareness of hazards, as it suggests, in agreement with Gautam et al, (2017) that **approaches to changing perception and behaviour needs a spatially bespoke approach and appreciation of the intended audience.**

Developing resilience requires the students to turn perceptions and awareness into actions to reduce risk (Ronan et al, 2016). While this was not the direct focus of this study, **there was evidence for a link between socio-economic background and measures taken to reduce disaster risk. Students from households where parents achieved a higher level of education often had made greater provision for disaster risk preparation.** This is relevant because it will enable DRR agencies to work more specifically with selected communities who have lower socio-economic status. Further study needs to be undertaken to understand how long-term changes in perception affect this, and account for other variables which may influence taking increased or decreased mitigation.

This study did, however, understand how students learn about hazards, which is critical in developing an effective disaster risk reduction education strategy. **While adults in Dominica look to radio technology, younger generations in Dominica favoured the use of the internet and TV** to learn about hazards and get DRR information. While the role of the parent and the school is important, educational practices, both implemented in school and by local DRR organisations need to account for the preferences shown. **Students also showed that they responded to and engaged with locally relevant information more than generic hazard information.** This is critically important for DRR agencies because leaders of these will be responsible to produce community messaging. It is important therefore

that these **DRR messages are adapted for a new future audience, for example the current student population**. Encouraging student participation in DRR capacity would benefit these organisations.

The final part of this study aimed to assess the impact of different educational approaches in altering student perception. Education in a disaster risk context is commonly implemented by non-governmental, or specialists in DRR, rather than using resources developed by teaching staff. These approaches have commonly focused on knowledge transfer, but Kagawa and Selby (2012) advocate improved understanding of probabilistic approaches which assess vulnerability through action and participatory methods. Johnson et al, (2014) emphasise the need for student centre approaches which could lead to action within the community (Wisner, 2006). The lack of involvement of educational specialists in production of material for DRR education has resulted in pedagogic methods (Aubrey and Riley, 2019) being overlooked in DRR education. **This study therefore sought to understand the impact of different educational methods on student perception**. Using three strategies (interactive, surrogate and fieldwork/action) recommended by Kagawa and Selby, (2012) sessions with a Caribbean and Dominican context were developed. **All sessions had some impact on changing perception. The fieldwork session, limited in participation due to post Maria restrictions, showed the greatest impact on changing student awareness and perceptions. This session successfully allowed students to make improved decisions regarding access to DRR infrastructure**. These findings have great importance for both local DRR agencies, for example ODM Dominica, but also for regional and international agencies, e.g., CDEMA, who are responsible for designing and creating future DRE resourcing, teaching and learning. More needs to be achieved by the academic community to promote the link between pedagogy and DRE. This needs to be re-integrated back into future DRR frameworks to encourage national organisations to carefully plan an integrate DRR into their education system.

Student assessment of resources used in the DRR sessions, showed that localised sessions were important for improving engagement and awareness. However, **despite interactive games being popular amongst students, they were not recognised as useful for DRR education** unless they were place specific. **Therefore infographics, maps, plans and leaflets were considered most helpful for personal and communal use by students assuming they were not text heavy**. This finding is significant especially as DRR organisations produce vast amounts of DRR educational material which is not tested directly for its specific audience.

Analysis of the education system in Dominica, especially after Hurricane Maria, underlines the importance of integrated DRR education within the curriculum, using a student-centred approach which integrates both a top-down and bottom-up focus. The government of Dominica has embarked on this venture with an NGO, IsraAid, despite reports of current issues with the project. Further study of the

success of this proposed top-down approach on student perceptions will be a useful benchmark for the success of DRR education projects.

This study has adopted **an interdisciplinary approach to understand longitudinal student perceptions and its impact of educational methods, testing and advocating the use of a novel methodology**. It adds support that **effective DRR requires a top-down and bottom-up focus**, integrated into all levels of the community. **This includes the views of the youthful population**, who are still overlooked by DRR organisations. Education plays an important role in changing the perception of disaster risk. This study adds support to the notion that **impactful education**, which could alter the actions of students, **needs to go beyond knowledge acquisition, and should develop a decision-making element to increase its relevance. Effective methods to educate DRR principles should encourage action and participation, for example through fieldwork, or engagement with DRR officials**. This approach, however, needs to move beyond the traditional approach of one-off simulation to an integrated curriculum (Mathew, 2003) , which has a direct focus on the role and inter-relationship in the local community (Mitchell et al, 2008) to avoid knowledge decay (Ronan et al, 2012). **This study has shown that the design of resources for disaster risk reduction needs to incorporate pedagogic theories and take input from education professionals** who better understand learning strategies, support for learning needs and student engagement. **Taking this approach will help increase student engagement** in education for disaster risk reduction thereby improving awareness in the student body and the wider community leading to a more sustainable and resilient population, a key goal of the Sendai Framework.

This study acts as a benchmark for future study. It has shown the benefit of a longitudinal approach to understand the perception of the relationship between frequent and less frequent events. It has shown that gender and location are important considerations when understanding the nature of risk perception. It has shown the importance of understanding learning styles and gaps in the DRE curriculum based on student perception. It has also set out a need for integrating pedagogy into DRE curricula and resources to improve engagement. Finally, it has shown that participatory approaches are more impactful and locationally bespoke. It is hoped that the findings from this study provide the grounding for future work into DRE to improve the lives of students, or at least their awareness of the multi-hazards environments in which they live.

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Appendices Summary

Appendix A – Details of taught sessions 1-3 (taught 2016-2018)

Appendix B – Field notes for session 3 - Roseau

Appendix C – Field notes for session 3 – Portsmouth

Appendix D – Field notes for session 3 – Castle Bruce

Appendix E – Information to support Supplementary files – PRISM data.

Appendix F – Transcriptions for DRR experts taken 2013-2018

Appendix G – Permission letter from MoE to work in Dominican schools.

Appendix H – Ethics forms

Appendix I – Risk Assessment form

Appendix J – PRISM questionnaire

Appendix A Lesson plans and resources for (lessons) sessions 1-3

Lesson plan for Session 1

Target audience – students of 3rd form – these are students in Year 9 in UK (aged 13-14). This lesson is aimed at students who have not yet selected their options for Fourth Form.

Session aim – to develop a global understanding of natural hazards and disasters focusing on cause and impact.

Session Introduction (10-15 mins)

Students begin session with a paper version of the PRISM Exercise 1 technique – each student is issued with a replica of the PRISM board and circular stickers. The board is explained, and an example is given with the PRISM board (magnetic) – this is then undertaken by the students (note in Exercise 1 – Red replaced purple disc as the purple disk has gone missing).

Lesson sequence

- 1) Students are then introduced to concept of hazard – what does it mean to them? What is the difference between a hazard and a disaster? Share their own personal perceptions.
- 2) Students are introduced to the main hazards to affect Dominica and the Caribbean – they are asked to share their experiences of them. Show the PowerPoint images if there is facility or print and use the pictures of slides. Students asked how these images may mis-represent the hazard to someone who has not seen them before.
- 3) Split the students into groups (4-6 students - based on recommendation of the class teacher) to create a disaster profile. First activity is to issue the sorting exercise information – but first, just information about hazard formation – students need to sort which explanation goes with which hazard. They are then scored on their understanding as a group. They are asked to go through their answers on board. Finally, after each group given answers then the correct answers given.
- 4) Students work together in groups of mixed ability to card sort the names of six hazards; hurricanes, landslides, floods, earthquakes, volcanic eruptions and tsunamis, with information about the number affected in 2015, number of deaths in 2015 and number of disasters. The groups collaborate and then as class discuss the outcomes – each team is scored so an overall winner can be deduced (allows for comparison between schools).
- 5) The groups discuss how these answers differed from their expectations – and why they might be different. Groups given an opportunity to give opinions.

6) After session on hazards (use of pictures in support of discussion) redo the PRISM exercise to reflect on the exercise. Students could reposition the circles with arrows pointing to new position.

Student learning

To understand the differences between hazard and disaster

To understand the different types of hazards (terms meteorological / atmospheric and geophysical)

To understand what can cause the formation of these hazards.

To interpret data on hazards and link to type – justifying reasons for choices

To compare hazard / disaster data to known perception

To improve group work / collaboration and public speaking

Notes for lesson

a) Will need to prepare the card sorting activity in advance.

b) Students should be in mixed sex groups (preferably non friend groups)

c) Establish rules of speaking for the class so that individuals do not get interrupted and establish timing allowance to speak so manage time of lesson.

d) Allow time for the second PRISM task to allow for adjusting positional markers.

Please contact me for other supporting information pertaining to session 1 including the PowerPoint used.

Lesson information (for card sorting activity) (answers given for teacher use)

Hazard	Number of disasters in 2015	How do they form	How many people died because of them	Total number of people affected (2015)	Can we get this hazard in the Caribbean?
Volcano	8	Magma from plate boundaries or hotspots rises through the crust onto the surface.	0 (none) deaths	960 000 people	Yes, some famous recent examples include Montserrat (1902) and Martinique (1902)
Earthquakes	19 Over magnitude 6 – only 143	Stress builds up at plate boundaries or along fault lines.	9635 (8964 from one event) deaths	7 million people	Yes, there were 3 recently, Puerto Rico, BVI and Dominican Republic
Tsunami	5	An earthquake over magnitude 7 (often) on the sea floor leads to sea water radiating in all directions from the point.	46 deaths	106,000 people	Not recently
Landslide	20	Water soaks the slope leading to it becoming weak and therefore falling or sliding	1369 deaths	50 332 people	Yes, every year!
Flood	152	River levels exceed the banks or the water table rises above the surface – due to rainfall	3310 deaths	27.5 million people	Yes often
Hurricane	90	Evaporating air on a massive scale forms into a tropical storm, then a depression then a hurricane. Need sea temperatures over 26.5 degrees	996 deaths	10.5 million people	Yes – this past year

Blank table for student completion

Hazard	How many disasters were there in 2015 (hazards causing damage)	How do they form	How many people died because of them	Total number of people affected (2015)	Can we get this hazard in the Caribbean?
Volcano					
Earthquakes					
Tsunami					
Landslide					
Flood					
Hurricane					

Session 2.

This session was conducted with 4th form students (equivalent to Y10, 14-15year old. students in UK).

Aim of session.

The aim of this session was to focus on developing the understanding of six hazards (used in session one) found in Dominica based on the use of a variety of resource types. The lesson had two principal aims – to improve knowledge of the hazard and to understand which forms of learning were most effective and realistic for students.

Lesson sequence

1) Start of session involved a PRISM activity to benchmark student perception and understanding of hazards since the previous session. (10 mins)

2) A brief recap of information from last session. What were the different hazards focused on? What could students remember about the formation of these hazards and which ones were considered (globally) most frequent?

3) Students divided into small groups of 2-4 students (denoted by member of staff). The room was set up in such a way to encourage rotation around a series of stations. Students would spend 10-15 mins per station and would be encouraged to interact with each set of information and either partake in an activity or complete some questions. The stations were set out as follows:

Station 1) Top Trumps volcanoes cards – these are devised by STREVA and the University of East Anglia. They involve a game of Top Trumps – which requires students to learn by taking part in a game. The cards focus on chosen known volcanoes from around the world and teach students about the location of the volcano and other facts including height, deadliness, potential for disaster. Students pit cards against other players in a comparative game in which the winner of each round can collect the cards – with the overall aim of winning all cards.

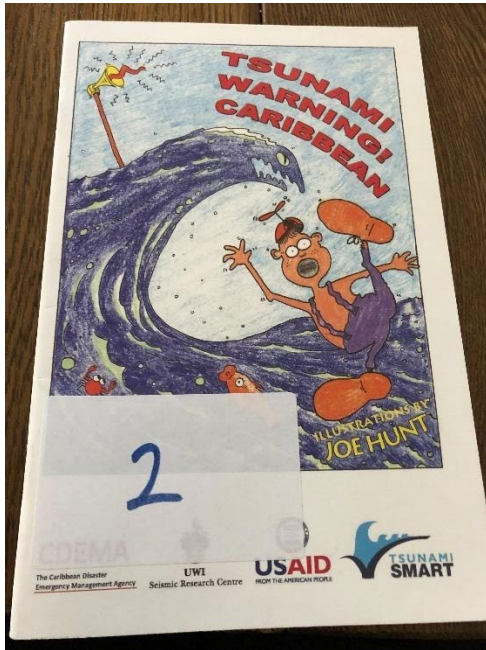
The aim is to play the game to understand the different types of eruptions there are. Then think about the application to Dominica – what does this mean for people who live near volcanic areas?



Examples of Top Trump cards.

Station 2) Stories - Tsunami story produced by US AID, UWI and CDEMA. A cartoon story book focused on a family as they prepare for the threat of a tsunami. The book is a series of cartoons with supplementary text explaining stages from pre-earthquake to post tsunami strike. The story is based in Barbados and gives information about the process of emergency and warning. The context of the book, while focusing on the impact of the tsunami, looks at the wider global interactions in dealing with such an event.

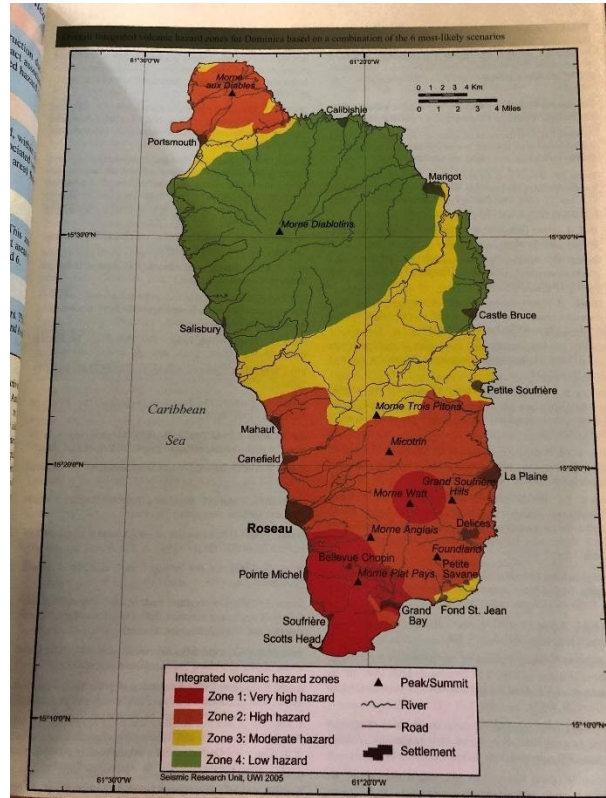
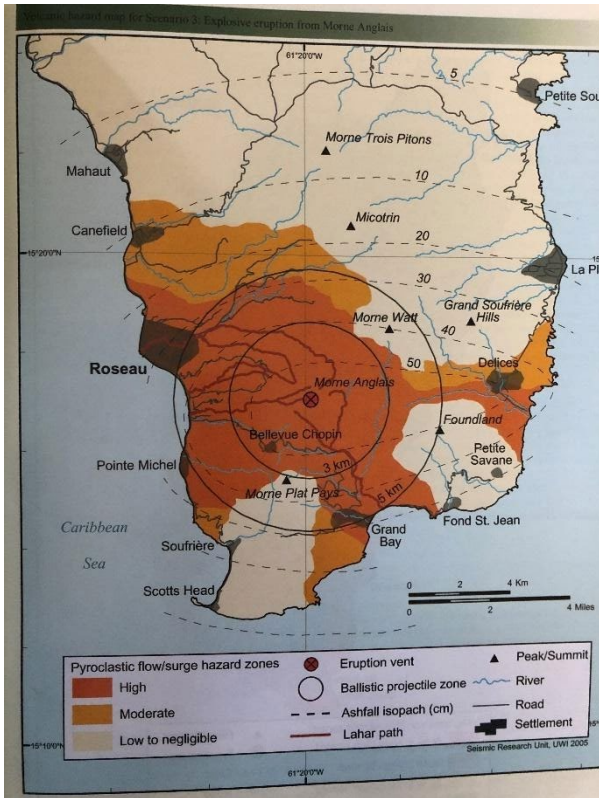
Students had to read the book. Think of the implications for living in Dominica – what would the possible impacts of a tsunami be and what could you do?



The CDEMA (UWI) produced tsunami storybook.

Station 3) Hazard maps – there were two maps shown to the students – i) a geological map of Dominica showing the different locations of volcanic centres, some structural tectonic cross sections and the different rock types and deposits on the island and ii) volcanic hazard maps of Dominica (and select areas) which divides the country crudely into zones based on their likely impact due to a volcanic eruption – zones were divided into colours based on the severity of the risk. They are focused on the entire island of Dominica.

Students had to think about the maps they could see. They had to locate themselves onto the map based on school location and think about what the possible impacts could be for different coloured zones on the map. What would people on the island need to do about this?



Photographs of some of the maps used in the session (Lindsay et al 2005)

Station 4) Leaflets – the leaflets are public information leaflets produced by UWI, Red Cross or ODM (Dominica) to inform people of what to do or how to act in different natural hazards, ranging from earthquakes, tsunami to hurricanes. The leaflets are often folded A4 or A5 in size.

Students had to read through the information. They had to decide whether they had learned anything new. If so what. How might this information be useful for people in Dominica?



Examples of leaflets sourced from ODM (Dominica)

Station 5) Plans – by the Red Cross or the ODM on steps individuals and families could take to prepare themselves for the onset of a forthcoming natural disaster. They offer information on different potential hazards.

Students had to read the plans and complete their own mental checklist. What do they have in preparation for a hazard, what could they improve on? Would these be useful within their own community?



Photographs of the family disaster plans – sourced from ODM and Red Cross Dominica.

Station 6) Game ‘Tsunami Girl’ – a App devised by university of Singapore to teach people about the threat of the tsunami. The game requires individuals to choose a difficulty level (each level is determined by the area under risk – higher levels of difficulty involved more complex urban or rural settings) and then spend a budget on preparatory resources, followed by the spatial allocation of the purchases. The aim is to prepare a local population, accommodating all levels of disability and age, for a tsunami and earthquake hazard. A timer counts down the onset of the earthquake and the success criteria is based on the number of residents one can save.

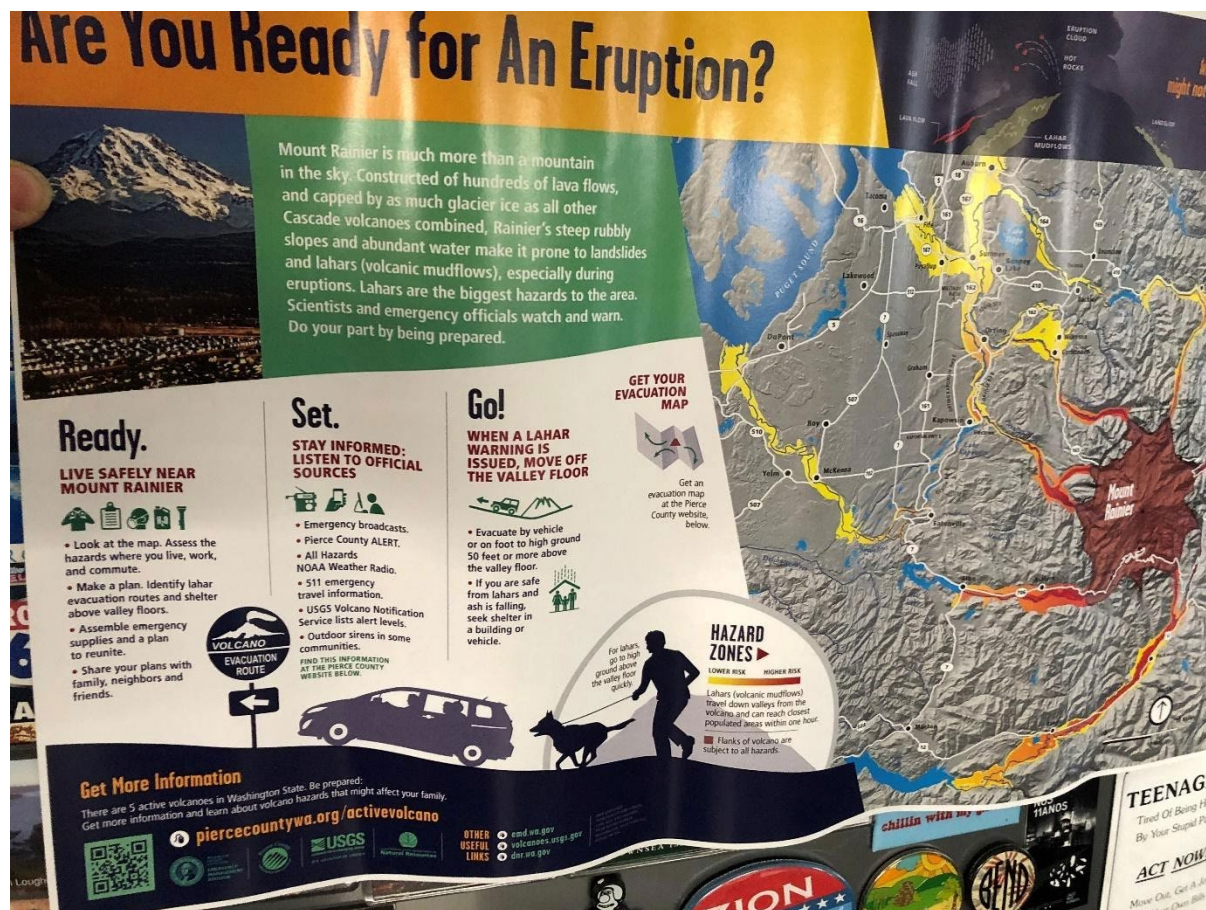
Students were asked to simulate the ocean island urban setting on beginner level. Success was judged after one attempt based on number of populations saved as a percentage of the total. Students were asked to assess the implications for Dominica based on their findings in the game.



Examples of screenshots from the Earth Girl App.

Station 7 - Posters – posters were designed to show information or hazard maps on how to deal or react to a particular hazard. Posters were often A3 in size and were a combination of text and images or infographics.

Students were asked to assess the poster and inspect the information given on each. They were then asked to think about usefulness of the images and think about whether such posters were used effectively in Dominica and to think about the design of future posters.



A photograph of an example infographic used in the session.

4) After all stations had been visited, students were asked to complete a summary task.

They were then asked to write a summary of why it was a useful resource (what appealed to them) and how it could be improved to gauge / improve their understanding. After looking at all of the resources they were then asked to cast an overall vote on which resource was most interesting to them, which helped them learn most about a natural hazard and which was most helpful to their community.

The resources were shown to both teachers and students to help understand a how important they were to different age groups.

5) Students were asked to conduct the PRISM task to give perceptions of their hazard understanding in Dominica.

Students were given (90 mins to complete the entire session)

Hazard Resource Evaluation Form Name _____ School _____

In this exercise I would like you to give your opinions on the resources shown. Spend 4-5 minutes with each resource.

Resource Number	What is it about?	Why is it useful?	How could I be more useful?
1			
2			
3			
4			
5			
6			
7			
8			
9			

Which resource is most interesting to you? _____

Why? _____

Which resource helped me learn most about a natural hazard? _____

Why? _____

Which resource would be most helpful to my community? _____

Why? _____

Session 3

This session was conducted with 5th form students (equivalent to Year 11 students aged 15/16 in UK schools).

Session aim

To determine the extent to which fieldwork and decision making can influence the decision of student's hazard understanding and perception. The students were attempting to recognise features in the 'field' which they could link to known hazards (previously studied), and they could apply this information to practical decision making to reduce disaster risk in their local area.

Session sequence

- 1) Start of the session with a PRISM activity to determine the current perception of hazards which affect the students within their local vicinity of the school.

- 2) Introduce the different types of hazards (they believe) would most likely affect the local area. Brief class discussion based on student perceptions. Introduce the concept of classifying these hazards into hydro-meteorological and geophysical hazards.

- 3) Split the class into two groups. Each group has a 20 min session (includes a brief presentation and Q and A with the students in group setting circle seating) to discuss the causes of i) local hydro-meteorological (talk given by author) and ii) geophysical hazards (talk given by island expert Dr Robert Watt a volcanologist from MVO). Students had the opportunity to make links between processes and what is happening locally – accounting for local geomorphology, relief, ecosystems, and human activity. After 20 mins the groups swapped and heard other talk.

- 4) Students were then given a map of their local area and were tested on their knowledge of shelters, emergency services and safe zones from different hazards. Students located these onto the map with coded stickers and were then asked to give a brief written description to justify their choices.

5. Students were then taken on a fieldtrip of the local area. Each area (Roseau, Castle Bruce and Portsmouth) had pre-determined sites which were used to either analyse the geomorphology, the geology, or locations of human land use in context of hazards. Students were given opportunities to take photographs, discuss ideas and ask questions. At each site, a brief introduction to the site was given by the author or Dr Robert Watt.

6. On return from the fieldtrip students were asked to complete another decision-making exercise to identify shelters that they thought were inappropriately placed and located stickers to show now the location of safe areas away from different hazards. Students commented on their maps the reasons for their choices.

7. Students undertook a second PRISM activity to determine the perception of different hazards in the local vicinity.

Copies of the maps and the field guide are given as an example in the appendices for one of the locations.

Map used for part 4 of session (session 3) – sourced:

<http://www.caribbean-on-line.com/islands/dm/rsmmap.shtml>

Map used for part 6 of session (session 3) sourced:

[Dominica Reference map of Roseau - MA603 Roseau reference-300dpi.pdf - MapAction.html](#)

Please contact the lead author for access to the field guide.

Appendix B Field sites notes for school classes in Dominica April 2018 – Roseau Notes

Created by Simon Day and amended by Martin Parham.

3 excursions

Roseau

Sites can be visited in different order to suit different start points (Convent School and Orion School)

Alternatives for first location (or use both), depending on level of concern about risk from traffic at Bath Road Bridge roundabout

Portsmouth

Castle Bruce

- Emphasise for all three excursions that a key aim is to learn how geological evidence can be used to identify hazards from rare, extreme events as a first step in preparing to mitigate their effects.

Roseau excursion

1. Bath Road bridge roundabout and/or River Street
(view across river to pyroclastic flow outcrops)
2. East side of King George V Street bridge to Bath Estate

Check that this location has not changed due to repair activities and revise as needed 3. River bend 50 m south of King George V Street bridge
(view across river to debris flow outcrops)

3. Botanic Gardens (boulders under trees)

(Suggested order 1-2-3-4 for Convent School, but might instead be 2-3-4-1 for Orion School)

4. *Location 1v1 – Bath Road bridge roundabout*

- GPS 15° 18.178' N 61° 23.185' W
- Group children on grass beside car park entrance from roundabout, at east side of outcrop (right photo below)
- Pyroclastic flow deposits
 - Possibly reworked given cobble-rich layers, erosional surface at top of deposit
 - Comparison may be with post-1991 lahars at Pinatubo.

Erosional surface at top of outcrop



Cobble rich layers in eastern part of outcrop



Location 1v2 – River Street looking at north side of river from south side (road on north side of Cricket Stadium)

- GPS 15° 18.201' N 61° 23.006' W
- Group children on wide pavement on north side of road, looking across river.
- Sequence of pyroclastic flow deposits exposed in cliff forming opposite bank.
- Multiple flow units, with mainly planar contacts between them and no evidence of hiatuses (erosional surfaces, soil horizons)

View across river and
downstream to western
end of outcrop



Location 1v2 – River Street - Some possible activities

- Ask students to draw a sketch, showing:
 - How many layers are present?
 - Where there are soil layers or other evidence of time gaps between layers
- Explain what the layers are.

(Pyroclastic density current (flow) deposits) and where they are likely to have come from (eruptions in the Micotrin / Wotten Waven area)

- Ask them to recall previous lessons on volcanic hazards and say what the effects on Roseau would be if something like this happened again.



Location 2 – King George V Road bridge to Bath Estate

- GPS 15° 16.105' N 61° 22.856' W
 - Measured at east end of bridge.
 - May be better to group students about 20 m south of bridge on open ground on Bath Estate bank of river.
- If possible, view eastern abutment of bridge to show damage caused by undermining.
- Use this location to discuss the damage caused by floods during Hurricane Maria (to compare with location 3)

- Get the children to describe what the area looked like immediately after
- Highlight the role of boulders and tree debris in damaging the bridge and exacerbating the effects of the flood.



Views of damage to King George V bridge

- Point out the deep narrow channel that has developed under the bridge — scouring like this has damaged many bridges in Dominica and caused some to collapse.
- Perhaps ask the children what they think that the solution to this might be? Possible answers:
 - Deeper abutment foundations?
 - Build the bridges wider so, the abutments are not in the river channel but set back on either bank?



Location 3 – riverbank south of King George V bridge

- GPS 15° 18.105' N 61° 22.856' W
- Walk south from bridge (location 2) along east (Bath Estate) bank of river to bend.
- Depending on river level, either view west bank from between trees or from sandbar at river level.
- Explain that the erosion during Hurricane Maria has exposed the deposits upon which central Roseau is built.



Possible activities at Location 3

- Ask the children to compare the modern deposits in the river with those exposed in the opposite bank, identify similarities and differences.
 - Both contain boulders.
 - Deposits in riverbank contain much more fine-grained sediment (mud and sand)

- Explain that the riverbank sediments are mudflow deposits formed when landslides flooded the valley with wet sediment and the fluid mass flowed downstream.
- Ask where the river would have gone after the whole riverbed was filled with mud.
 - Answer to be found at location 4.

Locality 4 - Botanic Gardens

- Return across King George V bridge and enter botanic gardens at eastern entrance.
- Starting at first group of trees on east side of road through gardens, ask the children to look in and around the trees to see what is in the soil exposed between the roots.



- If you trust them, ask them to walk through the gardens in pairs or groups, and reassemble by the Banyan tree (opposite the crushed

bus) to report on what they have found; or keep them together while they make their observations.

- Reassemble by the Banyan Tree, location GPS 15° 17.879' N 61° 22.965' W, to discuss what has been found
 - **Answer, lots of boulders**

Locality 4 – boulders in the Botanic Gardens

- Discuss what the boulders are like
- Key point is that they are rounded, like the boulders in the river.
- Also, the largest ones are similar in size to the boulders in the river.
- Ask how did the boulders get here?
- Answer, a flood like that in the river channel during Hurricane Maria, but one that covered the whole area now occupied by central Roseau (since the Botanic Garden is the highest point in the town centre)
- Implies that any river channel present at the time was completely choked with sediment (like the mudflow deposits at Location 3) and so the flood spread out.
- Compare with the catastrophic 1999 debris flows and floods in Northern Venezuela.



Ideas to review before leaving the field and returning to school.

- Deposits seen, upon which Roseau is built, are from volcanic eruptions, debris flows (aka mudflows) and floods.
- These record the extreme hazards that have affected central Roseau in the past.
- These represent rare but highly destructive events worse than anything in the historical record.
- How can the effects of such events be mitigated?
 - Think about this on the way back to school as this will be discussed in the next session.

Portsmouth excursion

1. St John's Catholic Church
 - Building construction for seismic resistance
2. Burroughs Square (main bus stop)
 - Seaward side of square, to view bay and set up activity on walk back through town.
3. Northwest corner of sports field
 - Introduce the idea of seismic wave amplification on reclaimed swamp.
4. Portsmouth Hospital

Note that this excursion is as much about mitigation of hazards as about the hazards themselves.

Location 1 – St John's catholic church

GPS 15° 34.659' N 61° 27.381' W

Group students outside the building

Arrange access in advance if you want to go inside.

Ask students about history of this building.

- What did it replace and when?
- What happened to the old church?
- Compare photo of building under construction with its appearance today.

- Question 1: what features of the building increase its resistance to seismic shaking?

Question 2: what other hazards might affect this building?



Photo taken after November 21, 2004, earthquake.

Note unreinforced masonry construction of old church walls and tower.

Photo taken in 2013.



Features for resistance to seismic shaking revealed in this photo:

- Light steel frame roof structure (low weight, high strength)
- Roof frames supported on steel pillars embedded within concrete columns (so steel frame roof structure braces these pillars)
- Concrete columns are short and large diameter (less likely to topple)

Other hazards that might affect this building, and implications for its use as an emergency shelter.

- Windstorm: Ask students how was it affected by Hurricane Maria?
 - Roof largely undamaged (well-secured metal sheet roof panels not torn off)

- Punctures from debris impacts.
- Flood
 - Positioned just above level of town centre, so limited vulnerability to flooding

So, is this building to be considered a suitable emergency shelter in each of a variety of disasters (Hurricane? After an earthquake, while aftershocks are occurring. After a tsunami warning?)

[Answer: Yes, yes, no – because it is only just above sea level]

[You may also want to consider its vulnerability in a volcanic eruption, but perhaps not in the field – perhaps discuss this case in the classroom where Jan Lindsay's Morne aux Diaboles scenario hazard map can be made available to them]

Location 2: Burroughs' Square

- GPS 15° 34.407' N 61° 27.372' W
- Group students on the west side of the square, looking out to sea.

- Ask them what hazards can impact Portsmouth from the sea?
- Point out Cabrits, ask them what it is? (a volcanic dome)
- Explain about hot springs under bay, steep slope to Grenada basin offshore.
- What tsunami sources might be indicated by these geological features?
- Ask them how people would recognize that a tsunami might be about to strike Portsmouth?

*Activity on walk from Location 2 to Location
3 (Sports field)*

- Explain that they are going to walk along the main street of Portsmouth, which is close to sea level.
- Ask them to look out for buildings that house key facilities for disaster



response and recovery that would be vulnerable to earthquake and tsunami.

- get them to mark these buildings on the maps prepared in the initial lesson of the day.
- [some examples: police station, banks, social security office, port buildings and jetty]

[note – don't take the direct route to the sports field, but walk them as far north as the Pembroke Street junction to see the port buildings before walking inland and south to the north end of the sports field]

Location 3 – Benjamin Park sports field

- GPS 15° 34.547' N 61° 27.344' W
- Review results of the walk through the town
 - emphasise police station, port as key locations vulnerable to tsunami, and to storm surge.
- Ask students if they know what the sports field used to be?
 - Point out the drainage ditches, adjacent Indian River swamp, and that the ground is right at sea level.
 - Emphasise low lying ground with water-saturated swamp sediments beneath
- Discuss the implications of these features of the local geology for the vulnerability of Portsmouth town centre to amplification of seismic shaking and liquefaction.

Location 4 – Portsmouth hospital

- Need to walk from Benjamin Park up Pembroke Street on the north side of the sports field, to the hospital.

- GPS: GPS 15° 34.756' N 61° 27.153' W
- Note: road outside hospital or a little further upslope gives views of
 - Morne Diablotins and Morne aux
 - Diabes, so this may also be an opportunity to discuss the local volcanoes and volcanic hazards.
- Features of the hospital buildings and site that influence its vulnerabilities.
- Ask students how they think the vulnerability of the hospital buildings to different hazards compares to the vulnerability of buildings in the centre of Portsmouth to these same hazards, and why?
- Key factors:
 - Height above sea level
 - Ground beneath the hospital (volcanic rock rather than saturated sediment)
 - Reinforced concrete construction.
- So, can the hospital be expected to continue to operate after earthquake, tsunami or storm surge?
- What about in volcanic eruption situations?



Castle Bruce excursion

1. Ravine next to Castle Bruce school
 - Flash flood deposits
2. Channel in centre of alluvial floodplain
 - Cobble-gravel deposits in floodplain – where are they coming from?
3. Bridge over Castle Bruce River
 - Pattern of river flooding
 - Source of cobble-gravel deposits in floodplain established
4. Castle Bruce beach
 - Coastal erosion and other hazards

Note that this excursion is primarily about flood and coastal hazards since volcanic hazard at Castle Bruce is low

Location 1 – ravine and stream next to Castle Bruce school

- On west side of school, just downstream of road bridge
- GPS 15° 26.065' N 61° 15.642' W
- Banks of stream formed by deposit of small boulders and cobbles.
- Best seen in west bank, viewed from east bank, as a lot of the east bank is an artificial deposit.
- Note that the boulders and cobbles are quite angular – they have not been transported far

Location 1 – questions for students

- Where have these boulders and cobbles come from?
 - The slopes immediately behind the school • In what sort of event did they get here?
 - A flood, or possibly a (relatively small) debris flow
- Was this a recent event, or one further in the past?
 - The latter because there is a lot of soil on top of the boulder-cobble deposit.
- How far to either side of the stream does the deposit extend?
 - Note that the stream cuts through a slightly elevated fan surface, that is likely to be formed by this deposit.
- Is the school built upon them? [Yes]
- If so, what are the implications for the vulnerability of the school in an extreme flood or debris flow event?
 - In discussion later, you might want to consider which parts of the school might be safest [answer – upper floors at the eastern end furthest from the stream] and whether an evacuation route to the ridge to the east is needed.

Location 2 – centre of alluvial floodplain

- On road to Good Hope, where it crosses a low concrete culvert-bridge over a channel in the floodplain (not the smaller one to the N)
- GPS 15° 25.885' N 61° 15.577' W
- Standing in centre of bridge looking over east side: gravel and cobbles visible in stream bed below
- Cobble-size clasts also visible in stream banks

- Note that these clasts are much better rounded than those at Locality 1 (therefore, they have travelled further)

Location 2 – questions for students

- Where is this sediment coming from?
 - Perhaps from far up the valley, since the rounding of the clasts indicates that they have travelled a long distance.
 - Not from the fan near the school: since this deposit is found right across the valley floor in channels like this one, it is too extensive as well as containing rounded instead of angular clasts.
 - See Locality 3 for evidence that it is not sourced from the south side of the valley (so leave this possibility open in their minds for the time being)
- Does the small stream in this channel transport this sediment here all the time?
 - No, the channel is normally quiet and vegetated, as it is now.
- What sort of event deposits this sort of sediment?
 - Hint: did anyone see what this channel was like after Hurricane Maria?
 - Extreme flood events may cover the whole of the alluvial plain to deposit this sort of sediment.
- Would it be safe to build houses here? [No]

Locality 3 – Bridge over main channel of Castle Bruce River

- Continue south on Good Hope Road to bridge over river.
- GPS 15° 25.673' N 61° 15.665' (eastern end of gravel bar in river, but start beside bridge looking across river to south bank)
- After viewing south bank, cross to that side and take path upstream down to gravel bar if this is exposed and get the students to look at that.

- Also get the students to look from the gravel bar to the north side of the river where sand deposits are exposed in the cut bank.

Locality 3 – questions for students

(Ask the first two on the north bank, then the others when in the riverbed if this is accessible)

- What sort of material forms the slope south of the river, that would get into the river from there?
 - Red clayey laterite soils (on top of deeply weathered lavas, but it is the soils that form landslides on the slope)
- How much of the sediment visible in the river might come from there?
 - Very little, since the sediment is made of cobble and gravel grade fragments of fresher rock.
 - By elimination, this means that the sediment in the river almost all comes from the mountains far upstream (where it gets into the river in landslides)
- How do the clasts in the gravel bar compare to the deposits at the previous two sites?
 - They are mostly moderately too well-rounded like those at Locality 2
 - (Discuss the rock types?)
 - Rare angular clasts of bright red jasper (angular because they are much harder than the rest so don't abrade in the floods) produced by hot spring waters originate from volcanic centres in the interior of the island.
 - Implication is that transport of this sediment down river from the interior is confirmed by the occurrences of jasper.
- Having established that at times the plain between here and the school is covered by floods that deposit the sand, gravel and cobble deposits seen at this locality and the last one
- Does the plain always remain vegetated like it is today?
 - No, sometimes it is covered by floods that cover it in thick layers of sediment.

- Is it safe to build homes anywhere on this flood plain?
 - No, because these floods would be dangerous to anyone living there permanently (but it's safe to farm this land and only be here in the daytime)

Locality 4 – Castle Bruce beach

- Return to junction with main road in Castle Bruce, then take coast road to beach next to blue-painted guest house on shore

- GPS 15° 26.152' N 61° 15.467' W
- Examine the sediment on the beach.

Locality 4 – questions for students

- How does this sediment compare to that seen in the rivers?
 - Finer grained overall.
 - Varies up beach, from boulders and cobbles nearest the sea to sand and gravel at the top of the beach and amongst the trees.
 - Many tree trunks washed back on shore during Hurricane Maria.
 - But the grain shapes and rock types are similar, so most if not all this sediment was transported down the river into the sea by floods, and then washed back onto the shore.
- What evidence is there here for coastal erosion in storms?

- Erosion around roots of trees at the top of the bank behind the beach
- Is more building here advisable, and if not, why not?
 - Buildings here are vulnerable to coastal erosion and to rare events (storm surges, tsunamis)

Appendix E – Information to support Supplementary Material – PRISM Data files

This is a summary to the supplementary files which contain PRISM data.

The files are organised by school. All student names are coded.

Each contains the following information:

- Exercise 1 Raw PRISM data (including SHS scores – 1st column in named hazard and Angle data (second column in named hazard) for each hazard during each time. Time periods work from most recent to past so therefore the tables read as: Post session 3 – 2018, Pre session 3 - 2018, Post session 2 - 2017, pre session 2 – 2017, October 2016, Post session 1 – April 2016, Pre session 1 April 2016, 2014, and 2013)
- PRISM comments – to be found on the same sheet as Exercise 1 SHS data. The comments are transcriptions of student comments on the PRISM board. They are colour coded by theme. There is also a summary table which represents the cumulative frequency of themes across the collection period.
- Exercise 2 PRISM data – this sheet has ranked values per time (as per exercise 1) for importance assigned to learning options. Summary data table is included as are box and whisker plots.
- 2018 1st form PRISM data (set out for 2018 as per Ex 1 raw data to include SHS score and angle).
- Reciprocal test data for school 1 and school 4.

Colours used in title heading represent disk colours used on the PRISM board.

Colour codes used on the data tables have no relevance to the data presented unless otherwise stated.

Appendix F Transcribed data from interviews with DRR experts 2013-2018

Interviews with Disaster Risk Reduction players in Dominica (2013-2018)

Summary of meetings on each visit to underline the wider social, economic and political changes at work during this time.

Interview with Director of the Red Cross 2013

i) Can you tell me about the different schemes The Red Cross is involved with in Dominica to reduce the threat or the vulnerability associated with disaster risk management?

The Red Cross operates a **disaster risk management plan across 42 communities in Dominica**. As part of this it **conducts surveys** within each community to understand their needs. The Red Cross **operates a cdrt scheme** which helps **train local community members** to act as a **first responder** in the event of a disaster or a hazardous event. As part of this scheme The Red Cross runs a programme to ensure that the **community has the necessary resources , such as medical supplies, digging equipment, and training. Training** within the communities includes managing a shelter, triage, search and rescue, and risk management. The schemes are run within the local communities by a village council, for example in Grand Fond they have set up a climate change adaptation scheme and a health training element. This means that is the Red Cross can support each community with their bespoke needs.

Within each community The Red Cross has set up **a vulnerability and capacity assessment**. The aim of this is to produce a **hazard map for the local area Using Google Maps and QGIS** to provide **waypoints and evacuation routes**.

These projects have run since the late 1990s and are dependent on the availability or funding from DFID and CDEMA. At present we are dependent on funding to set up new CDRT schemes hence we only help 42 communities. The largest community we help is **Marigot, which has over 3000 people**. The basis of selecting future communities is dependent upon that community meeting our selection criteria.

How successful are the CDRT schemes in different sized communities?

One issue with larger communities is ensuring that all parts of the community are included. One example of a large scale CDRT scheme is the one implemented in Portsmouth since early 2000. In this case local people volunteered to be trained to cope with emergencies. However, because there have been no major emergencies people became complacent and stopped attending the community meetings, which means that the group is not active. Generally, we find that the **program is more successful in smaller communities of between 100 to 300 people**. The success of the scheme relies on the community identifying groups of people who are committed and interested. We did find that after the **2007 earthquake in Portsmouth that there was renewed interest in the CDRT scheme**. In fact, immediately after the event the CDRT trained volunteers did respond. Since then, there has been renewed interest in Portsmouth's CDRT scheme and recent training has revitalised the group. In the South of the island, south of Roseau, there has shown to be a lack of awareness about possible hazards. Therefore, we are **currently training a new committee at Ponte Michel**.

When The Red Cross set up a CDRT scheme how do you identify the location for shelter and what input is there from outside the Red Cross?

The government and local government planning provide the main input beyond what is achieved by the Red Cross. Local government planning will identify locations for shelters, these are often schools or public buildings. The government will send engineers to check the selected building to determine whether it is acceptable as a shelter. The Red Cross have to fit in with the **national disaster plan which has been in draft form since 2001**. **Many of the disaster risk reduction plans focus on hurricane hazards not multiple hazards. There is a disconnect between wind and rain produced by a hurricane and potential flooding and debris flows which will be associated with the hurricane.** This has been pointed out to the government, but the reply is often but there are a lack of resources. The office of disaster management currently has only **3 full time staff to deal with over 70,000 people**. **Dominica has a volcanic contingency plan which has been in draft since 2000 but needs to be updated. Currently, as far as the Red Cross is aware, there is no provision for tsunami preparedness and consequently no community on the island is ready for this event.**

What help does the Red Cross provide to local schools?

The Red Cross does not directly involve itself in educational projects. Some of the geography teachers are trained in the CDRT scheme. The Red Cross does not currently visit any of the secondary schools on the island what does have **links with some of the junior schools**. One issue is that this teaching staff need to take the responsibility to organise Disaster Risk Reduction. The Red Cross does have a **youth group and local school students aged up to 17 volunteers to be part of the group**. The

students may help with **community programmes and help conduct our local surveys**. The Red Cross does not just focus on **natural hazards instead it focuses on health-related matters such as sanitation and currently the zika virus**. For schools to be more involved with the Red Cross **teachers need to make themselves more available**.

Meeting with director RC in 2014

Can you remind me of the objectives of Dominican Red Cross in Dominica?

The Dominican Red Cross shares the mandate of the Red Cross. Dominica is a hazard prone area and we aim to alleviate human suffering. We try to achieve this through disaster risk management and medical assistance.

The Dominican and Red Cross provides an auxiliary to government and collaborates with the ODM. Our focus is mainly community projects which involves training or disaster mitigation. We share information with the ODM and provide assistance to affected people and places. We are part of many sub committees and in the event of a disaster we are a **member of in NEPO which means we help orchestrate contingency plans with the government**. We act and respond to all events regardless of magnitude all location. As an independent society we are guided by 7 principles of which 1 is independence. We base our responses on need of each area and we can also apply for donor relief to help with different communities. Our overall aim is **to promote independence in the local community through disaster and risk management projects** which help empower the community to respond sustainably. We achieve this with the help of our CDRT members who are responsible at community level in one of our 43 communities.

We also conduct vulnerability and capacity assessments which help us assess the level of human resources in each community, a map to show vulnerable areas, a disaster plan for the community and training in the community on how to respond.

How do you evaluate the CDRT schemes and what are your future plans?

We try to adopt similar schemes in each community however the schemes work better in some communities than others. Some communities have greater need therefore receive more resources, and in some cases, there is a disaster fatigue occurrence. We try to measure the success of the schemes after the scheme has been initiated and the training has been completed. However, we minimise future visits to evaluate levels of success. Currently, we take feedback from our response volunteers, or we assess the response after an event.

In the future we would like to expand the CDRT training to two other communities. In the past many of our hazard Maps have been created manually however we are trying to develop the use of Google Earth Maps to implement GIS mapping. When we assess communities as potential candidates, we assess the following factors; vulnerability, willingness to coordinate, Level of isolation, location and the extent to which any projects have already been undertaken. We work with the ODM to identify vulnerable communities however we are only able to set up new schemes when we receive funding.

Can you summarise for me current or future projects that you are working on?

As mentioned last time we are setting up a CDRT scheme in Point Michel. This project is in collaboration with the University of West Indies and the French Red Cross from Martinique. One aspect of this project will be to develop new signs for tsunami warning in the village.

Currently the ODM is focused on tsunami management in the North of the island around the area of Portsmouth. However, the island currently has no formal early warning system which means that Portsmouth would have very short time to respond.

We are introducing RDS (radio data systems) as a mechanism to warn people. We would also like to make better use of the Internet or SMS as a warning. Portsmouth has a high percentage of cell phone use therefore it makes sense to employ SMS warning systems. However, the costing is an issue and there is no buying from the company Digicel who provide mobile phone networks. In our communities we opted for the RDS receivers because they are inexpensive. The training to use these receivers is conducted with CDRT volunteers. We aim to run community simulations to test the equipment with a small number of the community in Portsmouth. Our continuing problem in Portsmouth is the response fatigue associated with the disaster response committee.

How can you improve disaster education within schools?

We feel that this is the responsibility of the Ministry of Education. We would be happy to be part of a wider plan. We feel that the school is one focal point within the community however we have not made any further progress since last year. We do however have a club 17 to 25 which is an active blood donor group which has proved successful and we are educating young people about disease.

Meeting with head of ODM 2014

What projects are the ODM undertaking to reduce disaster risk in Dominica?

ODM have started a CERT scheme, which aims to be practical, develop search and rescue and develop medical stability. The scheme has been set up as part of a government-based project in line

with the requirements laid out by CDEMA for disaster reduction in the Caribbean. The CERT scheme runs complimentary to the work of the Red Cross but is not directly associated with the CDRT scheme. The CERT scheme avoids training groups of the community, instead the scheme aims to be an ongoing project which trains individuals in a range of skills such as map reading, search and rescue, problem solving, team building and disaster management. Completion of the course is a qualification. To qualify for the scheme individuals would approach the local disaster committees at the village council and would have to meet certain criteria which would undermine their character and commitment to the scheme. The CERT scheme has trained 120 people already across different villages on the island including people from the Carib territory, The West coast, the South Coast, Castle Bruce and Capuchin.

In addition to the CERT scheme the ODM have been working with Dr Robert Watt, a trained volcanologist to assess volcanic threat on the island. Dr Watt has also worked with the Red Cross. The ODM are also trying to establish a hazard week on Dominica which would be in May. this would look to work with the corporate entities on the island such as DOMLEC to promote Hazard awareness in corporate companies. currently we do not have a national hazards week.

How have you tried to improve education of natural hazards in Dominica?

As part of the CERT scheme, we are trying to set up a school safety program. Previously we have not worked directly in schools. The school safety program will be called the CAP program which stands for common alert protocol. The common alert protocol is currently in use in Grenada and Antigua. Portsmouth secondary school has been selected as a test for the program. The aim will be to use media (film) and Theatre to dramatize potentially hazardous situations. Students will watch the films to determine what is the correct procedure and what is not. The programme will also develop simulation exercises for the community. The aim is to develop an alert protocol for a given school. The scheme will train teachers to act as hazard wardens. The scheme will use SMS messaging, radio, TV to develop hazard warning messages. after initiating a pilot scheme with Portsmouth school, the plan is to have a public meeting in Portsmouth about the threat from different hazards including tsunami. Portsmouth secondary school will use the tsunami smart teaching resources to develop student understanding.

In addition to the work completed in Portsmouth secondary school the common alert protocol will aim to develop a warning system for the fisherfolk community and the churches so that they are prepared for tsunamis.

Tsunami's are a focus for the ODM with the aim of developing tsunami ready towns. One such place where this will be developed is Calibishe. The aim of this program will be to develop awareness. the ODM will work with the village council and disaster committee in Calibishe to promote a combined understanding of volcanic , hurricane and tsunami threats. Using participatory methods local people will develop appropriate evacuation routes so that they can help other villages in times of disaster. This will also include developing signs in the village.

The only other school-based work that we currently complete includes inviting fire service man into schools to educate people on fire hazards.

Meeting with former head of ODM – 2015 – on gardening leave from post as head of ODM

Summarise the main events leading up to and during Tropical Storm Erika.

Prior to Tropical Storm Erika TS Danny passed 1 week before. Warnings were issued by the ODM for TS Danny as it was directly heading to Dominica. However, it shifted north and moved past Antigua and St Maarten. Tropical Storm Erika followed this in the same path as Danny.

Tropical Storm Erika also veered north of Dominica – on the evening of the 27th August it went north of the island and therefore the NOAA and the Dominican Meteorological office, responsible for forecasting, said there was no need for a warning.

The ODM put out a warning to all heads of division in the public and private sectors. In spite of the forecast about Erika we thought we should not be complacent therefore put some preventions in place.

At the time Tropical Storm Erika was 100 miles north of Dominica. However, a branch broke off and collided with westerly trough system which led to convection over central mountains of Dominica.

At the time Dominica was meant to be in moderate to severe drought. Dry air from the south Atlantic had mixed with moist air from South America which produced rainfall over the previous 3 weeks.

Many of the islands have their own meteorological service therefore there is a lack of collaboration. Barbados is responsible for the islands of Dominica and St Vincent while the French organise their own islands. There needs to be a collaborative system among the islands to both French and English speaking. Independence has created a burden of information.

We had tried to set up an Early warning system funded by the UNDP. But despite attempts to set up there were struggles. Emmanuel Joseph was trained in the system but transferred by govt to adult education from ODM. They had tried to introduce the use of RDS receivers through simulation exercises with Barbados and St Lucia to follow the Dominican model.

On the day of tropical storm Erica the ODM was open until 10:00 PM because of a CERT program. At 10:00 PM the head of the meteorological Department called the ODM to ask what they were doing. However, the ODM had received no concrete advice so they decided to go home. At midnight I received a phone call from Wayne Abraham who had looked at the internet and realised that a belt of rain was approaching a Dominica. However, at that point the NOAA did not have the island and warning. Wayne Abraham, through his research, had seen that the island was due to receive lots of rainfall predicted to arrive at 7:00 AM. As a result of this I decided to set up a warning which was issued between 5:30 AM and 6:00 AM.

At 2:00 AM the rainfall across the island had started to intensify, it was light but continuous. By 3:00 AM there were constant moderate showers and at 4:00 AM Steve Joseph (an employee of the ODM) telephoned to advise that the Bath Estate had been flooded. The fire service was sent to the Bath Estate but upon arrival reported that they needed assistance. The police were called, and a local task force was organised to install an immediate evacuation. Had the early warning system been working an alarm could have been sent which would have alerted people much earlier. We tried to send a message via the radio station however at this time of the morning it was on auto play. We had negotiated with Digicel to set up the early warning system, but they wanted something back in return. To install such a system required an updated radio system in the broadcasting building. The day after tropical storm Erica arrived the system was almost ready to go.

At 6:00 AM we had evacuated people from the bath estate and finally we were able to put a message on the radio station. This message advised people to move to higher ground and to move away from rivers. The most intense rainfall and damage occurred between 6:30 AM and 9:00 AM. many of the people who were killed in Petite Savanne had originally come out to look at the floods and the court by subsequent landslides.

The road North of cane field was blocked, and some bridges had collapsed which meant that access to the ODM in Jimmit was not possible. Therefore command control was set up at the radio station (DBS). the purpose off this was to issue announcements, to offer survival advice and to offer warnings. One issue that we faced was the government protocols were in place for more extreme events, for example hurricanes, not for torrential rain.

We realised that we had reached the limitations in terms of human rescue and so we had to activate an emergency centre although this was run by 5 people. We were going to use the police station as a conference room however the police needed this to oversee search and rescue. so therefore, we moved the emergency operation centre to the Red Cross and use them as help and then we moved some of the operations to the fire brigade. Eventually the rain subsided although many of the ODM worked 24 hours a day without any relief to ensure that people received help. After a couple of days The Dutch and the British arrived to offer assistance.

On reflection the main challenges facing us which could be improved included problems with communication, especially getting messages too communities. There was also the issue of local people who lacked a serious attitude towards the problem. And although we had set up many contacts locally and we had equipment these were inaccessible at the time of need therefore there is a need to improve community relations.

Meeting with the new management of the ODM - 2015

In the period since the visit in 2014 the head of the ODM was replaced by Cecil Shillingford and Fitzroy Pascal. Officially the previous head of the ODM step down on health grounds and was given gardening leave however many local people believe that he was replaced due to his political views which were not in line with the government. Cecil Shillingford is this previous head of the ODM and a US aid coordinator. Pascal is the previous head of the meteorological Department and a strong government advocate. This meeting represents the views of the new management in the ODM. They were asked about the needs of disaster management in Dominica, the following is their account:

The main issue currently is with the national planning management structure. There is a need for an established national emergency centre, and for an early warning system. Community is also important. Currently we are focusing training on the Southern District of Dominica (which was most affected by tropical storm Erica). schools are not currently a focus on the ODM however the island is following the school safety response program established by the UN and CDEMA and USAID.

The main issue for the ODM is to establish comprehensive disaster management policy which deals with people before during and after an event. We see the early warning system as currently obsolete

and not something we can depend on. With funding from the UNDP, we aim to establish an SMS style warning system supported by a radio-based approach. We have some public education as part of this funding which has been completed by independent consultants.

We will continue with the CERT scheme which has been promoted by CDEMA in the Caribbean. Our aim is to train a national first response through the emergency services, which will be based in Roseau. We would also like to establish a smaller version in each district which will build on the current local CERT scheme but act as a government subdivision. We believe that in the past the ODM had too many separate ideas which were not sustainable unlocked continuity. Our current focus needs to prepare people for the upcoming hurricane season. During tropical storm Erica warnings were issued by the Dominica meteorological service however there was the issue off watching what happened rather than acting. (This comment contradicts the message given by the previous head of the ODM).

We need to revisit the national disaster plan which was last updated in 2001. Our main challenges currently staffing in the ODM, as there are only now 3 people to serve the entire island. We also have the issue of funding as currently we represent 0.05% of the government budget and therefore, we need an increase in funds. The money received by the ODM has fallen from one million EC dollars to 0.5 million EC dollars. this means that we need to seek alternative funds from bids.

2016 – Interview with WA (Public Seismic Network in Portsmouth)

How did tropical storm Erika affect the perception of people in Portsmouth?

There has been a change in perception since tropical storm Erica although there was relatively little damage in Portsmouth some of us did lose power. Generally, people do not perceive hazards, though with recent work undertaken by Clement Richards there is a slight improved understanding of the tsunami hazard.

I have been looking at the earthquake map for Portsmouth and do not believe it is detailed enough to distinguish different areas which will be subject to shaking. Greater collaboration is needed and there is a need for a better resolution map. The surface faults have only been visually mapped and there is a need to undertake a bathymetric survey however the cost for this is too high meaning, but it will have to be undertaken by CDEMA or by The University of West Indies.

There is a problem steal of getting messages to the public. We need to have a link to up to date information and a public seismic network operated between the SRC and Portsmouth. Despite

tropical storm Erica I do not believe that perceptions will change for example I was in Dublanc and Coulihaut and people seem disinterested. public warnings need 2 be both on the radio, through government radio station, or on the Internet through Facebook and Twitter. Overall, we need behavioural change, education for the local people and a change in government policy.

Clement Richards has been leading the great shakeout project which was focusing on improving understanding off tsunami in northern villages. However, the ODM is shutting this project down which means there will be little input into schools. The ODM are not replacing this project with anything else. It might be possible to set up a hazard's day in schools, however staff are pressed for time and the project would need a member of staff to run it.

What other projects are you working on?

As you know I run my own public seismic network, but I do not have a job at present. There was an earthquake South of Roseau last week which measured 5.6 magnitude and was due to the subduction off the South American plate under the Caribbean plate. Portsmouth was not affected by this. Earthquakes happen 3 to 4 times per year and are often offshore and spread around the island. To help overcome this problem I believe but we need to set up a size bigger network however this would need funding. The work could be done in collaboration with the schools with the idea of setting up 10 micro sensors per school area with one in the school and 9:00 in the surrounding community spread in a grid with approximately 1 kilometre distance between them. This sensor could therefore show which areas would shake the most and would give data back to the local people. This can be achieved with simple Raspberry Pi kits at a relatively low cost. However, it could be limited but Wi-Fi connection and would need the support from Digicel or cable and wireless. To have any early warning system The Internet connectivity issue will need to be addressed.

Meeting with former head of the ODM 2016 April

The context of this interview is that done was transferred from the ODM to work in a different government Department in January. Until that point while he works in the ODI he completed administrative tasks and did not have access to current projects and did not communicate with the new leaders of the ODM.

What has changed since tropical storm Erica?

Tropical storm Erica showed that we had gaps in our preparation. Since then, the ODM and the government have been working closely together and there has been some replacement of the damaged bridges with Bailey bridges (these are temporary crossings). some of the roads have been patched up while some have simply been sectioned off. Some of the damaged infrastructure is still

awaiting repairs and reinforcement. There is still a need for a post tropical storm Erica assessment by the ODM. Tropical storm Erica has changed the landscape and made people more aware however it is not clear that we have improved our readiness for another storm hazard. If hurricane Matthew had hit Dominica directly (in the 2016 hurricane season) we would have been in trouble due to our weekend infrastructure. There is a need for us to pay special attention to the weekend areas. There is also a need for a coordinated effort between the forestry, engineering, public parks, and land survey to provide a report. This may be requested by the World Bank however the UWI could send a geologist to lend support. A recent report by the World Bank does suggest that our country risk profile is still low.

What has happened to the plans that you started to put in place before you left the ODM?

We were trying to establish a seismic network however, currently we only have basic analogue recording of seismic activity in the South of the island, which was installed by the SRC, however this may no longer work.

The great shakeout project which was being organised but Clement Richards with the help of the University of West Indies is no longer in operation and currently ODM have limited community involvement.

The seismology in schools project, which was being set up along the West Coast, called the tsunami smart scheme does not appear to be in operation. We had plans to develop a series of smart schemes to teach people about seismic, volcanic, and tsunami risk. Instead, the focus for the ODM apart from updating policy is on hurricanes. We also had plans to develop education on responsibility in society, to improve knowledge of the environment and develop survival techniques for hazards. We wanted to use Garmin technology in the schools as part of this programme post office. Currently there are a few programs in operation in the schools other than those set up by the individual teachers. Our schools and our education have been limited by a time constraint which was imposed after hurricane David so that students were only taught for half a day not completing the full day like in other countries. We should be continuing the development of communication in schools. Only more traditional people listen to the radio and some watch TV. Now many students use their phones to access entertainment. We should try to develop games for students which help them learn. Oh my God I tired Bing like today.

Meeting with the director of the Red Cross (2016)

Can you give me a summary of what has happened in the Red Cross since last year (2015)?

Tropical storm Erica causes many delays in supplies coming into Dominica for the Red Cross. Last week our supplies arrived via Montserrat having been delayed for 5 weeks. We have set up a course for students lasting 6 to 8 weeks to teach them about the following topics: Q GIS mapping, social media, crowdsourced mapping, knowledge and attitudes towards healthcare providers, and the perception of public health following a disaster.

We aim to develop the use of Q GIS within the Red Cross. Our main project since September has focused on Zika.

At the ODM Cecil Shillingford has continued in his role of helping Fitzroy Pascal lead the ODM. This role will be extended to the end of this year. Don and Cecil did not get on or mix with each other at the ODM and therefore there is much to do.

We will be providing refresher training between March and June for CDRT members.

This will include updated hazard maps and vulnerability assessments. We also have some new members to our CDRT schemes which include Coulihaut, Dublanc and Calibishe.

We have also attempted to set up a project with the UNDP to establish early warning in Dominica. Wild also completing sea AP surveys and vulnerability capacity surveys.

The tsunami smart program to educate the public did not name the support that it needed as there was the problem with people showing up for meetings. The ODM did not share their disaster plans with the local community. A key issue seems to exist still between the ODM and the Red Cross as information is not always shared and both organisations seem to work independently.

What support did you comma the Red Cross provide to people after tropical storm Erica?

It became clear that the Red Cross needed better communication after tropical storm Erika to avoid duplication of services. Post tropical storm Erica there was a lack of coordination between disaster response organisations. The Red Cross completed the VDANA reports to help provide relief, but other charities were also providing relief and, in some cases, people were receiving duplicated aid. The Red Cross decided to use the mega V software, which was used after the Haiti earthquake, to give us a ground report of need per household. This meant that we could determine need by household rather than by community as we travelled around the affected settlements conducting a ground assessment of damage. This enabled us to provide aid and other needed items only to the people that needed them rather than anyone who wanted them. However, the Rotary, the ODM and the Red Cross were all providing similar services such as clothing shelter packs and emergency food and water which led to chaos in some cases. The Red Cross told CDEMA, but no action was taken.

Before hurricane Matthew there was no meeting which was unusual as normally the emergency operating centre meets prior to an event, however, on this occasion the members were not notified, and we did not know what was going on. Fortunately, nothing happened other than some minor infrastructural damage.

After tropical storm Erika 46,000,000 dollars was pledged in aid, however, until 3 weeks ago (April 2016) only 26,000,000 dollars had been received. New homes have been built for the residents in Dubluc, while the village of Petite Savanne is being rebuilt in an area near Bellevue Chopin. The population of petite savanne is still being supported and there is a National Employment program to provide for people who have lost their agriculture. Many new jobs have been created in the construction industry and some in the hospital. The Red Cross has been in contact with the residents affected by tropical storm Erica to provide psychosocial support as well as first aid training full people from petite savanne. We have also set up a CDRT training scheme for the people in petite savanne so that they will feel more resilient in a future event.

We have concerns over the ODM CERT training scheme as they do not have the staffing or the resources to train people who are suitably qualified. Our other concern is that the CDRT scheme is always precluded by a CAP and VCA study to determine need, whereas the CERT scheme is just one-way training. We are also concerned that the national disaster plan and legislation are both in draft despite the recent events.

KPB October 2016

Can you tell me about the projects that you have been implementing in 2016?

There have been 2 main projects in 2016. The first one is funded by The American Red Cross and USAID. The focus for this project is the zika virus outbreak. We have tried to raise public awareness, to improve surveillance within the communities, to improve awareness in schools (with the help of UNICEF) and also to conduct surveys in schools.

To raise awareness among the public we have made a video which aims to answer people's questions. We have collaborated with the ministry of environmental health, and our video is to be aired on television within the coming months. We have also added information to social media Via Facebook and Twitter, and we have also made Flyers which we distribute amongst the community. We find that TV adverts are the most effective way to spread the message. We have conducted surveys across 5 communities including, Soufriere, Grand Bay, Roseau, Marigot and Portsmouth. The surveys aim to gauge an understanding of the zika virus and teach people about how it spread.

We conducted an initial pilot survey with 5 respondents per community, chosen randomly. Subsequently we have increased the number of surveys 2 over 20 per community.

We have also received training from Red Cross facilitators from Jamaica and Barbados.

Our second scheme focuses on non-communicable diseases. This project has 3 main aims, firstly to improve public awareness of the diseases, secondly, to organise and facilitate focus groups in communities to discuss these diseases. Lastly to focus on the black community who are more susceptible to heart disease and cancer, to try and give these communities an understanding of the main causes of the diseases and how to seek treatment.

How has Dominica coped since the damage caused by tropical storm Erica?

Recently, we were subject to a trough system leading to localised flooding which brought back memories of tropical storm Erica. Work has continued around the major centres on the island and to improve infrastructure. A new bridge has opened in Roseau, to replace the damaged bridge close to the sea, which has meant that there are less traffic jams in Roseau town centre because the traffic now flows more freely. The government realised that rivers on the island need regular dredging, however, this has not been done regularly. The government have also started building flood walls to cover up some of the damage done on the eroding riverbanks. This should reduce the number of times that the bank's collapse. The main issue with this building is that it is a reaction to tropical storm Erica and not pre-emptive.

The airport (Melville Hall) suffered large amounts of flood damage in Tropical Storm Erika. Some of the terminal building rooms suffered water damage and parts of the airstrip and taxiway were eroded by flowing water. This also caused damage to the road immediately outside the airport because the Kachibona River over tops the bank scouring the road outside the airport. This flooding also damaged the road leading to the North of the island making journeys to this area more difficult without a 4 x 4 vehicle. The government has started rebuilding these roads and dredging the River next to the airport to create a larger channel.

The CDRT scheme has been implementing refresher training and reevaluating the CA reports. This has been completed only recently across hour CDRT scheme villages. We are not presently planning to continue with this until Next September.

We have also started and open data kit training which involves the use of smart phones and asks people to upload information about their queries and we can therefore reply directly to people's questions. Currently we are piloting this technology. We have also designed and uploaded a Red Cross hazards app and first aid app which people can get information from as we recognise but there is an increase in the use of mobile phone technology.

Can you tell me about your relationship with the ODM in the past year?

We have had less and less contact with the ODM since it has been under new management. although it is being run by Pascal Fitzroy really Cecil Shillingford is in charge, and they are still updating the disaster management plan which was drafted in 2001. We do not think that the ODM were sensible when they took Don Corriete back into the office especially as they are not using his experience. The ODM is control too much by the government and therefore is chaotic, as it does not have enough freedom. The ODM has not been collaborative recently instead it has been taking advice from people in different ministries who do not have experience in Disaster Risk Reduction.

Meeting with WA in April 2016.

Currently I am not working. All the community-based work that I was doing in conjunction with the ODM has stopped and there seem to be no further opportunities. This has meant that I am no longer working on the QGIS project as there is no end output. However, I have been working on some local hazard Maps using Q GIS which can be used to show safe sounds for example in tsunamis. I believe but it is important to raise awareness in the local community and one way to do this could be using video.

One other project that would be of interest would be to set up strong motion sensors to pick up seismic activity. We would need 9-15 sensors to make it a success however the less we have the less effective the net will be.

At this point Wayne completes the PRISM activity.

This activity would serve well as an activity to improve understanding of local perceptions. And it could be used to understand gaps in local knowledge.

- 3) A summary of the PRISM data results from each trip (control group vs data collection).
- 4) A summary of the educational visits, observations and lessons taught during the study period.

Interview with the chief education officer for the Ministry of Education 2016

Can you explain to me how you provide hazard education to students in Dominica?

Students learn about natural hazards through social studies informs 1 to 3. Some schools develop their own curriculum around the state curriculum which gives them the opportunity to explain about natural hazards in more detail.

We have tried to develop technology in schools to help them with research. All secondary schools have access to tablets for forms 1 to 3. we are also working with partners to increase broadband width to secondary schools, and we now are developing ICT in subject areas. Last week the government discussed the provision of ICT in schools. Our IT systems Oh being supported by universities in Alberta, Canada. The Ministry of Education has set up a Moodle page (e-learning) to help schools receive information and for them to upload assessment marks which can be stored centrally. The Moodle page can also be accessed by the students. The school principals being encouraged to support IT schemes for Dominica schools. We aim to give each student access to IT to improve their ability to do research.

All schools have a school safety policy and a school hazards policy, and they are encouraged to undertake practice for dangerous circumstances such as fire.

There was further conversation which showed MF some of the e-learning systems that operate in the UK. MF then was asked about how the Ministry of Education checks on levels of education provided within each school and she commented that this was the role of the school education officer.

Interview with local historian LH April 2018

Explain the changes since Hurricane Maria.

Need to be looking at rivers. Most deaths associated with rivers. Particularly ravines, people judge water based on normal circumstances, but need to consider how big the watershed.

MP – people not to comprehend event before.

LH – Hurricane David happened 38 years before, but people did not have to comprehend this much water. Strong winds up to 220mph. And then water. All along this coast (for historic reasons). None of the plantations ever sold land for housing along the valleys. Rivers raged and broke banks but nothing to worry about. However, in Roseau, Coulibistree, Coulihaut never should have sold out land. Engineers reports about storms on west coast, numerous accounts of loss. In past there was 10 acres of limes do not live.

MP – not spoken to LH in over 2 years – therefore.

LH – CB school had roof damage and was closed. Most shut until Christmas. Some schools lost their roofs, and therefore only teach in afternoon.

Some primary schools have split lessons 8-1 then 1-5 but this is not suitable in hot weather.

In old days when I was at school, we had a lunchbreak, but it was changed after Hurricane David to 8-1pm to account for the long distances across the island.

Conversation about bus routes. Students take buses to southern part of the island.

MP conversation about comparison with school life.

LH continues to work (one or two times per week) – at Cabrits speaking to journalists and giving tours to ships.

At Cabrits, only the trucks survived, but because it is accustomed to sea spray, it has recovered more quickly. Of the 6 vegetation zones in Dominica, those nearer the coast recover quicker. The trees in the upland areas are like skeletons.

MP – were the ruins at Cabrits affected?

LH – not really – trees would fall but lean against the stonework. Gives an example of how resistant the Commandants quarters was.

MP – did you base you house on this?

LH – based on French colonial design, need to be able to deal with threat within a couple of hours. Have louvres. I feel the local radio reports served the public poorly as they reported the hurricane moving between Martinique and Guadeloupe. I listened to a range of radio reports and was able to understand the hurricane would enter the island from the SE corner, move across the island and leave in the north at Capuchin, which is pretty much the track it took.

Wind strength changed through the storm. Hurricane went from cat 1-2 to category 5 in a short period of time.

LH – reason – followed ‘weather underground’ – main web log carried out by professionals. The tendency was to increase rapidly. Could be two reasons – sea temperature deep was cooler, but approach is shallower and therefore more heat. The relief also caused the winds to rise. But local people were out of date with reports of category 2.

MP - you did your own research but locals reliant on others (radio).

LH – I had businessman (Whitchurch leader) speaking about the comments made by Cecil Shillingford (head of ODM) that the storm would pass between Martinique and Guadeloupe and would not arrive till Tuesday afternoon. LH said do not open tomorrow – it will hit us by 630pm and will rage through the night. Nassif (Fort Young and Secret Bay owner), wife was busy locking up – he continued as usual watching Terminator 2. But a small fall in their garden and a landslide came down with huge boulders and filled the house and nearly killed them. The water came in up to 8ft – but the family had to wait until 5am with Nassif injured. Some did not wish to believe it would be as bad as it was. Those people at Coulihaut and Coulibistree, at Point Michel and Loubiere, many killed by the water. The roof explodes so people go downstairs, but then the river then sweeps them away, killed by debris, and swept to sea. I never went to Roseau for two weeks to see mother, I followed steps of others, I got lost, as could not find where the road was underneath. Dominica was also cut off – much action in Roseau for weeks. Hurricane David – radio station operated on am – central transmitter station on the coast – you could stay in the Virgin Islands and had a power emitter – and listen in. However, in 1980s changed to FM – a local transponder – Roseau was transmitting – but others could not hear the signal. Some boats were coming over from Marie Galant, with supplies for his family. People were arriving up this beach (near LH house) because the beach is protected. Many people left Dominica. LIAT offered free flights. Ferries offered way out but had to be careful due to floating trees.

LIAT initially offered free flights, but these were day flights without ATC guidance. Flights still came in over the mountains.

MP – airport looks better than after Tropical Storm Erika.

LH – however airport has been tidied quickly with three ports. Have spent all of the money on Douglas Charles so why do we need an international airport?

Conversation digresses about international airport.

Post Maria – (after speaking to UN) when the census is completed in 2020 the population will be back to 50000. However, suggestion that will have to cut health centre provision to match. They may also close some of the smaller primary school schools to consolidate. However, LH believes these are political decisions.

MP – this would have an impact on community fabric.

LH – many officials come to the island and tell you what to do and then leave. It happened after David and now again. **There are few conversations about traditional architecture.**

MP – in reference to example of Haiti, to what extent has aid reduced.

LH – **aid provided / support provided has been sufficient. Farmers have been given support (though some complaining), some have got money they should not.** There came a time when there was no need for support food, but people do not like tinned food and had had enough of rice. Now things have come back – people started planting seeds and crops started to grow – example of lady who grew cauliflower.

MP – rainy season during hurricane into dry season – when do you sow crops.

LH – March-May is dry season – but people were able to grow crops. In Dominica, the statistics show worst hurricanes mid-August to mid-September. Few registered in June, none before late July. These are the Cape Verde hurricanes. The ones lower do not come this way. The Cape Verde hurricanes come across and curve into us. These form late July – August and September. As season progresses the hurricanes come north.

MP – plans for HM – other than house,

LH – **water tanks – except for telephone connection – I am totally independent. My own solar panels, and water tanks for 20 years. All old buildings collect own water – therefore I did not have to rush around like a mad person. I felt embarrassed that I did not get damaged.** It is important to develop a long-standing relationship with neighbours – locals came with chainsaws to help open up his property. People came for showers and ice. **Could link up with Orange (Europe) and therefore could contact relative overseas. Therefore, people lined up. Digicel was down.** Orange put out

signal from Marie Galant – the signal must reach Guadeloupe – the point where I live is within zone. People came around to use texts and wash clothes to stop mildew from clothes. Once rivers cleared of sediment they could wash there.

Those who had planted root crops (only if there had been landslide where they lost) – yams and dasheen – therefore there were abundant crops – as these were planted in June – September.

People knew the old cycles (particularly farmers). The urban community was divorced from the reality from the old cycles. The tourism industry asks to bring in people – and students leave school and LH gives workshops to teach people about tourisms.

LH gave a 30-minute DBS talk about the hurricane. He wanted to set straight the people who believed that god bought the storm,

People are so steeped in religion – in all aspects of nationhood – Dominica flag has a Christian cross – national anthem is based on religions and creator. Previous constitution never had such a religious focus. The ‘myth of religion’ works. Story of pastor who escaped damage – therefore god exists – no!

Shelters – were designated as church or school – without checks to determine whether they were suitable. In Portsmouth, Goodwill, DGS schools were damaged. Schools had little preplanning to determine worthiness. In Massacre – concrete roof but in course of school – happened to be ok. But Woodford school – roof blew off in hours.

LH – government has not really invested in DRR enough. After hurricane David – Dominica Freedom Part – under Eugene Charles – all schools (USIV scheme) had cast concrete hoods and breeze blocks. You were secure but wet – programme not carried forward. Now they find that the walls to the schools cannot support an improved roof – walls need more supports. Now the walls will have to be widened – leading to greater cost in repair and redo. They should have put a programme in which repaired one school per year. Even new wing of DGS – shelters had to house people for months.

MP – lessons needing to be learned – for whole island.

LH – rivers and buildings. Rethink the distances that are legislated. Many lost homes in Castle comfort – due to boundaries for properties near streams – people build up to the boundaries therefore properties get damaged.

LH – it is the watersheds not the rivers that are important. Do not build in the valleys – it is matter of physical planning. Legislation says not to build within 100m of riverbanks – politicians get involved and give people a chance. Police station at Calibishe with brand spanning new

specifications – in front of forest reserve – people squatting in the forest and chopping trees.
Cutting these will lead to landslides - but no one moved people on.

MP – do government use your knowledge.

LH – no – the only time was the head of planning invited LH to presentation – he spoke about the historical background. Roseau is the island ‘down there’. Hurricane created ‘self-contained’ communities and village councils important.

MP – old focus of ODM – community-based response teams. Large event left communities fending for themselves – but less prepared.

LH – One village community leader employed a fisherman around the island. He went to Jimmit – but it was locked up – but moved to Roseau – so what was the point of building in Jimmit. He spoke to people in Roseau and asked them not to forget them. In meantime the fisherman had partaken in looting and boat was filled with TVs. So, village councillor walked home.

MP Did some villages get support because they supported government?

LH – In reality the settlements closer to Roseau were helped first. Here the French helped us but we were ignored by the government.

How about KT?

They were affected badly – over 80% damage. Went through territory and all that were standing were the toilets (concrete cast). One contractor commented when rebuilding we should have one room which is concreted as a bunker (like old French Cachou) / panic room. I build one here – with all important documents.

MP – hurricanes are focus – if something else happens to island – what would it be and how well prepared is Dominica?

LH – do not forget earthquakes and volcanic eruptions – in 2004 when EQ destroyed churches or 1843 destroyed all of point a pinche. The rush is to put in concrete roofs (casting). If engineering not proper – and a tremor – it will rust in framing or collapse.

VE – it is clear that next eruption will occur south of Roseau – head of seismic – John Sheppard – said that might need to evacuate. Hence the Jimmit location for ODM.

MP – what about tsunami? DM a target for this hazard.

LH – in Calibishe and Point Michel has signs – attended an interesting lecture at St Augustine UWI – he said policy should be made not to construct government buildings up to 150ft above sea level. This is bottom of battery at fort Shirley. My house is 50ft.

MP – Calibishe a pilot scheme – RC set up Point Michel – but neither been followed up. CDEMA said that we were woefully unprepared for 2 cat 5 hurricanes. What if hit by tsunami?

LH – Soufriere – original village – 12ft below sea level (450AD) village was covered in tarish – but many escaped. Roseau valley people were historically swept away, and Roseau built on them. These problems have been happening for years.

Interview with JS - Temporary director of Red Cross – 2018

JS – not know the country well.

MP – understand that took over in December – summary since then.

JS – call in December – would I be willing to assist Dominica – thought id be here for few days. But it was actually two-three months – turned into 6 months. I was asked / told not coping well with HM – the structure of the organisation not working well.

MP – the RC sent in a team prior to 2018 – to assess structure.

JS – have national society here – with branches in the communities – tentacles – the federation comes in to assist the national society – to assist with finances and resources. After HM the national organisation did not have the capacity.

MP – did the federation know the local did not have capacity.

JS – federation were aware the national organisation lacked structure therefore needed help.

MP what is a successful structure

JS – board which is properly constituted – a team of staff – and fully functional branches.

MP – your job to make branches functional.

JS – yes – then have general assembly to elect new board – set up organisational structures which make the management function.

MP – how many staff employed.

JS – currently 6 – when I came in 3. I will be bringing in 2 more.

MP – people in regional centres – paid?

JS – they are voluntary. If we have resources, we hire director for local area.

MP – how can you be sure they will continue to function afterwards.

JS – if I were able to show you, you could see the changes – all but 2 have been reactivated. The frustration they were not previously given support or were discouraged. They felt that programmes were sporadic, and they therefore lost interest.

MP – am aware of CDRT and govt CERT schemes. Would not be logical to put together?

JS – not a problem – two different structures and we collaborate – there is need for us to work together – send a letter to work with director of the ODM.

MP – be interested to hear about success of working with ODM – the two schemes have previously worked independently of each other.

JS – I agree – having spoken with government we are looking to get these schemes ot work together.

MP – do you feel desire to restart – because of HM?

JS – difficult to say – I do not know what existed before – **the expression is that people having been longing to reconnect and reorganise** – they only became dormant because of the environment.

MP – what would I expect to see in a fully functional centre (in time)

JS – they have just been reactivated – therefore trying to find their way out – bringing them in for training next week – give them time,

Each year branch needs to have full awareness of local issues, members trained CDRT and members that are able to respond. Typically, when know hurricane is coming – liaise with people 0- ask them what needs are – and preposition supplies. Expect breach which is structured and has preparatory work done so that they have capacity. They will be trained for any emergency.

MP – what about the impact of other hazards

JS – **country is susceptible to flooding, as we saw with Tropical Storm Erika – rain was almost unprecedented. There are earthquakes and volcanoes and susceptible to fires.**

MP – Has HM made other hazards more likely?

JS – **yes removal of trees could be problematic – if there is a rainy season any time soon there could be tremendous landslides.**

MP – what is RC plan for forthcoming hurricane season.

JS that is what keeps me awake at night. Less than two months away. WE are just being reorganised now. Legwork needs completion at 100 miles per hour. My staff are implementing planning – we are linking to ODM, we have training, we will not be as ready as we need to be but we will be better than last time.

MP – RC provide funding

JS – yes, we will. I have a project related to disaster preparedness and we have resources.

MP are resources available because of event?

JS – yes – some societies e.g., American national society have more money because of the impacts of the hurricane. Had support from ECO project. So, some of the resources are always there.

MP – how has the RC balanced work with the other agencies that may disappear.

JS – we balance it well – we coordinate activities – but we are here to stay – there is a task ahead of us that they do not need to do.

MP – is task based on communities where your centres are? – or more broadly?

JS – the set up here is different to normal set up – normally done based on political areas – the centre in each region covers the local area and the surrounding areas which extends beyond the political zones. This extends across a wide area but less so than in other areas.

MP – are the ODM also going to focus and organise in the same way.

JS – not sure – will find out in the coming weeks.

MP – are there plans to work with schools.

JS – branches will reactivate the youth groups in schools they are our future successes.

MP – how do you perceive this work to go – one off event or within curriculum.

JS – finding someone who is interested (e.g. teacher) for them to pass the information onto their students. The best way is to find people who already have a connection.

MP – education covers a generic view of natural hazards – only those who select geography in 4th / 5th form are exposed to regional hazards – little reference to specific teaching to events in Dominica. – so therefore, student out of school is not really prepared other than experiences.

JS – my hope is that the RC work will be part of the curriculum – if you can grab the youths, you will get their parents.

MP if another hazard happens will they be prepared.

JS – this is a problem as minds have been focused on the hurricane threat.

MP – anything else you wish to add.

JS – the last two branches will be established in Delices and Penville.

MP what was response in RC

JS – very good.

Discusses Wayne Abraham.

JS after this process is complete, we have a general assembly – we have all executives in place and appoint a new board.

MP – do you write the DRR report for Dominica.

JS this is in place – but this will be revised. I want to see policy in place and their plans can be made. The RC policy will take in what the national government policies are.

MP – what is national policy.

JS – I will be in a position to learn this in the coming weeks.

Discusses past policy.

JS – I do not see how they can keep an old policy if they are to implement a new climate resilient policy.

Discussion with Head of IsraAid

Introductions – interested in talking to you because you have been helping the schools since HM.

IA – came after HM (week)

CS – was it first time?

IA – bought in by Jewish lady on island – helping people in the east – came on emergency mission – based in east did several projects there – built 100 roofs near La Plain with locals

Between Jan – April – 22 charity spaces and education programme (started in January). Worked with UNICEF. Built a toolkit to assess hazard vulnerabilities. 6 sessions – 2 hours each – train teachers. Then teachers go back to school and work with students. Initially 20 schools and then MF insisted that should go beyond pilot, and then roll out to 73 schools – we roll the programme out. We had feedback and it was positive – but only 15-20 children from each school. Every group of children had to come up with a project which assessed a natural hazard impact at their school. They are reporting on this now, e.g., fencing, slippery steps, a field trip to ODM – based on assessment they did. IA provided a template.

CS confirms that it is the template we had seen.

IA – when I came – I assumed the schools had not read this. They had to read 30 pages and put names of CERT team. But nobody was engaged with it or read it. Till end of July, they needed to submit this to Ministry of Education. Then the Minister can say all schools have emergency pre.

UNICEF and IsraAid – are putting in an education system in schools – in different activities and aspects. I) make booklet easier to read and cutting out repeated paragraphs – make clear what each school has to do – can just open the booklet and retrieve the information easily. Not sure what they will actually do – it is my dream.

I want to train the local staff – to train the teachers with this simulation kits. That would be the first step I will use.

CS - that is what you will like / what will happen.

IA – that is what I want – I will not be here next year to see it through.

MP – Can I just confirm that this links to the training that took place at the end of last year – you had two teachers from each school come in and have training. Did you go to each school?

IA -No, we did teacher training – one teacher from each school came here (Roseau) and then we trained them, and they went back to their school and passed on the information.

MP so you had a collective – they came to you.

IA – yes

MP – are you going to assess each of the 73 schools.

IA – yes, we need to check each of the schools – we cannot accept that one teacher will go back and set up – we have been into the schools and worked with some psychosocial help – we did art and activities, to help with psycho help after HM. If I would be here, then I would make sure that each of the teachers are trained and do simulation training. I would then send them away and get them to train others.

CS – who teaches the teachers – are they specialists on Caribbean islands or geographical education?

IA – no they use this booklet – they just use booklet. No, we do not have educated people in emergencies we use local people who are willing, and they train the teachers – this is what we have got (mumble). We use the people who helped with IA in ‘child friendly spaces programme’ (psychosocial) and IA continued to use them so,

MP – one question I have – after conversations with principals and teacher – is their understanding of different types of hazards – hurricane is not a good example – but perhaps there is a sense in the school they would adopt the same approach for all hazards – e.g., tsunami may require a different drill as an earthquake. There was the feeling that they would adopt the same approach for all hazards – was that your intention? Would different hazard require a different approach?

IA – there are protocols, and this booklet has different protocols are different hazards.

MP was your intention to have different approaches? E.g., are different hazards going to have a different signal for different hazards. I felt for them as some of them did not know. They did not have technical understanding to help.

IA – hopefully, the sessions will provide them with technical aid. Two weeks ago, we notified the schools that they need to identify the hazards around their school. Hopefully, we will be able to come up with tailor made scenarios for each school – cannot have one for tsunami and another. We will run simulation based on the local hazards. Once we have worked with teachers and then with the students. You mention Maria – one of the messages from the minister was that they were unprepared. Many of the students were sent home, windows were shut, and a few hooks put on windows. Many of the schools did not open for weeks to months after the event. This is hopefully something we will be able to engage. Nobody in community wanted to help but we need to engage them. We need to develop understanding that schools were important.

MP – many of the schools were shelters so they could not reopen.

IA – yes some of them – but not all of them – like chicken and egg... some of the parents asked / demanded from school that their children do exams 3 weeks after HM – but ministry decided they

would have 3 days of non-teaching to get through this – it wasn't about the community getting together and using the school as a base in the community – it was about taking my child – I have to fix my house – and you need to take care of my child.

MP – 2 questions more you are using RC or ODM to help set up – a long lasting relationship

IA – up till now had a meeting with ODM last week (for the first time) but up till now just working with the Minister.

MP – are you working with the local disaster councils?

IA – not enough – one of our programmes is community engagement – so – in ideal world the disaster community would work with the schools.

MP – some of the teachers are part of the DC so this would be helpful to you.

IA – ahh, UNICEF is putting money to develop the children – the perspective is child engagement not the community.

MP – one of the questions is – I know how the teachers teach – are you changing this (the programme of study) to bring this into the curriculum – most of them said 'no' they do this in Science or Geography – I said yes but – if you must implement this how do you bring this to everyone? For example, only students study geography in the 4th form as part of CXC and therefore if only 30% of the students choose geography, then 70% miss the information so, how do you bring this to everyone?

IA – laughs.

MP – it has been an issue I've raised with the ministry in the past – I have spoken to ministry about having a week of hazard awareness and then teaching these concepts through different subjects – e.g. art, to underpin the concepts – in this time bring in local experts and services – schools are keen – but you need someone to organise it – therefore I like the fact that you are bringing people together.

CS – some staff of the ministry –

IA – MF was brutally fired.

MP – has she been fired.

IA – she was told a week before school – she had lots of holidays – she was written a letter by the minister to say take an extra couple of weeks / months off.

CS when I spoke to MF recently, they were trying to put disaster reduction in the curriculum. They were not clear about when. They mentioned IA – they were talking about a programme with the Canadian relief agency (Connect to Learn) – they were suggesting that between us and IA that you would implement these aspects.

MP – can i just add that Connect to learn (the resources the schools will use) – IA will implement framework whereas CTL will look at the styles of learning to reinforce these to learn about DRR. (Summary of my credentials) I am very keen to write resources that fit bespoke learning to ensure that students are engaged and understand the local hazard. One method used is to design local bespoke activities , with the help of a local volcanologist – to design fieldwork exercises to engage students. Using local maps and seeing how students respond to local maps.

IA are you doing a programme here.

CS – not the Canadian charity – it is actually a govt dept that supports development – which is supporting a programme called CTL – funds have been allocated already. That is why we want to connect with you. We are working with Erickson – to provide a platform – but the local schools will populate the information –

MP – it is an e-learning.

CS – schools are receiving 30 laptops each.

Ia really

MP – schools have just got them, but they should have been here 2 years ago – they are meant to have on per pupil – but they have delivered 30 per school.

IA – where are they?

CS – each school has a crate.

MP – for state secondary schools

IA – on the curriculum – in my view and according to my programme – 2 method –there is infusion – i) teach DRR through geography and science and topics and mitigation – that you get a different topic (mumble) ii) second method – instead of infusing – get another topic – so you build an emergency preparedness class – add another topic into curriculum – our partner UNICEF – in favour of infusion system. I do not understand why it is better. It makes the need for Maths's teacher to understand another topic. In a more (pause) – we did teacher training weeks ago – Risk = vulnerability...

MMP – laughs.

IA sees DRR as more than the formula – so after this how do I teach DRR maths? Had a meeting with Roberts Gits – senior officer for curriculum and blessing of Dr Blaze – he is doing a fantastic job – things have started to roll – he is delegating – just go and do – we met Mr Gist – how to infuse the emergency ideas in curriculum – he shared all the classes in the curriculum – I do not know what they are going to do about it. I do not know how - but it is on our agenda – our thinking was to engage each child in education 3 times – i) 3-5 yrs. old (4th grade primary) and then in 3rd form – they can do in family class.

MP – social studies)

IA – have in separate topic – all children have exposure to measures.

MP – will teachers that have these topics w- will they have training?

IA – will train DRR. Will teach all teachers on island.

MP – just wondered specifics– issue is that teachers come out of state college and start teaching – this would not be the case in UK – they often admit they do not know and just read out of the book.

IA – this is the problem with infusion method. They will come out of state college and teach e.g., maths and then must teach another subject they do not know.

MP – we have a system in the UK we teach like you describe (cross curricular) – have a topic in different subject – but applied to their own subject –

IA – which topic do you do this for?

MP – in our school we do 3rd form holocaust – they are taught this in all subjects.

IA – how do you do this in Maths. (Talk about Jews)

MP - they are not that crude – teachers create and integrate.

IA – it is possible – but in Dominica it is harder. Something in the preparation of teachers – in training of teachers to be creative – more difficult.

MP – it is out of your hands.

CS – I met people from IA, and they were doctors - what is remit

IA – they are DRR and work in 80 countries – Dominica – is first country where they have done education – they often stay for 3 years. It is social support or physical support.

CS – everyone talks about it they thought it was a positive thing, but they did not think it work for the psychological – but they did not think it was enough – we talked for a couple of days – but they felt that they needed more than a couple of days – they said it was great and they provided support for teachers. Is it possible that they would need more?

MP – everyone loved this (teaching) – some did sessions with other staff – all groups set up with students – but this year they have not carried it on. It is important – it is not their priority – you need to go back into schools.

IA – we had opening ceremony – this hopefully will spur them on.

MP in the classes I taught – I was involved in – students were keen to be involved – students were asking when the programme were starting this year – if you can go back in it would be important for the students – if you can get message – one of the schools bought 2 students from each class – provided the sustainability – idea was a student led programme – students create film and resources for other students e.g. assembly – I thought a wonderful idea.

IA – in focus group – students engaged – the 20 students were engaged – they did not have to sit and write.

MP – if those students worked with DRR then you integrate with community – if you speak to the communities, it was how they responded after HM – so

IA – not sure Ia has capacity to hold it .- perhaps one step for teachers and principals to develop the idea – not sure IA has capacity to bridge this gap,

MP – it is good that you are providing this authority – my concern is that you will go and that they will not carry it on.

IA – 2 things in plan – for this year – established to continue – i) is the 3 learning points in the curriculum – but if they use infusion it may be different 0- but if we are using 4th grade teachers they should be able to continue for 2 years and continue – I was able to get the chief of the fire to train all in first aid – to do this without charge and go around all 11 formers and train first aid – IA will support this this year – hopefully all will have training in first aid. I did my job –

MP – create an empire.

Ia – not difficult to do – they have training in place.

MP – who will replace you.

IA – do you know name.

MP Sawana Fabien (of course)

Discussion about HM

IA – there was no discussion about hurricane before HM –

MP – some do not broach subject at all.

IA – this will be interesting for you guys

Discussion of different hazards on island

Meeting with the RC. – New director – October 2018 (poorer sound quality)

RC – we are working to improve hygiene and encourage the community and the schools. **We do not have direct plans in the schools for DRR management.**

CS – the ministry, ODM and RC would be a strong message if worked together – the RC should understand the response.

RC – we will be in communication with the ODM.

MP – when spoke to DR Salmon- he appointed a lady to oversee RC outreach. You have more staff now – do you have a responsible

RC – we may have one in the branches –

MP – what would the branch managers do

RC – training – keep the branches active.

MP do you still take volunteers from state college - you have some outlet to younger people –

RC – we have youth group and the college students.

MP have you thought about installing this into schools.

RC – we have yes – but it is about developing resources – we have managed to have some success in local school goodwill but less successful in other schools – it is difficult to get the teachers to support.

MP – reason I ask is that each school has to write a DRR plan and a teacher has to be responsible for this and therefore they have to be involved.

RC – yes, yes, but the teachers may not be pleased with extra work.

MP – so I could link the responsible staff to the RC.

RC – yes, but in the branches the teachers could work with the branches.

MP – could you explain the branches – are they different from DC?

RC – yes, they are different entities, even the health teams are trying to work with the DC in each area – but we work with the DC to develop training.

CS – which communities are most active – we have been doing interviewed about Maria.

RC – Layout has an active community post Maria and trained their community.

MP – is Mero a good group.

RC – yes and La Plaine

MP – Pointe Michel still going.

RC – yes but not very active

CS – so basically – introduce us – we are familiar with the RC – we have been working with students to collaborate with RC – students (explains the Portsmouth programme with RC) discusses the prospect of other students coming and working with RC in future? Example of projects undertaken in the past. Discusses the importance of working with RC in past. Would like to continue the collaboration – RC seem happy with this.

MP – can I ask – you have 8 communities you work in – plans for expansion – develop existing.

RC – **yes to expand.**

MP is long term plan to build a network.

RC – we are looking to develop CDRT schemes in each district rather than in each location – we do not have much coverage on the west coast – we have this one, Portsmouth and Layout.

MP – will each centre have responsibility for a series of villages – so you are creating a network?

RC – in some areas we have two/3 branches.

MP – relationships with ODM

RC – decided to work together to cover in areas of DRR – we involve them in areas of DRR – for training.

CS – will they provide all the training or some of the background.

RC – we work with the ODM for training (we work closely).

MP - is CERT scheme focused on same areas.

RC – not sure what areas they focus on – not the same

MP – in future – after an event e.g., Tropical Storm Erika – not as close a link –

RC – CDRT / CERT?

MP – no Jimmit and here – are you working together.

RC – will be working on NEPO – once the EOC is set up we will be present – we will work alongside ODM to work on distribution – we will speak with them about what we would like to do in regard to the National disaster Plan. There will be more NGO there – so ODM will want us to play a part – we will be doing so much for the country – it has been suggested that we could help with the management of the shelters – try to improve the govt shelters, but we do not have the capacity to do this – there are existing shelter teams on the island, but we do not have the staff base.

MP – good

CS – people monitoring shelters were hoping for some assistance as it was not straight forward - - need more support for the safety.

MP shelter job voluntary.

RC – yes (talking over in agreement).

Some people were like I am not staying in the shelter.

CS – some of the results will be the different communities had different facilities in the shelters –

RC – problem of shelters – churches and schools – local centres used as space – therefore if in the shelter there may not be the same facility – depends on the people.

CS – shelters and health centres – it is important to get the students out of the home if damaged, so these shelters were very important.

Rc – churches and schools complained about the disrespect. (Mumble).

When we are training we are trying to teach people how to manage the shelter and keep it safe as possible. We have a long way to go

CS – it is never easy.

RW – hard to get the funding to deal with the shelters.

MP – in addition to 8 centres – have zika programme at present – are there other programmes at present or is it just rebuild? Which awareness – whole nation programmes planned?

RC – not right now – we will continue with our programme of DRR – but we will continue to focus on training and developing training plans

MP – of the resources you produce – e.g., pamphlets – which of these are most effective – my wife works WaterAid, and they do research on what works – are you going to consider this – why spend a lot on resources people may not read?

RC – after the training and intervention we evaluate the training – but we do not formerly look at this.

MP – speaking to KPB – about social media – is there a plan about social media – many young spend time on phones.

RC – you mean Facebook.

MP – we have a comms person who deals with this?

RC – we have some films and adverts.

MP – did you say the officer works downstairs ? I might organise myself to annoy her.

CS – talks more about projects on the island.

Some conversation about HM – and thanks for time.

Interview with Chief Education Officer 2018

MP – how long had you completed job before HM.

MF – came into role in July 2013.

MP – were you in post on day of HM.

MF – no as PM had shut down schools – and had to drive to southern part of the island.

From the Sunday evening locked the offices down – then went home with partner. Which was a good decision.

MP – how long till you got back to office.

MF – 2 weeks – bad access – I could have taken a boat – but I was not brave enough.

MP how did you cope in Bagatelle?

MF – only 3 houses with roofs. Mine was one of them. Monday was a day of waiting. Asked myself how do I prepare? My husband wanted to go to work on the Monday morning. Matter of waiting.

MP when did you lose utilities?

MF – when lost power (late afternoon) when we lost power, we thought it was a category 1 or 2.

We could hear the river and then the whistling. Hey this is serious. We made some preparation – but this is serious – we need to put things down.

MP was your roof concrete?

MF – no it was a pitched roof – but we were lucky. We thought the galvanise was gone because it was leaking but the next morning the galvanise was still there. WE did suffer the loss of some windows which were broken – so we had some flooding in bedroom – I spent nights bailing out water.

MP – outside evidence of mudflows / debris

MF – everywhere was covered in mud – I saw homes which I had never seen before – because the trees had all gone. I walked to the river which was damaged after Tropical Storm Erika – but HM made it worse. There were many landslides after the HM. The boulders were huge – taller than me, bigger than a room in a house.

MP has landscape changed permanently?

MF – around Bagatelle there was some loss of landscape – but in Pichelin – the land has changed much more – the land was all river – which means areas near river expanded across the whole valley.

MP – warnings received?

MF – Met office gave frequent updates – TV for me allowed me to monitor – I also used the internet national hurricane centre and domnica.gov website – I checked both and made my own judgements.

MP at what point was you aware it was a category 5?

MF – when wind started whistling. When I last was able to watch TV it was Cat 1 and 2.

MP – did this impact people reactions?

MF – yes – it was probably good people not aware of cat 5 – as they would have been more fearful. People still made some preparations.

MP – people aware of previous hurricanes – what impact does this have on ability to prepare.

MF – since Maria we will be better prepared than before.

MP – how would you do things differently?

MF – we are fixing house, guttering and windows need to have shutters and be better prepared. Water – I am working on better storage. We are fortunate that in community there are 3 springs. People use this as drinking water. There were few effects from drinking this. But for me I want storage.

MP would you consider moving towards renewable power.

MF – this is a possibility. We would consider this.

MP – was shelter nearby.

MF – yes primary school and church building – however the PS did not fare well this time as windows were broken and there were people in the buildings. These people all had to move to the basement.

MP – was Grand Bay used?

MF – no – glass windows on one floor so we felt it was not safe.

MP – government actions – how is government moving forward.

MF – PM wants Dominica to be first climate resilient country in the world we have been looking at this within the education system – this is now our top priority.

MP – current form of teaching – general teaching about hurricanes in lower school – then geography in form 4 and 5 a Caribbean general approach to hazards. Change in focus?

MF – one of things changing – school emergency plans – working on this now – so that schools have a plan by the end of July. In doing this we are using a participatory methodology that uses students and the community.

Discussed session three fieldwork with MF.

MF – we are going to do a 2-day training with teachers – and then they will nominate student leaders – which feeds into their plans – so that by the end of June the plans are complete.

MP – what you like to see by the end of next year.

MF – besides schools working on plans and working on safe school policies. We will have an assessment tool developed by CDEMA as we move around the schools. Out of that assessment will come the action plans. We want to look at the curriculum and how the whole disaster theme is enthused in the curriculum. We need to look at the lower years and see how we can introduce hazards into this – the plans will help understand this. So, if the plans suggest a need for first aid or search and rescue, we will train the teachers. We would like to see drills and simulation in the schools.

MP – are you thinking of making a hazards week more important event.

MF – eventually we hope these plans will be incorporated across the school year – however we hope to have a drill (national) in the summer of this year. WE are working with UNICEF, and we hope to have a closing ceremony.

MP – are ODM going to help – and other agencies.

MF we want to work with the ODM – we hope to continue working with other agencies. We need the plans to be sustainable – we have tried to keep it simple – but after this we want the emergency management committees with focus on health and preparedness – so that people know who is responsible.

Discusses lockdown drills in UK.

The schools will have to identify the effect of different hazards e.g., flooding, earthquake, to suicide or fights. So that they can have an understanding.

MP – if you could get officials of hazard working in disaster management – could you get them to work with the schools?

MF – the template is based on the tsunami smart scheme template. Schools need to assess their own vulnerabilities. So, Bellevue Chopin will not have the same preparation for tsunami as a coastal school.

MP – do you see the students working to teach the community?

MF – in local government department / districts – in each community there are disaster councils – we need to get more out of them, and we would like students. We are looking for student leadership through the student council – working with UNICEF to develop small projects.

Discussion of local fieldwork plans sharing with local schools.

MP – what is your expectation from the schools.

MF – we need some guidelines to help the students.

MP – do you have direct contact with SRC – through the ODM.

MF – through ODM but not directly.

Educational interviews with teachers.

The following transcriptions represent a summary of the school and teaching of Geography within it. Staff were given the following questions to summarise:

- i) How does the school operate daily.
- ii) What is the provision for Geography and teaching?
- iii) How is the school resourced?
- iv) do students study natural hazards as part of the curriculum?
- v) Do students attend fieldtrips to support their understanding of local hazards / geography?

Interview with GW (Portsmouth High School) 2013 – a summary of the education system in Portsmouth High school.

Teaching is like the UK. Students use textbooks and exercise books mainly in class. Sometimes students work in groups. Fieldwork is not regularly completed rather students use textbooks to learn fieldwork skills. The fifth form complete a school-based assessment which is an individual project like coursework. Students have access to the Internet in IT classes however these need to be booked. There are no computing facilities available to students in geography classrooms. However, students are sometimes able to see videos or DVD's if we can book The TV facility. However, this is not common.

Students are in form groups of 20 to 25 pupils, during their first 3 years at school. During this time the students learn social studies rather than history or geography. At the end of the 3rd form students are given the opportunity to select CXC options, of which geography is one. Of the 100 students in a year group approximately 15 to 20 choose geography. Students learned about natural hazards in the 4th form and the 5th fall , however, they do not cover this in social studies. This means that students who do not study geography as an option do not study natural hazards. The whole school sometimes has an outside speaker in assembly; however, this is normally for a 15 to 20-minute period. The students have been visited by the fire brigade to teach them about the risk of fires, however, this is not an annual occurrence.

HS (deputy head) – summary of education in Castle Bruce Secondary School (2013)

Castle Bruce high school has over 500 students. Students are taught in 5 forms between the age of 11 and 16 And each class has an average of 28 to 30 pupils. school starts at 8:00am and finishes at 1:00pm. Local students may participate in after school programs such a sport. During form 1-3 students learn social studies for one term per year, instead of history or geography. The end of form 3 students can opt for geography as one of the CSEC options. The schoolteacher's students from a range of backgrounds and locations including students from the Kalinago territory which make up roughly 1/3 of the school population. The school has a computer lab, and some classes have access to a portable whiteboard and projector. Most students are meant to receive a laptop however the school has not received these yet from the government. The Internet access at the school is intermittent.

In social studies students will learn about landforms, the Caribbean and tourism. In the second form students learn about hurricanes. However, most learning about natural hazards is completed in the 4th and the 5th form as part of the option subject geography. The focus of natural hazards teaching

in the 4th and 5th form is mainly whole island or the Caribbean. Some teachers may take their students outside of school on local field trips however this is not common.

Interview with LM (2013)– Deputy Principal of Orion Academy (Roseau)

Orion Academy is a private school where students pay fees of 400 pounds or 1600 East Caribbean dollars. In 2013 the school had 35 students. The school follows a standard education program however, it is not required to follow the state schemes of work for students in forms 1 to 3.

Most students will leave Orion Academy in the 5th form and attend State College in Roseau or move to another school abroad. Students travel from across the island to come to Orion Academy, however, most live within half an hour drive of the school. One student drives from Marigot which takes them between one hour and 90 minutes.

All students study geography informs 1 to 3 and have at least one class per week. Students learn about different natural hazards which can affect the Caribbean, however, mainly learn about the impact of hurricanes on Dominica. Currently, there is no fieldwork which is specific to geography. However, because of the small size of the school, all students attend trips such as visits to the Layou River, or hikes to the Boiling Lake.

The school has and an IT room which can be booked by the teachers or used to research by the students. Many students bring their own laptops to school and use these in the classroom to research what is being taught in the lesson. The school has a projector which can be used by the staff if booked. Staff teach their lessons using their own laptops.

The school day runs from 8am - 2:30pm. After this time, students mostly go home however some extra classes are put on for form 4 or form 5 near the exams.

Interview with BP (Deputy Head and Head of Geography)– Convent High School, Roseau (2013).

Convent school is a Catholic Church school for girls in Roseau. In 2013 the school had 536 girls with an average of 115 students in forms 1-3. The school is run with a government assisted grant which helps pay the teaching staff. However, so that the school can purchase resource is and some equipment the school charges student of 580 East Caribbean dollars(approximately £100 per year). the students come from all over the island, however, most students are from Roseau. Students are required to achieve a certain academic level to enter the school which is conducted via test. Some

students who score lower than the expected level may gain entry through an interview, however, there are only 13 to 15 places per year available in this way.

The school day is unlike most schools in Dominica. School starts at 7:50 AM and ends at 4:00 PM. Most other schools in Dominica end at 1:00 PM however to maintain the high academic standards set by the school a longer day is necessary. The school has 3 computer rooms each with 40 computers and it also has a resource centre, which is like a library, where there are 20 additional computers for students and staff to use. Teachers often use their own computers in lessons, and many will use projectors to teach their lessons. Fieldwork is often conducted annually in the local area, and it is encouraged in geography lessons. Geography is taught through forms one to 5. The school has 5 dedicated geography teachers including the head teacher and the deputy head teacher. Students choose geography at the end of form 3 as one of their CSEC modules. As part of this course students learn about natural hazards. However, in form 1-3 the students learn about hurricanes and their impact on Dominica as well as volcanic activity in the Caribbean. Students will also learn the local area which refers to local hazards. Many of the students who leave convent will attend State College and then attend University, either at the University of West Indies or in a different country. Some of the teachers at this school and others in Dominica study geography at convent.

Interview with GW Portsmouth SS – 2016

This was a discussion to understand natural hazards provision in the syllabus of Geography for form 4 + 5 students at Portsmouth and her understanding of local hazards.

The form 4 and 5 students spend one week on natural hazards as part of the course. This mainly focuses on earthquakes, volcanoes and hurricanes. This part of the course is taught from a Caribbean perspective. One example that we study in the Caribbean is the Haiti earthquake from 2010 with a particular focus on the specific hazards, the concept of risk, the cycle of management and hazard Maps. We also look at how volcanoes and earthquakes are monitored. The other part of our study includes a threat of hurricanes and measures taken to overcome those threats in the Caribbean.

Currently we have 24 students in the 4th form and 16 students in the 5th form. The number of students in the 4th form is an increase from our typical average of 16 students. This may be due to tropical storm Erica. Neither The Red Cross or the office of disaster management have visited our

students. However, a person did visit the school to speak to teachers about the risk of tsunamis and did a short session in a day. This session spoke about warnings and simulating risk.

Tell me about the hazards that you have experienced in Dominica?

The most common hazard that we face is landslides. Floods are also common, for example those associated with tropical storm Erica, for those who live near rivers. Many landslides occur in areas that have steep slopes, lots of rainfall and a certain rock type, for example Petite Savanne. Although storms are common, we generally do not get hit by strong storms. The last major hurricane to hit Dominica was in 1979 called hurricane David. Tropical storm Erica did not do much damage in Portsmouth but did give heavy rain to the South of Dominica. The main impact nearest to Portsmouth was the collapse of the bridge South of Picard.

Portsmouth has received earthquake activity, the worst of which was in 2004 where the epicentre was 10 kilometres to the North. This caused the church in the town to collapse. Generally, we do not receive much seismic activity near Portsmouth. I believe we have a ground motion sensor to monitor activity. It is possible for us to have a volcanic eruption and there was volcanic activity in 1997 near the Valley of desolation. Volcanic activity is monitored by the SRC at The University of West Indies in Trinidad. They use seismographs to monitor the activity. We would be heavily reliant on the authorities were there to be a large earthquake. I am aware of the threat of tsunamis however do not think it is likely to happen. The most likely threat is from an earthquake or volcanic activity but believe that this is unlikely.

Currently we do not have student participation regarding natural hazards, and we also do not have a geography club.

Interview with BP from the convent school in Roseau, 2016.

Can you tell me about the provision of natural hazards education for students in your school?

Currently we can adapt the syllabus to match our circumstances. We can change the lesson and the topic based on events locally which gives us greater freedom to explore hazards as they happen. At present form 1 studies transport and hazards. Form 2 covers hurricanes, earthquakes, volcanic eruptions and tsunami hazards. This includes information on responding to a hazard such as drop cover hold for earthquakes. Form 4 covers earthquakes and volcanic eruptions and we link to tsunamis. We recently had an earthquake off the South Coast of Dominica near Martinique. Some children were fearful, so we focused on the impact to reduce anxiety. We have also had experiences

of ashfall from the Montserrat eruption in the 1990s. we use Google Maps to teach students about bad weather for example the track of hurricane Matthew which led to a lesson on how to prepare for a hurricane. We like to take as active approach as possible in lessons. Approximately 40-50% of students opt for geography in form 4.

We try to develop student understanding outside of the classroom with cross curricula weeks in the school year. For example, we have a history day which looks at the history of Dominica. We also have a hazard stay which uses each lesson to improve student awareness. We have also run sessions on recycling plastics and the use of seat belts while travelling.

How are you affected by tropical storm Erica?

There has been an increased perception of hazards by both staff and local parents. This is mainly because of the flooding of the Roseau River after tropical storm Erika. The response time of the river was approximately 2 hours after the heaviest rainfall. Some areas on the coast received some coastal flooding and some people in the South of the island subject to landslides however there was no such landslides in Roseau. There was also a 5.6 magnitude earthquake this past week Which cause my fridge to rattle. We often get seismic activity once every couple of months although no significant damage was caused on this occasion.

Interview with MB teacher (Orion School) 2016

Can you tell me about the influence the Ministry of Education has on teaching?

If you are a government school and you request help from the Ministry of Education the inspectors will come to the school to check the curriculum that you are teaching and offer technical assistance however, they are not commonly active.

People higher up in the Ministry of Education do not know what is really happening on the ground in the schools. Often the chief educational officer he's not well informed and her dignitaries do not carry out their jobs properly.

Students are meant to receive a laptop in forms 1-3, however this is not the case as many of our students bring their own computers. The Ministry of Education was meant to increase bandwidth for the Internet after a request by schools however the fibre optic cables that the ministry was meant to use have not been laid. In most schools the teachers are responsible for the provision of learning. Many teachers use Google classroom and construct their own curriculum. Many teachers do not have University qualifications to teach and instead start teaching soon after State College. Some

teachers will offer extra classes after 1:00 o'clock in the afternoon such as debating, environmental science, IT, or PE.

Interview with HS, deputy head of Castle Bruce school in 2016.

Can you summarise the natural hazard education for students at Castle Bruce school?

Our students study social studies in forms 1 to 3. In this time, we only cover the hazard of hurricanes however we sometimes talk about landslides especially in the area between Castle Bruce school and petite Soufriere. we do this when the weather is bad in case the road is cut off. Sometimes due to the steep relief we must send students home early.

As the warden of the local hurricane shelter, I believe it is important to study hurricanes. We sometimes get earthquake activity, but it is at best intermittent, occurring once, twice or maybe 3 times per year. We do not teach students about tsunamis even though they can threaten the low-lying areas at the coast.

In forms 1 to 3 we cover hurricanes through project work, relying on the experience all family and friends. In forms 4 and 5 Those students who study geography for CXC study cover natural hazards in greater detail but only around 20% of students do this.

The government officials very rarely visit the school. At present we do not have laptops for the students in forms 1 – 3, though we have recently received a delivery from the Ministry of Education with a small number of laptops. The Ministry of Education was meant to install fibre optic broadband, but this has not happened. We do have an IT room that teachers can book if they want their students to do research.

Interview with HS April 2018 Castle Bruce – post Maria (headmaster and shelter).

HS – I am only manager of shelter – for now. Volume of work is high – but role is voluntary. The ministry should pay us.

MP - were you paid by the school?

HS – yes.

MP – have you worked with village disaster council.

HS – I worked with VC as shelter manager – also did program CERT – with Mr Corriete – a certified CERT provider.

MP – do people come to you?

HS – a team of (10) us and people come to us. All 10 people were in CB when HM. Different people did different roles, but my role was to manage shelter independently.

MP – is teaching your main vocation?

HS – yes

MP – other than CERT scheme and shelter – any other experience of DRR

HS – been shelter manager for 4 years – asked because worked at the school – and because of being senior member of staff.

MP – what is role?

HS – tantamount – it should have been a team effort – but team did not pull weight – I had to monitor arrivals, set up rooms, I had to deal with problems. I had to manage keeping peace, and deal with difficulties managing waste.

MP – did they have to sign in / curfew in shelter.

HS – some persons stayed full time – some stayed part time – people were coming all the time from different organisations and asking about what their needs were. I had to manage food.

MP – how was food managed?

HS – persons were overwhelmed difficulty – some people lost roofs – therefore I had to take care of food preparation – persons who should have been there did not turn up – therefore looked for other volunteers to help with food preparation. I had to stay at shelter at times.

MP – did your family stay at shelter.

HS – at start – yes but in October my family moved. I have running water at home now but no street lighting or electricity. Teams are gradually working to restore power.

MP – before event did you receive warning – and how?

HS – There were radio announcements – as part of CERT team received messages.

MP k- -were they accurate.

HS – no we were told cat 3 but it turned to cat 5. After time announcements said maybe 4.

MP what were strongest winds

HS – winds up to 150mph in hurricane David – but it was worse this time.

MP Warning by radio – or do you look by self?

HS – I chose to listen and research myself and listened to other people or by WhatsApp.

Son started job on Monday – at Ministry of Education – but job did not start because of the hurricane.

Conversation about son.

MP – before event – in shelter – how far in advance did you receive notification about need for shelter.

HS – one week before – met with thought something was happening – with emergency services – one week before – shelter was opened because of harsh weather – one lady came in advance.

MP – how many times opened shelter in past 4 years.

Hs – few – some people take weather for granted.

MP – what personal planning did you make at home?

HS – my work – did not board windows or doors – took for granted that the house was safe because of the concrete roof – important documents were safe, food in the house and fuel in the house. Some of this was damage as doors blown away and windows damaged. The house was not totally hurricane proof – but never worried that the roof would be lost.

MP – what produced most damage in CB?

HS – combination – not one factor – sounds like trees were being torn apart – which made me fearful. I wished I was home – but by 7pm I was locked in the shelter with assistant shelter manager and several families were in shelter. Some came late – up t 12pm at night – with one of cousins – she had to run. She had come from new houses, but these were not sufficient.

If hurricane had occurred during day, there would have been more deaths.

MP – would people take seriously if in day.

HS – people may have tried to run once seen damage – which may have caused damage. One person joked that the new national flag was galvanise. Wind took 95% of roofs. Few galvanise roofs remained.

MP Was second main damage flooding?

There was lots of water – but main damage was wind. There were landslides all over the place – some people were drowned and places were impassable.

MP – were routes out of CB passable?

HS – all routes were closed, people had to walk – but some people came and used machinery to clear roads. There was some success – food preparation was a success. People also made efforts to get back to their homes – sense of pride.

MP – how long was shelter open until

HS – until October.

MP – what was not successful in shelter.

HS – cooperation of persons – some people called me the member of parliament – to negotiate – I felt overwhelmed with the responsibility – difficult to keep the area clean. Some people were misbehaving – and I had to threatened them with the police. Some people came to stay.

The shelter was also damaged to an extent – damage attributed to people staying.

MP – when did school start.

HS – by October – some teachers back – some students back in November but they returned gradually.

MP – will people make better preparations for the future.

Hs – some were not insured therefore unable to get repairs. Insurance payments were made by some companies.

MP – what would you do differently?

HS – board windows and doors as these were greatest losses.

Ronald Austrie – Portsmouth – Headmaster Portsmouth SS –

MP – were you in DM during HM.

RA – yes – we had school until the day before – on the day we had to send students home in the morning – and I was back the day after.

MP – school is a shelter – are you in charge.

RA – during the time PSS was used as a shelter I could not access the site – run by the shelter warden– in previous times shelters were only opened for 1-2 days. But this time the shelter was opened for much longer – 11 classrooms used – the shelter was used just after the students were sent home. The organisation was a little chaotic.

MP – were you given warnings – if so, how many?

HS – lots of warnings came through – disaster coordination unit put out warnings the Prime Minister also put out warnings (general) but he also declared that schools should be shut and people with family.

MP what is the main way messages received?

Ra – main way is by radio. Hurricane was not expected to be strong – then message said it was directed straight toward Dominica, we were told it was cat 2 then 3 but we did not know that it would be cat 5. WhatsApp and telephone enabled message transmission. Still a lot of people did not know it was cat 5.

MP – were population experienced?

RA – many people in Portsmouth had not experienced hurricane David and therefore unable to pull on experience.

MP – was main damage wind / water.

RA – lots of damage from both wind and water, mainly water. Many lost roofs, and home flooded. Debris came from the hillside, but many did not know where these boulders came from – the flooding would have to be huge to move these boulders. Tree trunks up to 5ft across came down mountain – intense winds for 5-10 hours.

MP – do you feel the students were well prepared?

RA – no- we had not faced a hazard of this scale – even hurricane David was different as winds were still strong but there were less constructions therefore more homes lost roofs, so therefore there was more debris. We could not prepare for this.

MP – how would you prepare for students in future.

RA – heed the warnings – I did not protect my windows – many thought it was just another warning. Therefore, people did not adequately prepare for it. You must learn lesson from Maria.

MP – will you do something in school this year.

RA – we are putting together a disaster management plan – we will do some drills and cover some other types of hazards – we recently did a fire drill. We will be using the student council to sensitise the students so that the students become more aware.

MP When will you do this.

RA – we will put this into place by the end of the academic year. So by 1st June we have to have a functional plan before the end of the academic year. We already have templates to work with, since 2016 for disaster and emergency planning. We have to customise it for our local needs.

MP – will you encourage teachers to teach more on hazards in class.

RA – we do this, but we need to take more focus. Since the event we have taken more interventions, we have undertaken psychosocial interventions – students are briefed, and activities undertaken – aided by international agencies. This happened after Maria. The organisation was Samaritan purse and UNICEF conducted these approaches. There is much talk about resilience on the radio. The PM is proposing Dominica to become the first climate resilient country in the world. Resilience is a word in our vocabulary. We also need to add the word sustainability.

MP – how do you personally make yourself more sustainable / resilient.

RA – reconstructing roofs differently. In our buildings we have to put hurricane ties. When fixing zinc – we need to put screw in each corrugation. Before Maria we missed out screws. Now instead of using 50 screws we now use 100. We also space out the screws to improve security.

MP – did you lose electricity.

RA – poles were blown.

MP – did you use solar panels?

RA – that is a good method, but they need to be designed so that they can be removed so they are not damaged by the passage of the hurricane.

MP How long without fresh water

RA some villages do not have piped water – but a water truck supplies to villages. In some villages the storage was compromised. We had to get water from the spring. The main supply was back on within a month.

MP – was the main urban areas fixed first.

RA – not sure of pattern – I think that I depended on damage. In my village we used to get supply from the mountain but now the water company has rerouted from Salisbury. Depends on the damage sustained.

MP – what is the biggest threat in terms of hazard for the future. Will people think less about other hazards.

RA – hurricane is going to stay in your memory for a while. We have experienced damage, and this will stay in your minds. We may be at threat from fire, and there is the threat of tsunami. Chemical attack might present the other that we have not faced (pollution). There is threat from earthquake, tsunami and fire and hurricane.

MP – 11 families – damage to shelter.

RA – 11 rooms – but hundreds of people. We had some undesirable people who stole stoves from the cooking area and stole food. People also used school indiscriminately starting cooking fires in passages between classrooms which caused vandalism – people did not use the facility well.

Interview with LM 2018 – school principal of Orion school

MP – where do you live.

LM – Point Michel – it was badly affected.

MP – what were you doing in time before / during / after HM.

LM – working as principal.

MP – how long was school open?

LM – school open until Friday. On 16th we had a schoolwork day to invite parents and students in to help build the outhouse. We did not hear about the storm.

MP – When did you hear the storm was coming your way.

LM – I used the internet to find (NOAA) to find out about the path of the storm – but I was uncertain that it was going to hit Dominica until the Saturday evening. I use 'Weather Underground' also because it is reliable.

MP – what predictions had you heard about.

LM – storm would pass through us, but it would be cat 1 or 2. We had gotten complacent after Irma – we got ready and then it passed us by.

MP – On Sunday what did you think – when did you think you needed to prepare.

LM – they only classified it as a cat 5 on the evening of the Sunday – but I moved up to Springfield guest house on route to Pointe Casse. It is a tropical research centre. I was invited there because of the storm.

MP – what information did you receive from government / officials.

LM – Skerrit came on radio on Monday evening – but I did not really listen until that evening – they basically told us 'Stay safe'.

MP – what point did you lose power.

LM – the power went down by Monday afternoon – or perhaps it was the internet. I remember losing electricity early (than the storm hit).

MP – did they cut the electricity before on purpose.

LM – I think so.

MP – was this like Tropical Storm Erika or Hurricane David

LM – was off island for this.

MP what caused the most damage – wind or flooding.

LM – wind ripped off roof – but only had some flooding – but this was minimal.

MP – Did the river bring out debris - did you go out and look the following day.

LM – the river was full of trees, but I do not remember large boulders, however I remember tonnes of mud.

MP – before event – have specific plans for school and personally?

LM – tell you truth – no – we are working on disaster management plan sent by Ministry. This needs to be done by summer. We did not prepare by bringing in water at Springfield as we thought there would be spring water – but it got blocked – though we had some water.

MP – do you think the teaching in school helped students.

LM – probably not.

MP – did you find the teaching of hazards is too generic.

LM – yes. It needs to be more personal.

MP – are you going to change the curriculum to localise the impact / preparation.

LM – yes – we can use the local volcanologist to help.

MP – perhaps you should involve the students to gain their perspective.

LM – we intend to do this. We had a principal meeting before Easter break – which discussed the prospect of involving students.

MP – do you feel there were things you did well in advance of the storm?

LM – do not think so.

MP what would you do differently.

LM – more specific education – learn from mistakes, what we needed to do.

MP – is it the school's responsibility or the responsibility of the organisations and NGOs?

LM – this would be great. I think they are the experts, and they should come in and help.

MP how was the school impacted was school used as a shelter.

LM – - not a shelter - we are still being impacted – the ceiling is still falling. The second building had two sets of trees falling on it – cook house. Looters came and took anything out of the building they could find. They also broke into this building and took tablets and projectors.

MP – are you insured and did govt help?

LM – no insurance – we have asked govt for help.

MP – impact on school numbers

LM – had 53 – lost 16 – went overseas – but back up to 51. Conversation about students.

MP – will you be able to accommodate those that left.

LM – some will not come back but we can accommodate up to 75.

We had two weeks of school at the start of term –

MP – decision not to come in by you or govt?

LM – by govt.

MP – when did you return.

LM – following Monday – people took advantage of empty buildings. The effect of the hurricane was bonding – aside from the looting there was good community experience. I did not have a vehicle – got rides easily – people were friendly and sharing their stories,

MP – is community spirit stronger.

LM – I think so.

MP – is there less tension walking around town?

LM not noticed change in tension but better community spirit.

MP – have people been cared for well?

LM – psychosocial training given to the teacher s- we coped well with this. We have close bonds with the students – we talked a lot and we did a few activities.

Discussion about relevance of activities.

The kids were great, the teenagers were not whining – we only had a generator after one month. We were allowed to open in October due to having running water. The kids did not complain about the little things. They had experienced something much bigger, therefore they did not complain about small things such as dirty clothes. They were more resilient.

New poster encouraging climate resilience – but it is strange that the poster is a white person's hands.

MP – support from organisations?

We got the generator from Samaritan's purse. We also had big burly men from UK (from DART) who were here removing fallen trees from the site. I did not even ask them to come – they just turned up.

We also received some new chairs and they were supposed to give us solar lights, but this did not happen. We gave the government a list of missing resources but have not had this. We also received help from a Muslim organisation as we have Muslim students.

Conversation about teaching in Dominica.

Interview with BP (Principal – Convent)

MP – What were events up to HM?

BP – up to HM quite relaxed there was no sign it would be bad – thought it would be a tropical storm. We chose to leave the alarm system. Before the storm I was in Pointe Michel as my home in town was being reconstructed. I was nearest the ravine where people died.

Monday I was called by ministry to do a review of teachers – but then the storm was due to come along so they did not arrive. I went home and then at 830 I lost internet but lost power the next day. I could still use my mobile until 10pm to track hurricane.

MP – what sites use?

BP – storm pass – I like this as you can see margins of the storm – and 'Weather Underground';

MP – do you use the government site.

BP – I am a geographer therefore know what not to use – the government one is for Canefield only.

On Monday HM struck at 1030 and first piece of galvanise started to remove – only then did I realise it was going to be bad. When service of phone went down, I knew it would be bad (not a category five).

I left my car in Point Michel but was stopped due to HM. The ravine was full of logs. Next day I decided to walk to town – left at 615 – arrived at 9pm – checked on my godparents. Journey normally takes an hour but this time I was climbing logs – passing through water and passing through mud.

Saw that the school lost roof at back, we lost part of the school. I envisaged what I had to do. Gave my keys to a local teacher – I came in every day in the office to act like security guards – which means that people did not try and loot.

Shows me the video from the alarm – to show me local sites – lost roofs and subsided homes.

MP – was there a shelter in Loubiere.

BP – there was around 6 people I know and 20 people in total.

Showing me damage from local area near Pointe Michel.

MP – was there surface water – had it passed down slope – were there mudslides?

BP – there was no water – there were little mudslides but there were tree trunks and boulders which had passed down the ravine. Along the ravine people housed there lost their homes as the road, river had no boundary. Normally the ravine is not managed and has little water.

MP – will they manage the ravine –

BP – yes – they will now.

MP is there a problem with landuse management.

BP – yes – people build where there is space. But HM took these houses.

Discusses pictures taken locally.

MP – aftermath – what worked well on the island?

BP – clearing of the roads – was amazing (compared to hurricane David) – by 20th October I could drive my vehicle around the island.

MP – why was this.

BP – heavy duty material in local community.

MP – was this done by locals or govt?

BP – both – govt did main roads locals did connecting roads – people wanted to get out.

MP – relief how organised?

BP – French bought in boat loads of supplies every weekend – so people could receive bread, water, supplies.

MP – did the people in need receive.

BP – some people who did not need came forward – some people pushed forwards more to get more.

MP – failure

BP – we did not work together – we depended on the government – we did not realise that we could work our way out of this.

MP – should it be community led or government led.

BP – both – schools should not be shelters – the govt should build community centres – and then pay community leaders to provide support.

In hurricane David we recovered slower. We have rebounded quicker. I still do not have electricity – and have adapted to this.

I decided to open school early to help people get back to normal.

MP – government pushing forward with climate sustainability – what would you do?

BP – all housing needs to be built to certain codes and structures. If not done properly should be knocked down.

Need to move away from fossil fuels and towards renewable energy. Need to get away from spaghetti infrastructure (power lines).

Need to stop schools being shelters. Need to focus on buildings. Lots of buildings are facades - not earthquake secure.

Need to dredge rivers – and the pillar bridges do not provide the solution – we need suspension bridges like we used to as these have lasted for years - large discharge never troubled us with these. Land use management needs to be managed properly – stop people just building on open space. Need to enforce the laws.

MP – do you think the government will change.

BP – they can – depends on what they want to

MP – village community disaster council – are you on one?

BP – yes – but as principal – but I am not active. We have CDRT scheme, but problem is that people trained may leave the island. But after Maria

547 before HM – 479 – immediately after – 529 – now

Allowed students from other schools temporarily registered to come to the school – some stayed – others went back.

MP – what measures will you bring into the curriculum to change teaching of DRR- for future disasters.

BP – emphasise geography programme more – more on mitigation – more on effects of looting – show that it is not fun – introduce emotional intelligence – psychosocial assessment.

MP – do you need more applied focus to local areas in DRR?

BP – teach them in general but then use examples of different settings – for different community settings.

ML (Head of Geography CV school)- 7months as Hof G – 14 years teaching - 2018

MP – when work till before HM

L – hurricane Harvey stopped my trip to Houston – hurricane Irma affected Barbuda – concerned me as I have family in Antigua – before HM we did a play at school to donate to the affected of Irma.

HM 24hrs before turned on us – we did not feel threatened – we did not think that it would make landfall – not as a 5.

We were told to prepare on Monday morning – but not many people took it seriously – as we thought it would be a cat 1.

By 6pm windy and rainy – reports from news said people in coastal areas to move.

MP – which radio made morning?

L – DBS – flatmate worked there – in most instances ODM staff – Cecil Shillingford – and Fitzroy Pascal came on to make warnings. Water was shut off by 630. We had electricity up till 7pm.

In Dominica we do abnormal things before a hurricane – so people buy alcohol – people buy canned food and bread and do a cook up – and drink rum. I did cook as a hurricane was going to pass. At 730 winds picked up quickly – to show that cat changed from 3 to 5. I sent message out in WhatsApp group. People use WhatsApp groups as social groups to share information. Around 730 – a large branch came through front door. Glass in kitchen. Water entered my home – live in Kings Hill. Windows were burst – flooding from rain – we do not normally get flooding.

MP – do you think people were aware of the damage from both water and wind.

L – for me I do not live near a river, even though I live near a ravine – I was more concerned about missiles and flying things. I used a mattress as a shield – doors were banging, and one was lost – we had to use series of sheets to stop water entering home. Tool shed was flattened, and nails became missiles. Fell asleep at 3am – HM had a pin hole eye – 20 minutes of calm.

Dominica – cable and wireless stayed on until 9pm – I posted online – I contacted a past teacher (in Texas) to ask what they could see over the island.

Education secretary lost her home –

After first sunrise – total devastation – men and women weeping – mighty trees stripped – and felled.

Following HM I volunteered at DBS – people wanted to know where their family were – so people walked in, over trees and boulders. Everyday people from east and north coast – to tell of levels of safety in each community. Priests, ministers village councillors came in to determine level of deaths or injury in each community.

DBS started a charging station so that they can charge their phones. It was extremely important for people to get in contacts with family. However, one of the station engineers died (not related to the HM).

Had to deal with looting – most people said they were looking for food – which was almost acceptable – but then they started looting for TVs and computers – so a curfew had to be put in to deal with looting.

I had to source water – however when some of the sites became overcrowded, I had to travel to sites further away – to Wotton Waven, Springfield beyond Newtown. I had to decide how to use my 12 hours of daylight. Could not lie in. I had to make the most of my daylight hours. Rich people were in the same position as the poorer area. However once people got their own supply back people were less communal. I decided to do communal cooking. Medical announcements were given to advise on how to keep sanitary. Also, to advise people on the water quality safety and how to access medication like diabetes.

There have been no outbreaks of cholera but there were outbreaks of gastroenteritis. However, govt - did decide to ask people to ration food. Most of the advice came from the radio.

Utilities companies came on weekly to update about services. Mobile phone use went up therefore cost of data went up.

Communal cooking – code mar spirit – repairing houses one house at a time.

MP – what did people focus on in repairs.

L – some people just used materials which had fallen. Others could not access this therefore already had tarpaulins and used these e.g. farmers and mechanics – people had them from their jobs – not because they needed this from a DRR perspective.

Near Newtown – was one of the first helicopters to land – did a reconnaissance. By Wednesday and Thursday there were food drops. Foreign citizens were arranged to leave by their consulates. Many chose to leave because they were advised.

Some people lost everything – it took a strong mind or a blind eye to get through this. As a teacher of hazards, I showed a lot of videos so I did have a perspective of what might happen which helped with the preparation – now people will show the video of Dominica.

Saddened that this happened as we lost part of school, lost students, and families. However, life is biggest and best teacher – experienced a hurricane as biggest and strongest that you could have got – an act of nature – chosen to be here and endure this. Experiences will make you stronger. Maria has trumped them all!

Urbanisation was higher now (than during David) therefore recovery was easier. Now the impact was worse. Students have a great appreciation having endured.

The dust was a problem – we had to wear masks to town – these were included in rationed supplies. Family members (aboard) were sending hand sanitiser and masks.

MP – process of relief – how?

L - government briefed every day from his office. He also invited others to speak e.g., trauma team from Trinidad and Tobago – recount their experiences in rural areas – how to take care of their

mental health. There are US citizens here organising free classes on how to deal with stress and mental wellbeing.

As family members started sending stuff – govt stopped duty on goods. All goods arrived in port – it was chaotic – there were some thefts.

Had police officers from different countries in the Caribbean, Barbados, St Vincent etc, who helped ot deliver packages which arrived in ports. Some things took time. It was chaos and a mess, but we did get food.

Many of the supermarkets opened under guard so to reduce looting – they opened restricted times – 9-2pm – there were queues – for pharmacy – you just had to have patience. When the government got their relief they passed it onto communities – this was not done well – some small communities shared well – but in other areas it was horrible – some people did not share with their family members.

MP – what was done well – in aftermath.

L – clean up -excellent – commend government – by day 5 – were able to move. May not be able to drive past – communities were unblocked. After 7 days many communities were accessible by foot and by small vehicles – this was better in areas that were near main roads. I was able to drive all the way to the airport 14 days after the storm – I had to visit mother at the time – therefore to access money and visit mother I needed to get away from the chaos. Being here was stressful and overwhelming. It was a breaking moment. I cried at night. I lived in the day – had a face of strength. Getting water, a challenge. One day I had no water as I had not time – little things broke you. People enjoyed being back on work – we opened on October 4th – one of the first back – was a sense of normality.

MP – did you have a shelter.

My community had no shelter but there was a church there. TO this date there are people still there – the government focused on clearing the school first but there are still people in the churches.

The second thing was communication – this was done well.

MP – school – what would you like to do in geography / school to better prepare students for future hazards.

L – need more drills – we used to do this but not so much recently. We need to get people to work on autopilot. We need to teach more about what you need to do – practical approaches have drills. Teach about the construction of the school – we are working with alumni – a foundation – to donate money to better repair the school. We need a school that can withstand a disaster. WE are looking at green energy solar panels. Less reliance on diesel. After HM people bought generators – cost 50EC to power – but the smell of the exhausts was poor and the noise – all through the night. This allowed to have fridge, lights and charging – some people did not share. The costs and smells were very bad. At one point they would not sell more than 50EC per day.

Price increases also occurred. Coke went from 3EC to 10EC at one point. People even put their experiences of having cold drinks and fruits on social media.

Brewery was damaged – despite damage to the plant, and release of chemicals – just to get beer! Government had to step in.

MP how many died after the event –

L – 32 confirmed deaths – 30 missing (ish). My numbers not exact. We do not know about how many died exactly from the direct effects – so we do not know about what the secondary effects were. People who could not get insulin, people who could not get other medication.

MP if you had a say on climate resilience what would you do.

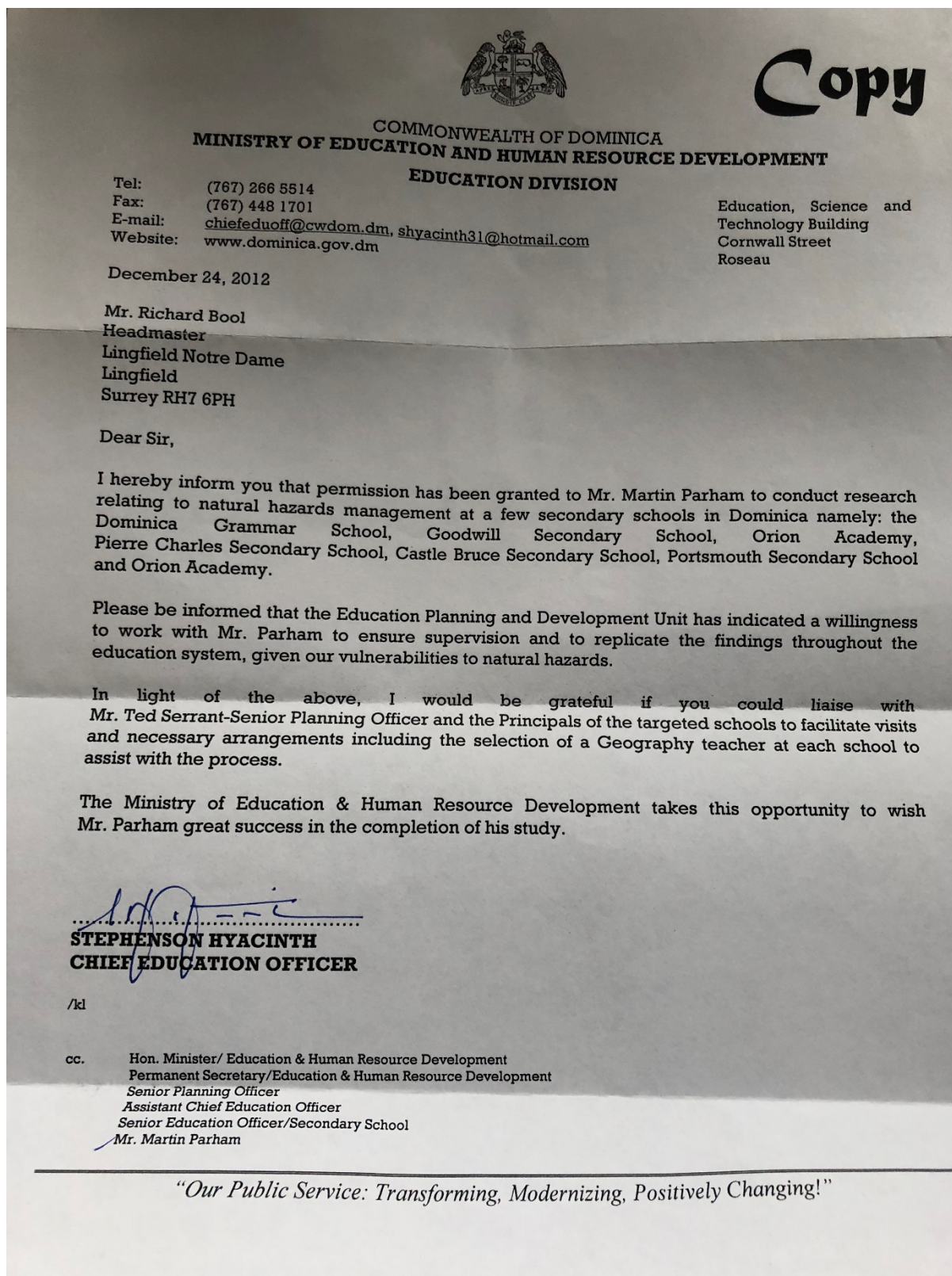
L – go green, pollution is an issue – we use too much plastic – managing garbage is an issue. We have an issue with rising sea levels – one of our biggest problems poor housing code – e.g., Bath Estate. Ministry of housing has let things go. Check hall also has large boulders and always flooded and therefore move people away from dangerous areas. We to stop selling land on floodplains. Tropical Storm Erika made a wish-wash of Bath Estate – so many communities are located between rivers. Land is limited. We are...arggh. We are sent back 20 years – we are already lagging rest of the Caribbean. Our land is very difficult to manage. Our same mountains which are a blessing to the island are a curse to our development.

Dominica will have another disaster. For example a large rockfall occurred on the Canefield cliff - which is problem if you need to get to the north.

I know of many people who lots of bodies but do not know where they so lack closure.

A lot of people underestimated – still advising people to move to higher land.

Appendix G – MoE permission document to work in Dominican schools.



University of Portsmouth Ethics Review Checklist

To be completed by **all** Staff and postgraduate students undertaking research

- You are required to undertake an ethics review of your Independent Study Research Proposal. Before completing this checklist, please read through the guidelines on the K:drive at: *K:\Science\Staff\Geography\Geography Ethics*
- When you have completed the checklist, submit it via Dr Carmen Solana
- *Ethical review is a University requirement for all research. This form constitutes a light touch fast-track mechanism to identify ethics risks.*

Name of Principal Investigator

Martin Parham

Research Title

Investigation the impact of education in the mitigation of hazards on Small Island Developing States

Please indicate Yes or No:-

Yes No

[A] Is the study likely to involve human research subjects or participants?

✓

If 'Yes', please go to Section [B] on page 2

If 'No', please answer the following:-

a) Are there risks of damage to physical and/or ecological environmental features? ✓

b) Are there risks of damage to features of historical or cultural heritage? ✓

c) Are there risks of harm to any animal? ✓

d) Could the research outputs potentially be harmful to third parties? ✓

If you have answered 'yes' to a), b), c) or d), then please provide details (in the space below) of how you plan to minimise any risks identified. You may attach additional information if necessary.

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Now go to page 4 and sign the Declaration (Section D)

[C] In terms of the primary data collection methods on human subjects, please answer the following:-

- Please indicate Yes or No:-
- | | Yes | No |
|--|-----|--------------------------|
| 1. Will the study involve NHS patients, staff or premises? | | ✓ |
| Do human participants/subjects take part in studies without their knowledge/consent at the time or will deception of any form be used? | | ✓ |
| 2. Does the study involve vulnerable or dependent participants (e.g. children or people with learning difficulties) | ✓ | <input type="checkbox"/> |
| 3. Are drugs, placebos or other substances (e.g. food, vitamins) to be administered to participants? | | ✓ |
| 4. Will blood or tissue samples be obtained from participants? | | ✓ |
| 5. Is pain or more than mild discomfort likely to result from the study? | | ✓ |
| 6. Could the study induce psychological distress or anxiety in participants, or third parties? | ✓ | |
| 7. Will the study involve prolonged or repetitive testing or participants? | | <input type="checkbox"/> |
| 8. Will financial inducements other than reasonable expenses be offered to participants? | ✓ | |

Please indicate whether there are any other general problems relating to research ethics:-

- Are there risks of damage to physical and/or ecological environmental features?
NO
9. Are there risks of damage to features of historical or cultural heritage? NO
10. Are there risks of harm to any animal? NO
11. Could the research outputs potentially be harmful to third parties?
NO

If you have answered 'yes' to 2, 3, 8, 9, 10, 11, 12 or 13 then you must provide additional details (in the space below) of how you plan to minimise any risks identified. Please attach any additional materials if necessary.

The study involves looking at how effective education is at mitigating hazards. As a trained qualified teacher of Geography in the UK I am well placed to undertake a study involving children as I am CRB checked.

In addition, I have received permission to work in schools in Dominica through the Education Office – Ted Serrant – on a previous visit to the island to work in named schools – Portsmouth, Dominica State, Orion College, Castle Bruce and Grand Bay. I have also been

in contact with the headmasters from these schools and some staff and in some cases have met with these people to discuss the project – on each occasion meeting no resistance. On this visit I will be interviewing students to ascertain a base understanding of their knowledge of natural hazards. On subsequent visits I will be teaching students and again assessing their knowledge of natural hazards on the island through questionnaires and surveys. I will not be using student names or information in the publishing of any of the study, though the names of schools will be used (with permission of the schools and the Education Ministry).

If necessary, I will take copies of an agreement letter to the students and ask them to sign to gain the permission for use of their views in the study.

Now go to page 4 and sign the Declaration (Section D)

[D] Declaration.

I confirm that the information provided is a complete and accurate record of my plans at present and that I shall resubmit an amended version of this form should my research alter significantly such that there is any significant variation of ethical risk. I confirm that I have read the University Ethics Policy (2007) and Research Integrity circular 28/E7 Nov. 2001 and have read “Research Ethics Guidance, Geography Staff and Students” (available at: *L:\science\Staff\Geography\Geography Ethics\Ethics Guidance*)

Where necessary, I will also provide a covering letter/information leaflet and/or consent form for the participants in my research.

Signed M Parham (Student)

Date 1/10/13

[E] APPROVAL RECORD *(completed by Departmental Ethics Representative after you have submitted the checklist)*

Dr Michelle Bloor or Dr Carmen Solana (Departmental Ethics Representatives) will review your submitted ethics checklist and will tick one of the boxes below. If there is a recommendation to undertake more work in terms of ethics consideration (e.g. undertaking to follow procedures to minimise risks or undertaking a more detailed ethics review) then instructions will be included with the returned form. If your proposal is not ethically viable then this will also be made clear and you will be asked to significantly amend and/or rethink your research.

Favourable opinion : INSIGNIFICANT risk

Favourable opinion : INSIGNIFICANT subject to comments listed below

Risks assessed as SIGNIFICANT referred for DETAILED Ethics Review

Not approved – reasons specified below

M. Parham is CRB checked and his work has been approved by the schools involved


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Signed 

Dr M C Solana (Department Ethics Representative)

Date 8 October, 2013

Appendix I – Risk Assessment form

 ASSESSING OUR RISKS PROJECT FIELDWORK RISK ASSESSMENT FORM School of Earth & Environmental Sciences									
You must attach an A4 map of your field area and, if appropriate, a tidal information printout for your field area.					Calculate: Probability multiplied by severity for No/Post control scores. NB: For scores of 10 (High), or more contact the Health & Safety department for further advice.				
Student Name :	Martin Parham	Student ID :	673056	Severity	Minor injury	Lost time/ Ill Health	Major / >3 days	Perm. Disability	Fatal/ Site Loss
Supervisor :	Richard Teeuw	Mobile Phone Number :	07742395254		Probability	1	2	3	4
Assessment Date :	June 2018	Project Dates	15th - 26th Oct	Highly Unlikely 1	1	2	3	4	5
Project Area :	Island of Dominica			Unlikely 2	2	4	6	8	10
Project brief:	Year 2 of data collection for PHD study - PRISM interviews, fieldwork and lesson observations			Possible 3	3	6	9	12	15
Locality 1 :	Portsmouth - area around high school/town			Probable 4	4	8	12	16	20
Locality 2 :	Roseau - area near Orion and DSG school			Certain 5	5	10	15	20	25
Locality 3 :	Castle Bruce - area adjacent to school			Students Signature :		M Parham			
Locality 4 :	Locations around island e.g., Grand Bay, Mero, Coulibistree, Calibishe, Picard, Bellevue Chopin			Supervisor Signature :		R Teeuw			
Locality 5 :				Health & Safety Co-ordinator signature :					

Locality	Identified hazards or Injury causes, highlighting risks (Injury focused - see checklist)	Score -No controls (Probability x Severity = calculation)	Control measures (existing controls, information, Personal protective equipment etc)	Score -Post Controls (Calculation)	Action Priority (H/M/L)
1-4	Weather hazards	3 x 2 = 6	Sensible clothing; suncream; wet weather clothing	2x1 = 2	H
1-4	Slips trips and falls - in areas around	3 x 2 = 6	Wear supporting shoes - careful footing	2 x 1 = 2	M
1-4	Aggressive local populatoin/animals	3 x 3 = 9	Avoid contact with locals other than those who we are meeting with	2 x 1 = 2	M
1-4	Insect bites, stings - mosquitoes	3x3 = 9	Take medication and DEET - mosquito net	3 x 1 = 3	H
1-4	Car and traffic hazards	3 x 3 = 9	Drive slowly - wear seatbelts - follow laws <u>Be vigilant in road crossing</u>	3x1 = 3	M
1-4	Ingestion of contaminated water	3x 4 =12	Drink bottled water and purchase water <u>do not use tap water</u>	3x 1 = 3	M
All	Natural hazard - landslide	1x 4 = 4	Be wary - contact ODM for updates	2 x 1 = 2	M
All	Cliff collapse	1 x 4 = 4	Wear hard hats near cliff, work away from cliff if possible, leave contact details.	2 x 1 = 2	M
All	Working near rivers - bank collapse - fall in	2 x 3 = 6	Avoid dangerous locations, work near shallow locations, check bank stability	2 x 1 = 2	M
1,2,4	Working near volcanic sites - gas, mass wasting, rock fall, slips	1 x 3 = 3	Avoid dangerous locations, take local advice, work with guidance of ODM	2 x 1 = 2	M

Local contact address whilst in the field:	Lennox Honeychurch lennoxh@cwdom.dm	Local contact address whilst in the field:	See Address
Local Emergency phone number:	0742395254	Is landowner permission required prior to visit ?	YES / NO
Local Emergency facilities <small>(Location and phone number for local hospital etc)</small>	Princess Margaret Hospital Goodwill Roseau 767 448 2236	If yes have they given permission?	YES / NO
		Landowner details:	n/a

**In the event of an accident or dangerous occurrence you must contact any one of the three persons listed below.
All accidents must be reported as soon as possible.
Do NOT wait until you return from the field.**

Important Addresses :		
Dr R A Strachan Head of School School of Earth & Environmental Sciences University of Portsmouth Burnaby Building Portsmouth PO1 3QL Tel: 02392 842279 (Work) 02392 460422 (Home)	Mr D Wright Health & Safety Manager University of Portsmouth Nuffield centre Portsmouth PO1 2ED Tel: 02392 843440 (Work)	Mr R W Pulley Laboratory Manager, Health & Safety Co-ordinator School of Earth & Environmental Sciences University of Portsmouth Burnaby Building Portsmouth PO1 3QL Tel: 02392 842243 (Work) 02392 262288 (Home) 07980 118448 (Mobile)

Appendix J - PRISM questionnaire

The following questionnaire was asked in addition to the main PRISM exercises. This information gave a contextual background to each student interviewed.

- Which ward/area do you come from?
- Which of the following items do you/your family have at home?
– *Note: the list included a car, computer (with internet access), mobile phone, radio (with batteries), clean running water and electricity supply.*
- What job do your parents do?
- What was the highest level of education received by parents?
– *Note: answers included no education, primary school, high school, college education or university.*
- List the provisions you have at home which help you prepare for natural hazards.

Note - students were given the option to select from a list and were then asked to add provisions of their own, if the list did not cover all – the list included keeping water, flashlights with batteries, radio with battery, emergency bag with important possessions, canned food.